

***ARIB's activities  
on mobile communications system  
in 2020 and beyond***

**1<sup>st</sup> September 2014**

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**ARIB**

# Introduction

- ◆ “2020 and Beyond Ad Hoc (20B AH)” was established in Association of Radio Industries and Businesses (ARIB), Japan, to study terrestrial mobile communications system in 2020 and beyond
- ◆ This material shows overviews of 20B AH organization and our interim study results
- ◆ Throughout the presentation, the term “5G” is tentatively used to denote the mobile communications system to be commercialized in 2020 and beyond

# Contents

- 1. Overviews of ARIB 2020 and Beyond Ad Hoc**
- 2. Market and user trends**
- 3. Typical use cases**
- 4. Framework and capabilities of 5G**
- 5. 5G definition**
- 6. Conclusion**

# **1. OVERVIEWS OF ARIB 2020 AND BEYOND AD HOC**

# Outline of ARIB

## ◆ Objectives:

- To establish technical standards for radio systems as “ARIB Standards” in the field of telecommunication and broadcasting in Japan

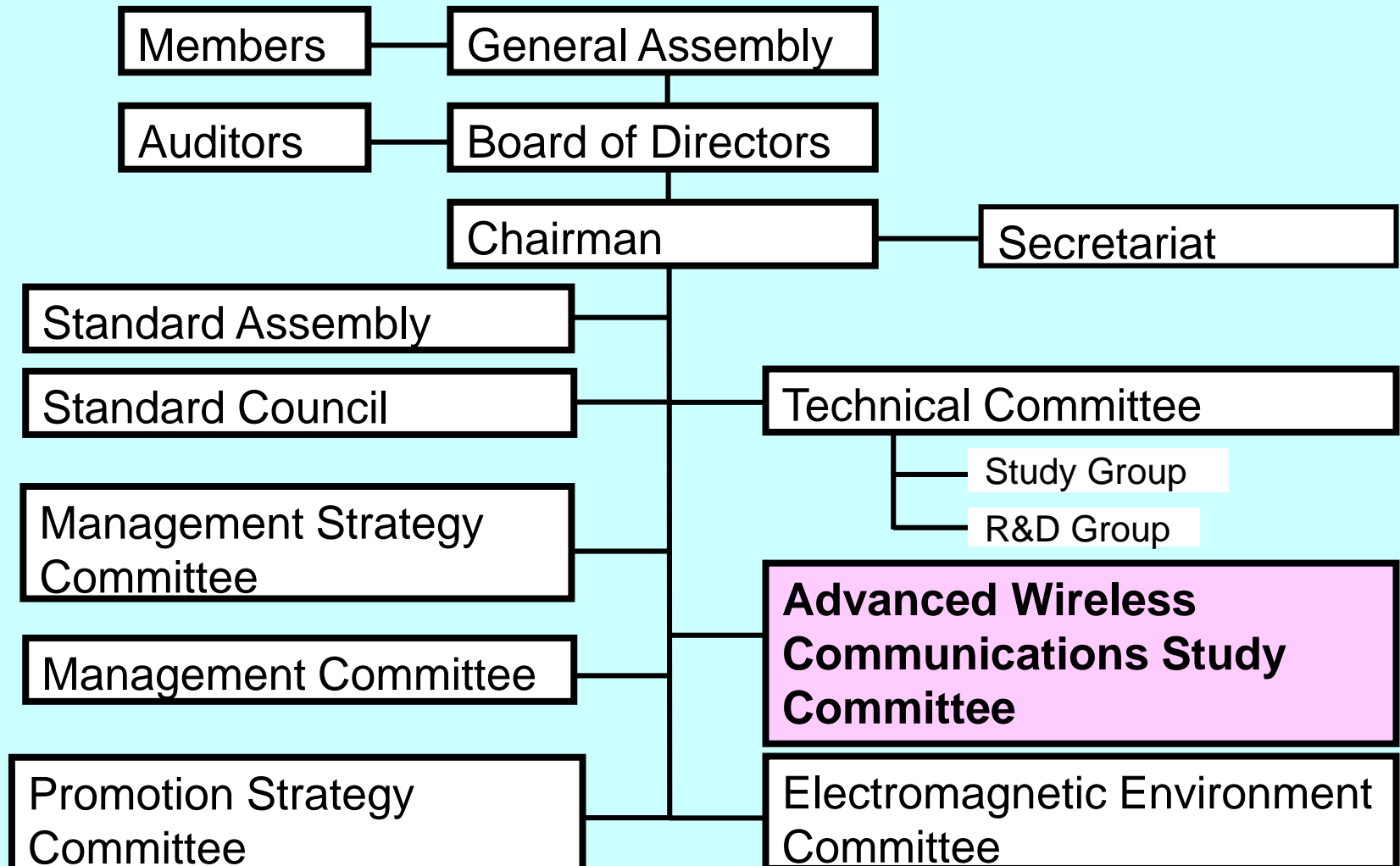
## ◆ Establishment:

- 15 May 1995 as a public service corporation by merging two organizations RCR & BTA
  - RCR: Research & Development Center for Radio Systems
  - BTA: Broadcasting Technology Association

## ◆ Members:

- 208 members (as of 1<sup>st</sup> July 2014), including telecom operators, broadcasters, manufacturers, etc.

# Organization of ARIB

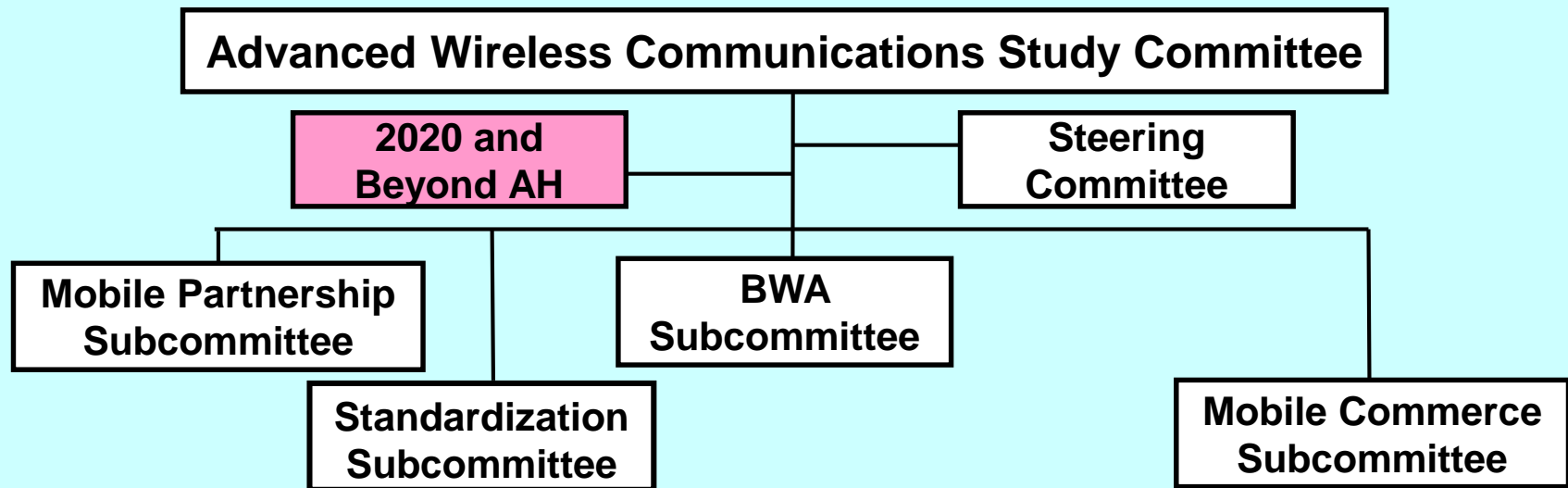


# Advanced Wireless Communications Study Committee (ADWICS)

## ■ Responsibilities

- To conduct technical studies on advanced wireless communication systems (including IMT) in cooperation with other related international/domestic organizations
- To contribute to international standardization activities

