

Defining 4G

**Understanding the ITU Process
for the Next Generation
of Wireless Technology**

July 2007



Defining 4G: Understanding the ITU Process for the Next Generation of Wireless Technology

3G Americas
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1.0 DEFINING 4G WIRELESS SYSTEMS

The communications industry is witnessing significant posturing about wireless technologies and systems that are claiming to be “4G.” Any claim that a particular technology is a 4G technology or system today is, in reality, simply a market positioning statement by the respective technology advocate. Such claims must be verified and substantiated against a set of requirements in order to qualify as 4G.

The International Telecommunication Union (ITU)¹ is the internationally recognized entity chartered to produce an official definition of the next generation of wireless technologies. Its Radiocommunication Sector (ITU-R) is establishing an agreed and globally accepted definition of 4G wireless systems that is inclusive of the current multi-dimensional and diverse stakeholder universe.

The ITU² is close to releasing a full set of documentation for this definition. It has held ongoing consultations with the global community over many years on this topic in Working Party 8F³ under the scope of a work item known as *Question ITU-R 229-1/8 “Future development of IMT-2000 and systems beyond IMT-2000”* (see Annex 1).

This work in WP 8F has woven together a definition, recipe, and roadmap for the future beyond 3G that is comprised of a balance among a Market and Services View, a Technology View, and a Spectrum View. These, along with Regulatory aspects, are the key elements for business success in wireless.

Significant work has been completed in ITU-R, establishing the nucleus of what should be encompassed in a 4G system. In particular, ITU-R, working under a mandate to address systems beyond 3G, has progressed from delivering a vision of 4G in 2002 to establishing a name for 4G in 2005 (*IMT-Advanced*). In 2006, ITU-R set out the principles for the process of the development of *IMT-Advanced*. These early deliverables have stimulated research and development activities worldwide, spawned ideas for potential technologies and promoted views on spectrum required to address a rapidly growing wireless world.

In early 2008, ITU-R will translate the vision and framework of this effort into a set of requirements by which technologies and systems can, in the near future, be determined a part of *IMT-Advanced* and in doing so, earn the right to be considered 4G.

During 2008 and 2009, ITU-R will hold an open call for 4G (*IMT-Advanced*) candidates as well as an assessment of those candidates' technologies and systems. The culmination of this open process will be a 4G, or *IMT-Advanced* family. Such a 4G family, in adherence to the principles defined for acceptance into this process, is globally recognized to be one which can grow to include all aspects of a marketplace that will arrive beyond 2010, thus complementing and building upon an expanding and maturing 3G business.

¹ <http://www.itu.int>

² ITU materials used by permission.

³ The home page for WP 8F is <http://www.itu.int/ITU-R/index.asp?category=study-groups&link=rwp8f&lang=en>. The terms of reference of WP 8F may be found at <http://www.itu.int/ITU-R/study-groups/docs/rwp8f-terms-en.html>.

Proceeding Toward 4G (*IMT-ADVANCED*)

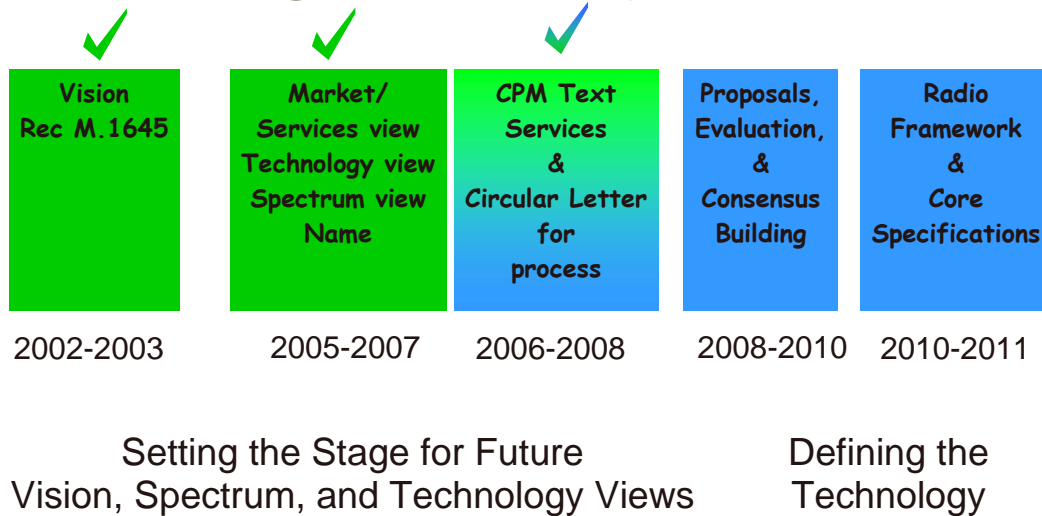


Figure 1: The Progression Towards 4G (simple view)

Conclusion

Third Generation Systems began as a concept that envisioned what a future wireless mobility marketplace would look like. Thus began a global process to foster the development of technologies to support that vision. What truly defined, and continues to define, the term "3G" is the evolving wireless marketplace. The definition of what comprises a "generation" manifests only after particular technologies enjoy deployments in major marketplaces globally. This is currently occurring for 3G technologies, and will certainly happen for 4G as well.

As a defined generation of wireless, 4G is therefore only in its adolescence. It remains the task of the stakeholders to take 4G forward over time. As it was for 3G, 4G will be defined in stages. The 4G development work is poised to move into the next stages: establishing criteria for *IMT-Advanced* and ultimately screening the technologies for inclusion in the *IMT-Advanced* family. Only then will we understand what is and can be rightly called a 4G technology/system.

2.0 REFERENCES & FURTHER BACKGROUND

These materials, available from the ITU,⁴ provide a deeper understanding of the 4G (*IMT-Advanced*) future. Specific details from some of the cited relevant references are provided as additional background.

This section addresses:

- 2.1 – Understanding the Future Vision, Market, Services, and Technology Concepts
- 2.2 – Understanding the Future Spectrum
- 2.3 – Naming 4G and Establishing Principles for a Process for Development of 4G
- 2.4 – Establishing the Criteria for 4G, the Call for Submissions, Deciding on the Technologies

2.1 - Understanding the Future Vision, Market, Services, and Technology Concepts

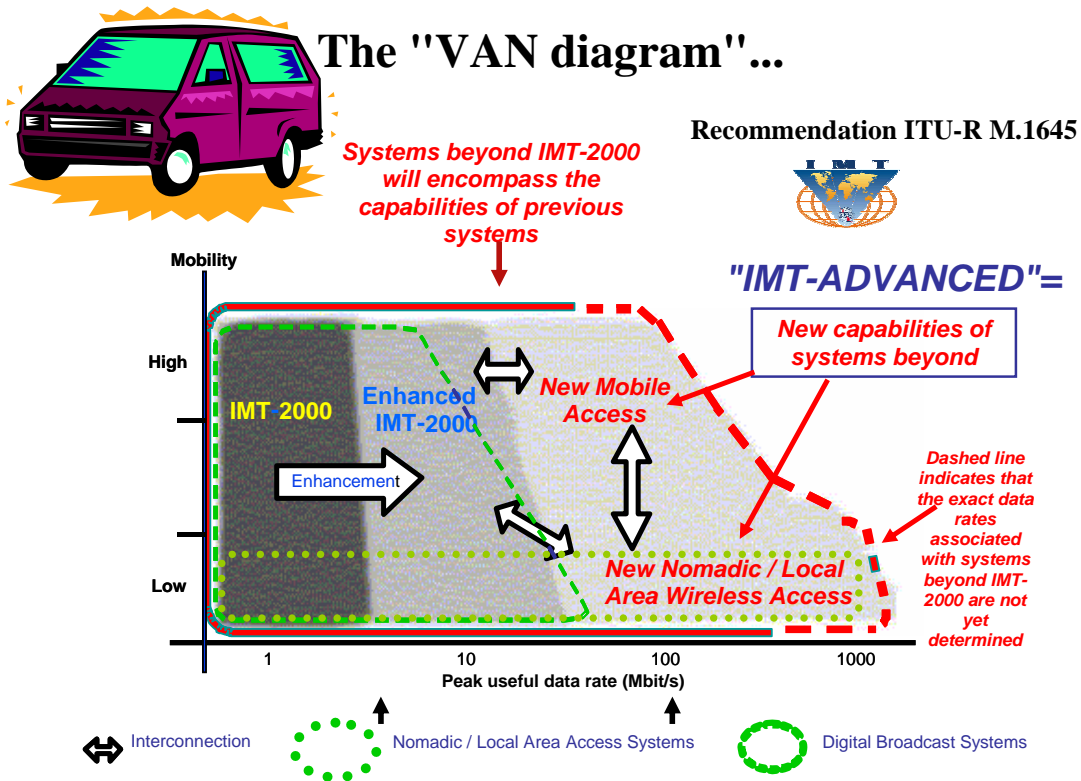
Vision (completed 2002/2003 ITU-R deliverable)