## ■ Structure of the Study Committee

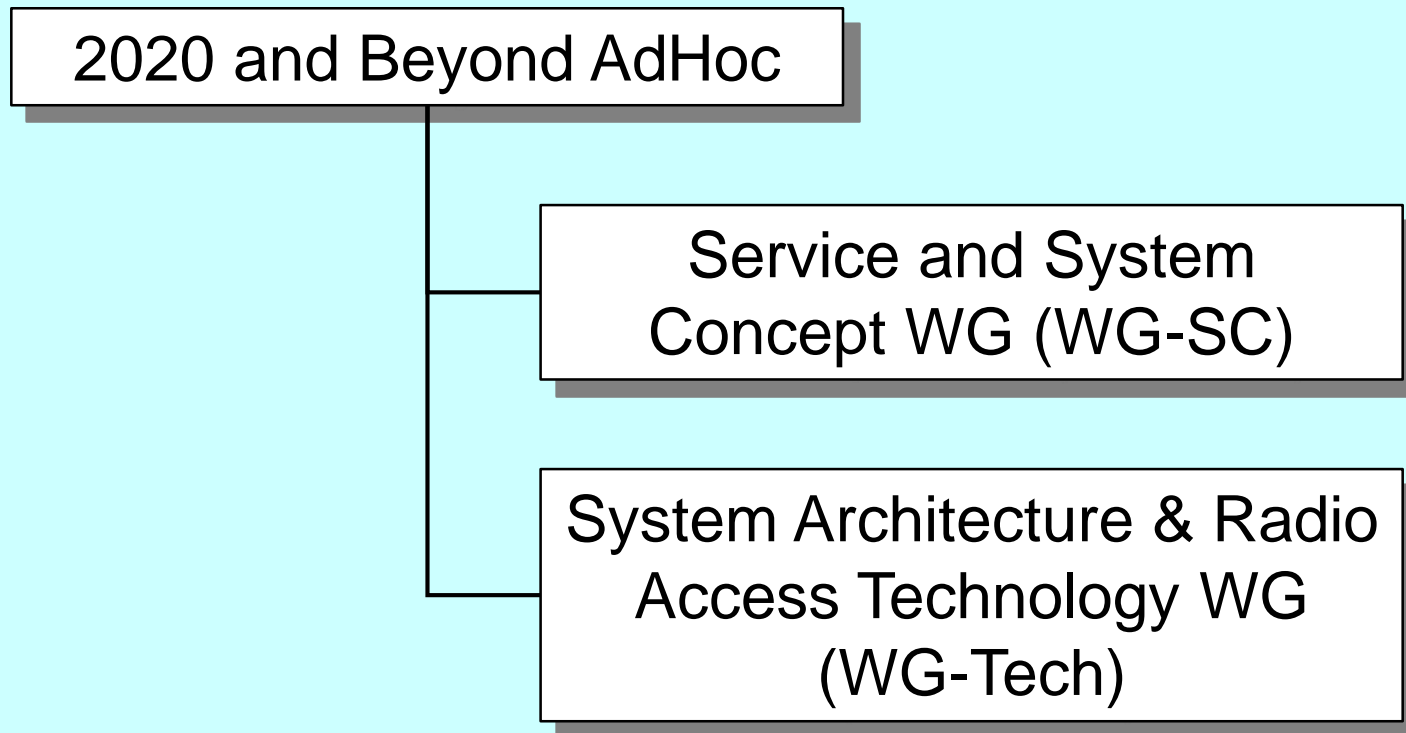


# 2020 and Beyond Ad Hoc (1)

- ◆ Established under ADWICS in Sep. 2013
- ◆ Leader: Takehiro Nakamura (NTT DOCOMO)
- ◆ 31 ARIB Members joining
- ◆ Objective:
  - To study system concept, basic functions and function distribution/architecture of mobile communication system in 2020 and beyond
- ◆ Task:
  - Study technologies used for system in 2020B
  - Study system concept and fundamental architecture of 2020B
  - Study services and applications offered by 2020B
  - Cooperation and coordination with other international/domestic organization
- ◆ Deliverables:
  - White paper, Contribute to ITU and other fora

# 2020 and Beyond Ad Hoc (2)

## ◆ Two WGs under 2020 and Beyond Ad Hoc



# Service and System Concept WG

- ◆ Leader: Akira Matsunaga (KDDI)
- ◆ Scope: Study services and system concept of mobile communication system (not limited to IMT) in 2020 and beyond
- ◆ Task: To clarify social roles, key capabilities and key functions of 2020B, study items such as follows
  - Use Case
  - Requirements
  - Capabilities including new Van Diagram
  - Spectrum
  - Traffic forecast

# System Architecture & Radio Access Technology WG

- ◆ Leader: Takaharu Nakamura (Fujitsu)
- ◆ Scope: Study trends of technologies to be used in 2020B, taking into account study results of Service and System Concept WG
- ◆ Task:
  - Study technology trends of radio access technologies and other major network technologies
  - Study basic functions and function distribution/architecture of 2020B

## **2. MARKET AND USER TRENDS**

# **Market and user trends (1)**

**1. “Everything can be done via the Internet” and people will enjoy its benefit.**

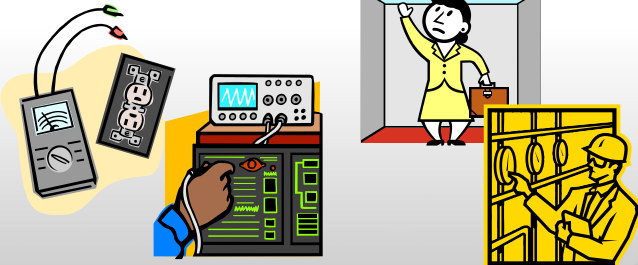
- Always connected to the Internet without users’ being conscious**
- Those non-connected will suffer from disadvantages**