Recommendation ITU-R M.1645: Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000.

A new radio access interface(s) is envisaged to handle a wide range of supported data rates according to economic and service demands in multi-user environments with peak data rates, as targets for research, of up to approximately 100 Mbit/s for high mobility applications such as mobile access, and up to approximately 1 Gbit/s for low mobility applications such as nomadic/local wireless access.

⁴ Publications for the ITU-R are specifically available at:
<http://www.itu.int/publications/sector.aspx?lang=en§or=1>

A picture that is “worth a thousand words” towards understanding the vision of 4G is included in M.1645 and is reproduced below.



Market (completed 2005 ITU-R deliverable)

Report ITU-R M.2072: World mobile telecommunication market forecast

Report ITU-R M.2072 provides a summary of the market analysis and forecast of evolution of mobile market and services for the future development of IMT-2000, systems beyond IMT-2000 and other systems. This Report has derived market related parameters and provided forecasts for 2010, 2015, and 2020 for the mobile market. These parameters are essential inputs in developing a spectrum estimate, for future development of IMT-2000 and systems beyond IMT 2000 in preparation for the World Radiocommunication Conference 2007. The findings of this Report are based on internal and external studies to the year 2020 as well as detailed data on the traffic forecasts in different parts of the world. It also provides examples of potential services and applications of future development of IMT-2000 and systems beyond IMT-2000 from the year 2010 onwards.

Technology (completed 2005 ITU-R deliverable)

Report ITU-R M.2038: Technology Trends

Report ITU-R M.2038 provides information on many of the technology trends concerning radio access networks foreseen at the time of preparation of Recommendation ITU-R M.1645.

The Report addresses technology topics that appear relevant to the future development of IMT-2000 and systems beyond IMT-2000. The Report considers these topics in three broad categories:

- technologies which have an impact on spectrum, its utilization and/or efficiency in this context;
- technologies which relate to access networks and radio interfaces;
- technologies which relate to mobile terminals.

Report ITU-R M.2074: Radio aspects for the terrestrial component of IMT-2000 and systems beyond IMT-2000

Report ITU-R M.2074 describes technical matters related to radio aspects, such as requirements for technical characteristics needed for spectrum requirements calculations, values of the required radio parameters, spectrum efficiency values, and suitable spectrum range preference from a technical aspect. These matters are reflected in the process to calculate the required spectrum and to determine suitable frequency ranges for the future development of IMT-2000 and systems beyond IMT-2000 from the year 2010 onwards to fulfill the framework shown in Recommendation ITU-R M.1645.

Services (completed 2007 ITU-R deliverable⁵)

Recommendation ITU-R M.[SERV]: Framework for Services delivered by IMT

Recommendation ITU-R M.[SERV] addresses the high-level requirements for services to be supported by IMT, including the future development of IMT-2000 and IMT-Advanced. It includes service descriptions, service enablers, service description parameters and service classifications of IMT. Various case studies are included.

2.2 - Understanding the Future Spectrum

Another important aspect in the future of 4G markets is the establishment of the spectrum needs that 4G would require. If 4G provides the building, the spectrum provides the real estate for this future marketplace. The understanding of what spectrum might be accorded to systems of the future, and what frequency bands, constraints, bandwidth, etc., that candidate spectrum may have, is crucial to the development of 4G type technology/systems that support data rates up to 1 GB/s over a wide range of environments. Many of these spectrum issues will be addressed at the ITU-R World Radio Conference 2007 to be convened in 4Q 2007.

⁵ Scheduled for conclusion in mid-2007

Spectrum (completed 2006 ITU-R deliverables)

Recommendation ITU-R M.1768: Methodology for calculation of spectrum requirements for the future development of the terrestrial component of IMT-2000 and systems beyond IMT-2000

In Recommendation ITU-R M.1768 the spectrum calculation for the future development of IMT-2000 and IMT-Advanced is addressed. New concepts were introduced, including a mix of services, multiple complementary systems, and Radio Access Techniques Groups (RATG) which are required to encapsulate a wide-ranging wireless future. It weaves together key impacts on spectrum needs into a complex multi-dimensional model accommodating a diversity of services and market demand scenarios with forward-looking technology aspects.

Report ITU-R M.2078: Estimated spectrum bandwidth requirements for the future development of IMT-2000 and IMT-Advanced

The majority of the future traffic is changing from speech-oriented communications to multimedia packet communications. Consequently, the methodology on terrestrial spectrum requirement estimation for IMT has been updated to accommodate the diverse aspects of IMT.

As indicated by Report ITU-R M.2078, the predicted total spectrum bandwidth requirement for both existing mobile cellular systems, including pre-IMT-2000 and IMT-2000 and its enhancements, and IMT-Advanced for the year 2020, was calculated for both low and high user-demand scenarios to be 1280 MHz and 1720 MHz, respectively. It should be noted that the lower figure (1280 MHz) is higher than the requirements for some countries. In addition, there are some countries where the requirement is larger than the higher value (1720 MHz). The spectrum prediction is based on an assumption of one network deployment. In case of several parallel network deployments in a country, spectrum requirements will be higher as provided by Report ITU-R M.2078.

Report ITU-R M.2079: Technical and operational information for identifying Spectrum for the terrestrial component of future development of IMT-2000 and IMT-Advanced

Report ITU-R M.2079 indicates that the prioritized candidate bands should focus on bands between 400 MHz and 5 GHz. Details are provided about the various bands with regard to world-wide applicability, as well as various advantages and disadvantages of each.

2.3 – Naming 4G and Establishing Principles for a Process for Development of 4G

A significant step towards the reality of 4G is the establishment of a more formal name for these systems as well as the development of principles to guide the development and selection process designed to qualify technologies and systems as 4G.

ITU-R has established two critical elements of 4G systems and technologies. The adoption of ITU-R Resolutions is anticipated at the ITU-R Radio communication Assembly in October

2007. These views, which have already been mainly accepted by the stakeholders of a future 4G world, are the *Name Resolution* and the *Principles Resolution*.

The *Name Resolution* specifies the nomenclature for the future development of IMT-2000 and Systems Beyond IMT-2000 through names uniquely associated with the advancement and continuation of International Mobile Telecommunications (IMT), and gives us the now accepted term *IMT-Advanced*.

The *Principles Resolutions* takes this further towards 4G by establishing the principles for the process of the development of *IMT-Advanced*.

Towards the ultimate goal of determining what a 4G system is, and what constitutes the *IMT-Advanced* technology set, ITU-R is in the midst of finalizing a process that satisfies the framework of the above principles, to be released in early 2008.