**2. ICT will be used in much more cases and will be applied for vast variety of services.**

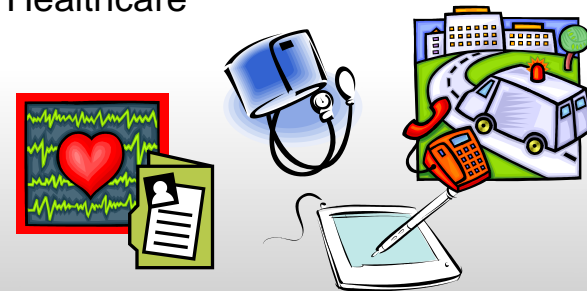
# Market and user trends (2)

Cope with a huge amount of data from a wide variety of applications, thereby fostering every industry innovation, e.g. M2M

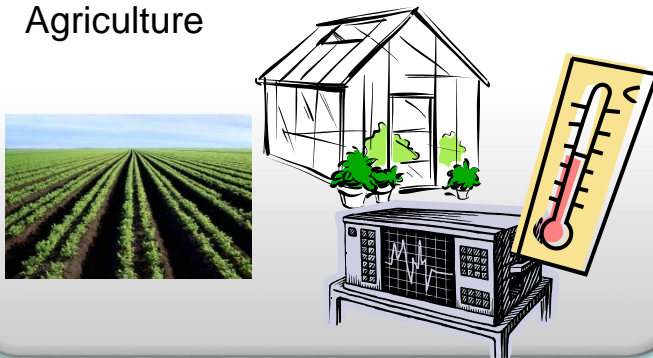
Structure



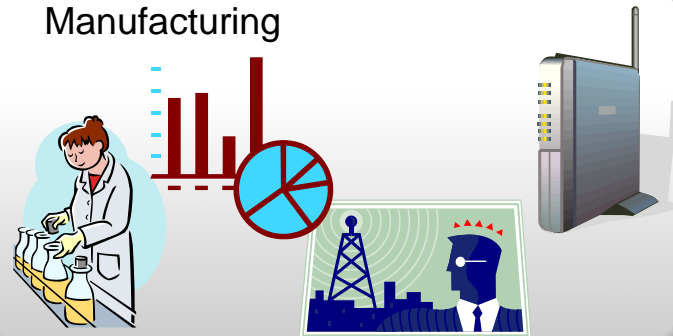
Healthcare



Agriculture



Manufacturing



# Market and user trends (3)

## Support flexible life styles

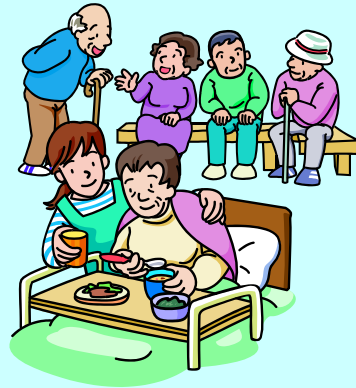
- e.g. working, learning, shopping
- creating community and interest group



# Market and user trends (4)

**Serve numerous socio-economic requirements in order to address**

- Disaster prevention and relief
- Super-aging society - Medical/Health Care, Nursing Care
- Resource problems e.g. energy saving
- Environmental problem