Naming (completed 2005 ITU-R deliverable⁶)

Draft New Resolution ITU-R M.[IMT.NAME]: Naming for International Mobile Telecommunications

In the Resolution ITU-R M.[IMT.NAME], the following conclusion is reached:

“ITU-R WP 8F, responding to the WRC-03 Resolution 228 mandate has determined the following nomenclature to describe the *IMT-2000 and Systems Beyond IMT-2000 universe* (see “Van Diagram” picture):

- that the term “IMT-2000” encompasses also its enhancements and future developments
- that the term “*IMT-Advanced*” be applied to those systems, system components, and related aspects that include new radio interface(s) that support the new capabilities of systems beyond IMT-2000
- that the term “IMT” is the root name that encompasses both IMT-2000 and *IMT-Advanced* collectively

This terminology is reflected in a draft new Resolution ITU-R [IMT.NAME].

This Resolution has been submitted for approval in the ITU-R Radiocommunications Assembly in October 2007.

Principles (completed 2006 ITU-R deliverable⁶)

*Draft New Resolution ITU-R M.[PRINCIPLES]: Principles for the process of development of *IMT-Advanced* (Question ITU-R 229/8)*

Resolution ITU-R M.[PRINCIPLES] presages the process by establishing the guidelines and principles for such a process that will ultimately result in not only the defining aspects of *IMT-Advanced* but also the actual selection of qualifying technologies for a 4G future. It states, in part, “that, in light of the above resolves, this process shall include:

⁶ To be adopted in the ITU-R Radio communication Assembly in October 2007

- a) the definition of minimum technical requirements and evaluation criteria, based on the framework and overall objectives of IMT-Advanced, that support the new capabilities expressed in Recommendation ITU-R M.1645, taking into account market requirements and without unnecessary legacy requirements;
- b) an invitation for Members of ITU-R, through a Circular Letter, to propose candidate radio interface technologies for IMT-Advanced;
- c) additionally, an invitation to other organisations to propose candidate radio interface technologies for IMT-Advanced, under the scope of liaison and collaboration with such other organizations through Resolution ITU-R 9. In such invitations the attention of these organizations shall be drawn to the current ITU-R Intellectual Property Rights (IPR) policies;
- d) an evaluation by ITU-R of the radio interface technologies proposed for IMT-Advanced to ensure that they meet the requirements and criteria defined in a) above. Such an evaluation may utilise the principles for interaction of ITU-R with other organizations as detailed in Resolution ITU-R 9-2;
- e) consensus building with the objective of achieving harmonization and which would have the potential for wide industry support of the radio interfaces that are developed for IMT-Advanced;
- f) a standardization phase where the ITU-R develops the IMT-Advanced radio interface specification Recommendation(s) based on the results of an evaluation report (defined in d) above) and of consensus-building (defined in e) above) ensuring that the specifications meet the technical requirements and evaluation criteria as defined in a) or g) above. In such a standardization phase, work may proceed in cooperation with relevant organisations external to the ITU in order to complement the work within the ITU-R, using the principles set out in Resolution ITU-R 9-2;
- g) reviews of the minimum technical requirements and evaluation criteria defined in 6 a), taking into account technology advances and market requirements changing with time. As the minimum technical requirements and evaluation criteria are changed, these will be designated as separately identifiable versions for IMT-Advanced. The process will include review of existing versions to determine whether they should remain in force;
- h) an ongoing and timely process where new radio interface technology proposals may be submitted and existing radio interface specifications can be updated. The process should have flexibility to allow proponents to seek evaluation against any version of the approved criteria currently in force.”

2.4 – Establishing the Criteria for 4G, the Call for Submissions, Deciding on the Technologies

One of the concluding aspects of defining 4G (*IMT-Advanced*) could be considered the actual publication of criteria for 4G, and the call for technology submissions the subsequent evaluations, assessments and decision making. This will launch the quantification of these developing technologies and ultimately establish the family of 4G systems.