# 3. TYPICAL USE CASES

# From socio-economic perspective, 5G will enhance user satisfaction for existing services



**Transportation**  
More efficient and safer  
Navigation  
Autonomous driving



**Richer contents**  
Multiuser UHD teleconference  
Purchase enriched video,  
music, book



**Health care**  
Remote medical  
examination




**House**  
Home security

**5G will  
enhance the  
socio-  
economic  
satisfaction**




**Disaster relief**  
Prediction  
Robustness to disaster



**Consumer  
electronics**  
Remote control

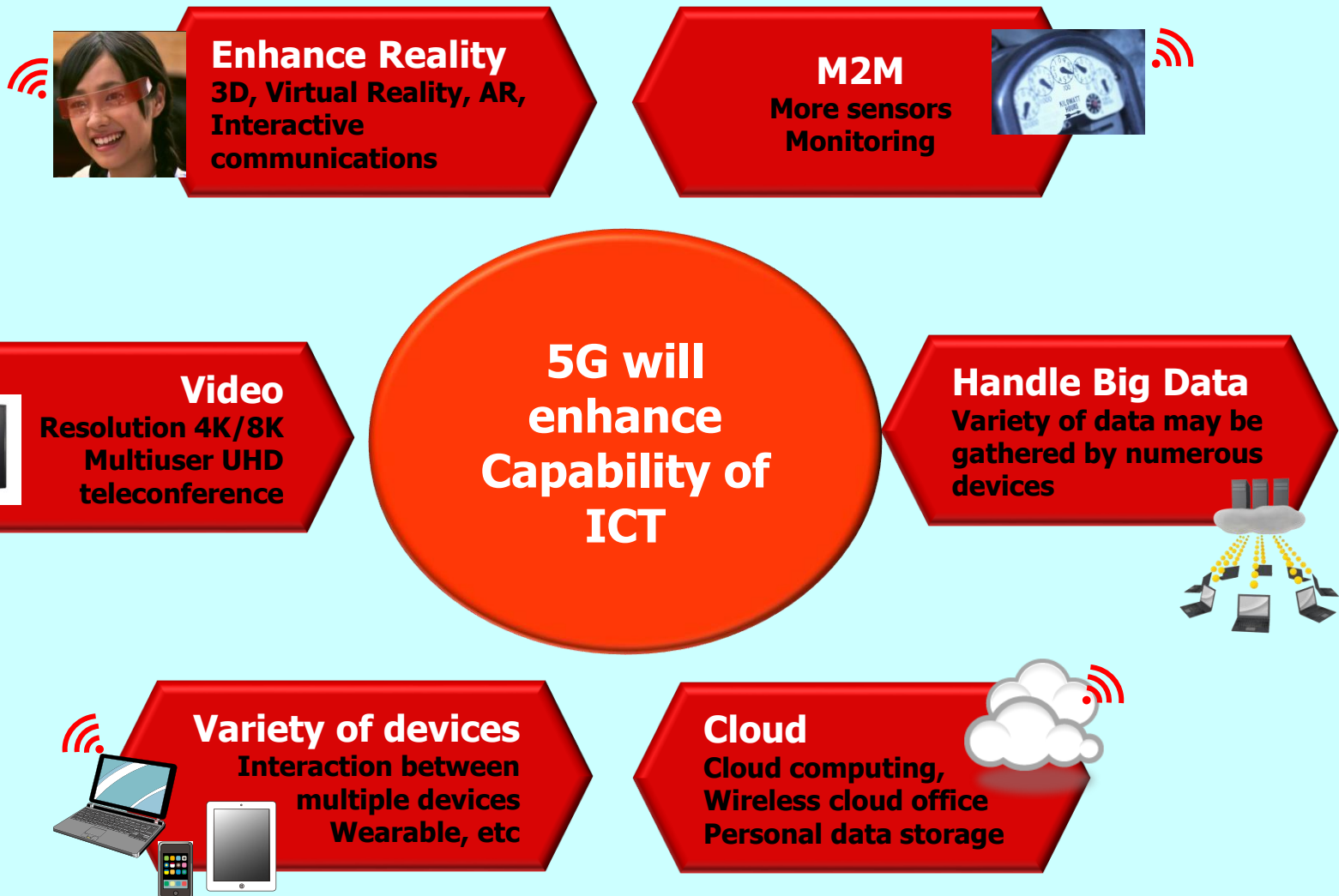


**Education**  
Distance learning  
Virtual experience



**Safety and lifeline system**  
Collision avoidance  
Rescue  
(Distress, Accident, etc.)

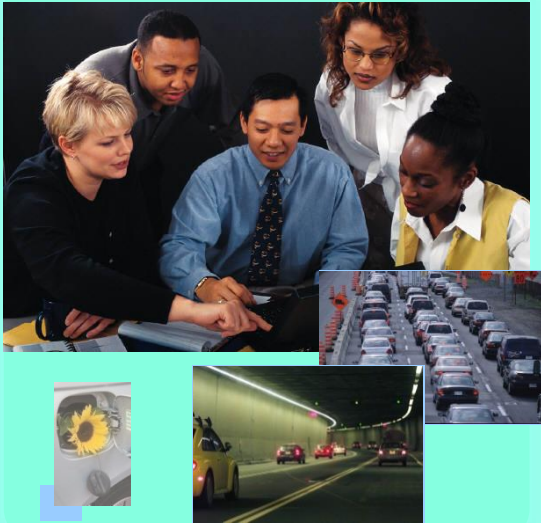
# From perspective of capability of ICT, capability will be greatly enhanced by 5G



# 5G will bear new roles and offer new use cases

## Smart citizen services

Knowledge creation  
Activity support



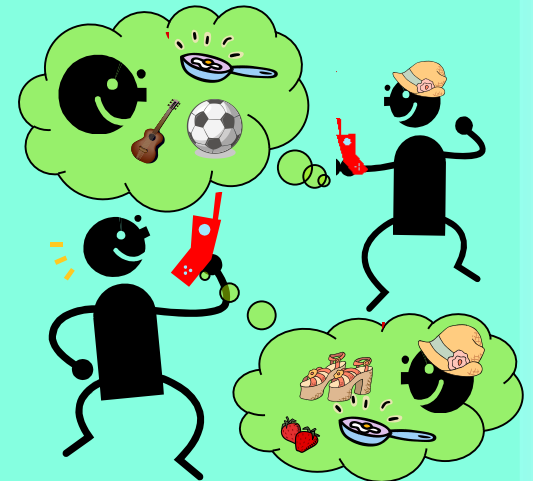
## Share experience

More fidelity, realistic  
Tactile



## Assist communication between unacquainted persons

Share information in proximity



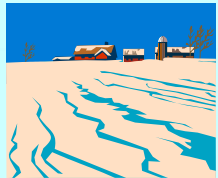
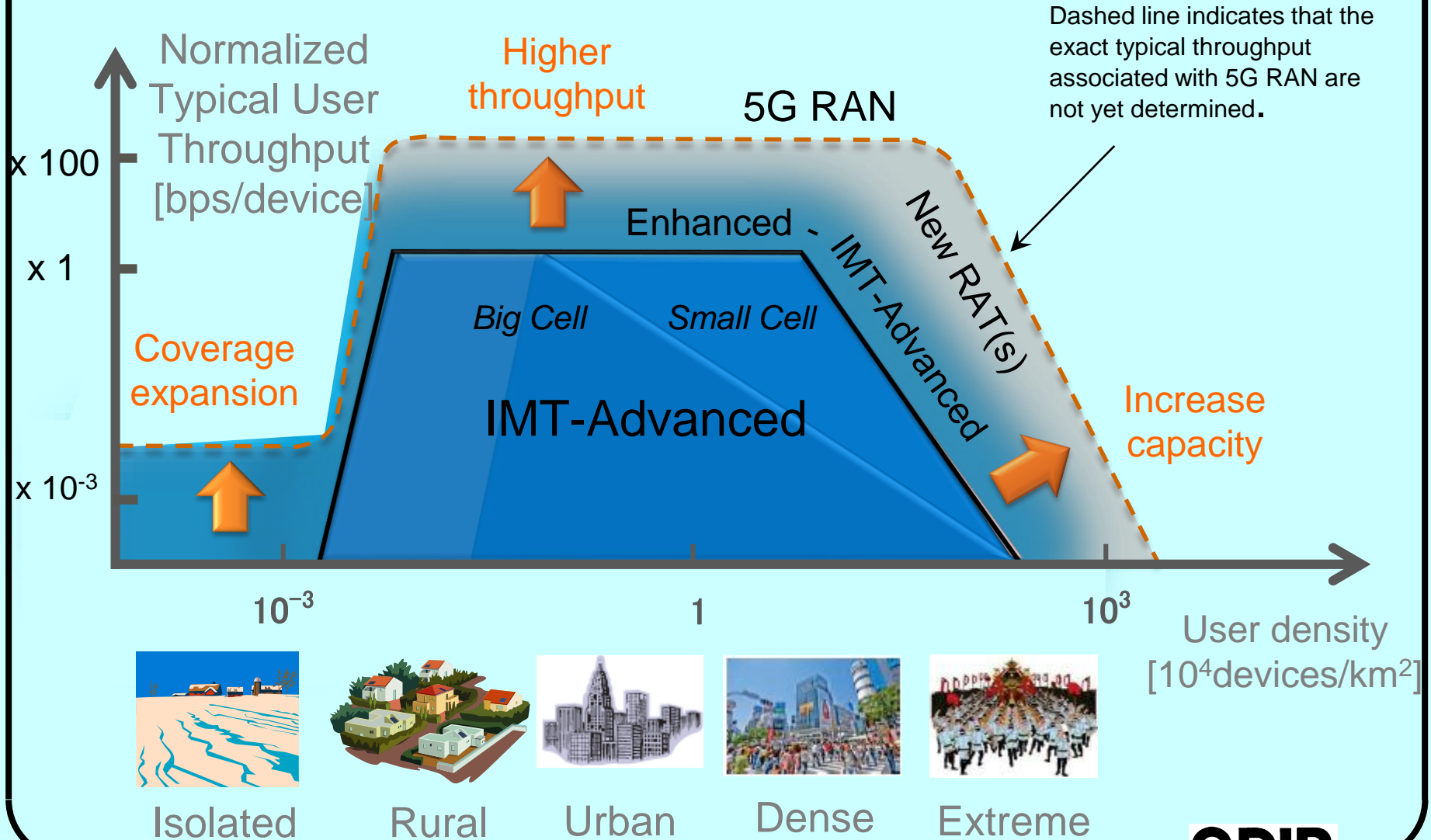
# **4. FRAMEWORK AND CAPABILITIES OF 5G**