In this stage of 4G, *IMT-Advanced* builds upon and expands the IMT-2000 (3G) foundation established by ITU-R and defined in Recommendation ITU-R M.1457, *Detailed specifications of the radio interfaces of International Mobile Telecommunications-2000 (IMT-2000)*. It is anticipated that relevant Recommendations paralleling M.1457 will be developed specifically for *IMT-Advanced*.

It is acknowledged that the Partnership Projects (3GPP⁷ and 3GPP2⁸) and industry Standard Development Organizations (SDOs) are and will continue to be an integral part of this global process. Other technology proponent entities will also be important contributors and an integral part of this process.

The basic processes utilized in the past, and currently for *IMT-2000/3G*, can and will continue to be successfully leveraged for *IMT-Advanced/4G* following the principles outlined.

Circular Letter on Process (in progress 2008 ITU-R deliverable)

*Circular Letter 8/LCCE/yyy: Request for Submission of Candidate Radio Transmission Technologies (RTTs) for IMT-Advanced Radio Air Interface*⁹

The purpose of this Circular Letter is to invite submission of candidate radio transmission technologies (RTTs), or candidate sets of radio transmission technologies (SRTTs) for IMT-Advanced for the development of a new ITU-R Recommendation (“Air Interface Recommendation”) describing radio air interface(s) to be used by IMT-Advanced. This Circular Letter also invites subsequent submission of evaluation reports on these candidate RTTs or SRTTs by independent evaluation groups. It will consist of a main body that provides relevant timeframes and deadlines, and various Annexes that provide specific details related to:

- Background on IMT-Advanced
- Submission and evaluation process and consensus building
- Requirements related to service capabilities
- Requirements related to technical system performance
- Spectrum related requirements
- Submission guidelines & template for details of submission
- Evaluation guidelines and test models
- Relevant ITU-R Recommendations, Reports and others
- IPR policy

⁷ Third Generation Partnership Project, <http://www.3gpp.org>

⁸ Third Generation Partnership Project 2, <http://www.3gpp2.org>

⁹ This is a working document in ITU-R Working Party 8F. Title, subject, and content may change.

3.0 RELEVANT ITU-R RESOLUTIONS, RECOMMENDATIONS, AND REPORTS

TYPE	NUMBER	TITLE
Draft New Recommendation ITU-R	M.[SERV]	Framework for Services delivered by IMT
Draft New Resolution ITU-R	M.[IMT.NAME]	Naming for International Mobile Telecommunications
Draft New Resolution ITU-R	M.[PRINCIPLES]	Principles for the process of development of IMT-Advanced (Question ITU-R 229/8)
Recommendation ITU-R	M.1645	Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000
Recommendation ITU-R	M.1768	Methodology for calculation of spectrum requirements for the future development of the terrestrial component of IMT-2000 and systems beyond IMT-2000
Report ITU-R	M.2038	Technology Trends
Report ITU-R	M.2072	World mobile telecommunication market forecast
Report ITU-R	M.2074	Radio aspects for the terrestrial component of IMT-2000 and systems beyond IMT-2000
Report ITU-R	M.2074	Radio aspects for the terrestrial component of IMT-2000 and systems beyond IMT-2000
Report ITU-R	M.2078	Estimated spectrum bandwidth requirements for the future development of IMT-2000 and IMT-Advanced
Report ITU-R	M.2079	Technical and operational information for identifying Spectrum for the terrestrial component of future development of IMT-2000 and IMT-Advanced

ANNEX 1

QUESTION ITU-R 229-1/8*

Future development of IMT-2000 and systems beyond IMT-2000

(2000-2003)

The ITU Radiocommunication Assembly,

considering

- a) that ever increasing demands for mobile communications requires the continual evolution of systems, and development of new systems where required, for multimedia applications such as high speed data, IP-packet and video;
- b) that future mobile communications systems will require higher data rates than those planned in the initial implementation of IMT-2000;
- c) that for international operation and economy of scale it is desirable to agree on the system technical, operational and spectrum related parameters, including interoperability standards;
- d) that the initial standardization of IMT-2000 radio specifications was completed by the end of 1999;
- e) that the implementation of IMT-2000 systems has commenced and that these systems are being continuously enhanced in line with market and technology trends;
- f) ITU-T Recommendations and associated activities that are relevant to this work;
- g) Question ITU-R 77/8 on consideration of the needs of developing countries in the development and implementation of mobile radiocommunication technology;
- h) that the cost of radio technology is continually decreasing, thus making the radio approach an increasingly attractive access option,

recognizing

- a) the timescales necessary to develop and agree on the technical, operational and spectrum related issues associated with the ongoing evolution and development of future mobile systems;
- b) that service functionalities in fixed and mobile networks are increasingly converging;
- c) that higher data rates, greater than those associated with initially implemented IMT-2000 systems are expected to be required to meet future needs;
- d) the needs of the developing countries;
- e) that the characteristics of future systems beyond IMT-2000, with data rates significantly higher than 2 Mbit/s, will require the adoption of more spectrally efficient techniques and may be best accommodated in frequency bands above 3 GHz,

* This Question should be brought to the attention of the Telecommunication Standardization Sector.

decides that the following Question should be studied.

Part A – Future development of IMT-2000

- 1 What are the overall objectives and user needs for ongoing enhancement of IMT-2000 terrestrial and satellite components, beyond that defined in Recommendation ITU-R M.1457, building upon service capabilities as defined in Recommendations ITU-R M.687 and ITU-R M.816?
- 2 What are the applications and service requirements associated with ongoing enhancement of IMT-2000, including the provision of enhanced IP based applications?
- 3 What are the technical, operational and spectrum related issues for the ongoing enhancement of IMT-2000?
- 4 What are the technical and operational characteristics needed to meet the requirements (such as utilization of identified frequency bands) for ongoing enhancement of IMT-2000?
- 5 What are the optimum arrangements required to facilitate harmonized use of the spectrum identified for IMT-2000?
- 6 What factors need to be considered in developing a migration strategy to facilitate transition from enhanced IMT-2000 to systems beyond this?
- 7 What are the issues concerning the facilitation of global circulation of terminals, mutual recognition agreements and other related aspects regarding the successful introduction of IMT-2000?

Part B – Systems beyond IMT-2000

- 1 What are the overall objectives for future systems beyond IMT-2000?
- 2 What are the service applications associated with these systems?
- 3 What are the technical, operational and spectrum related issues and associated studies as necessary, to meet the objectives of these future systems?
- 4 What are the issues concerning the facilitation of global circulation of terminals, mutual recognition agreements and other related aspects regarding the successful introduction of systems beyond IMT-2000?

further decides

- 1 that the results of the above studies should be included in one or more Recommendation(s) and/or Report(s);
- 2 that the studies of future development of IMT-2000, as described in Part A above, should be completed by 2005;
- 3 that studies of systems beyond IMT-2000, as described in Part B 1, 3 and 4 above, should be completed by 2005;
- 4 that the essential part of studies of systems beyond IMT-2000, as described in Part B 2 above, should be completed by 2005.



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Acknowledgements

The mission of 3G Americas is to promote and facilitate the seamless deployment throughout the Americas of GSM and its evolution to 3G and beyond. 3G Americas' Board of Governors members include Alcatel-Lucent, Andrew Corporation, AT&T, Cable & Wireless, Ericsson, Gemalto, HP, Motorola, Nokia, Nortel Networks, Openwave Systems, Research In Motion, Rogers Wireless, T-Mobile USA, Telcel, Telefónica and Texas Instruments.

We would like to recognize the significant project leadership and important contributions of Stephen Blust of AT&T, as well as the other member companies from our 3G Americas Board of Governors.