# Framework for 5G

**In order to illustrate the capability of 5G, three example diagrams under discussion in ARIB are shown as follows.**

- (1) Highlight the difference between IMT-Advanced and 5G**
- (2) Capabilities required by respective application from a user perspective**
- (3) Maximum capability of 5G from system perspective**

# Example of Framework for 5G (1)



Isolated



Rural



Urban



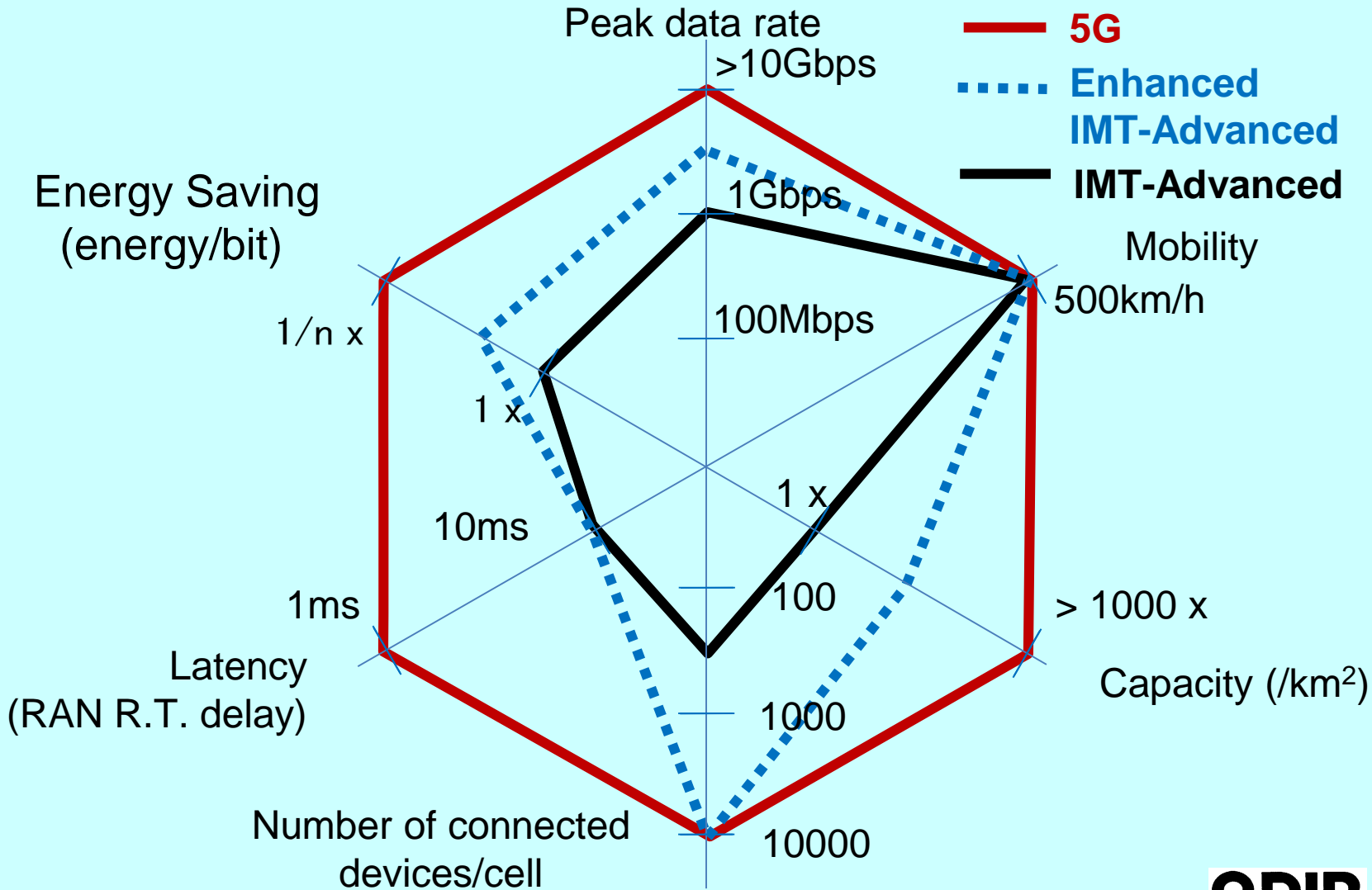
Dense



Extreme

# Example of Framework for 5G (2)

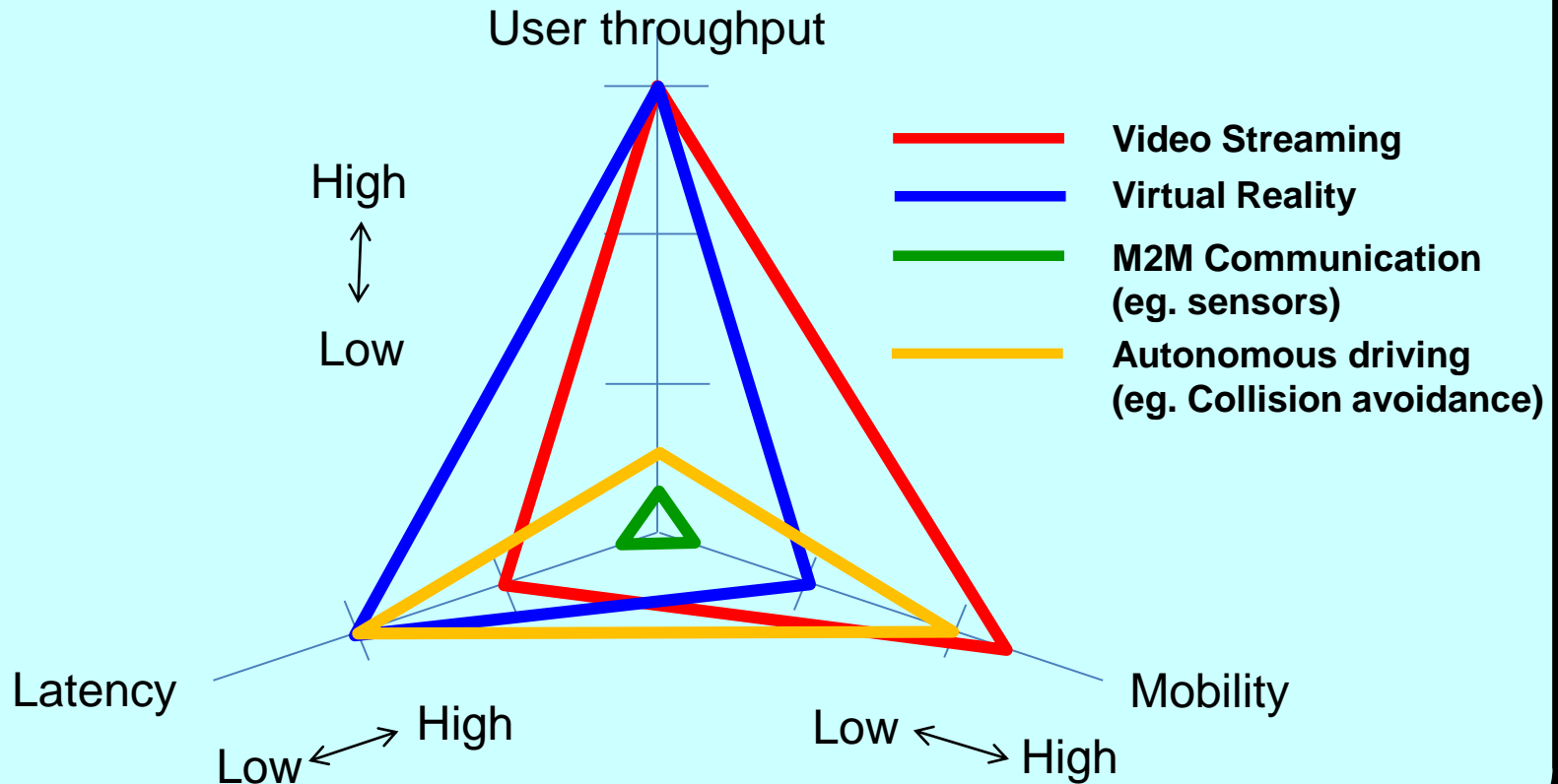
## Maximum system capabilities



# Example of Framework for 5G (3)

Required capabilities vary depending on applications from a user perspective.

Efficient use of resources will be desirable.



# **5. 5G DEFINITION**

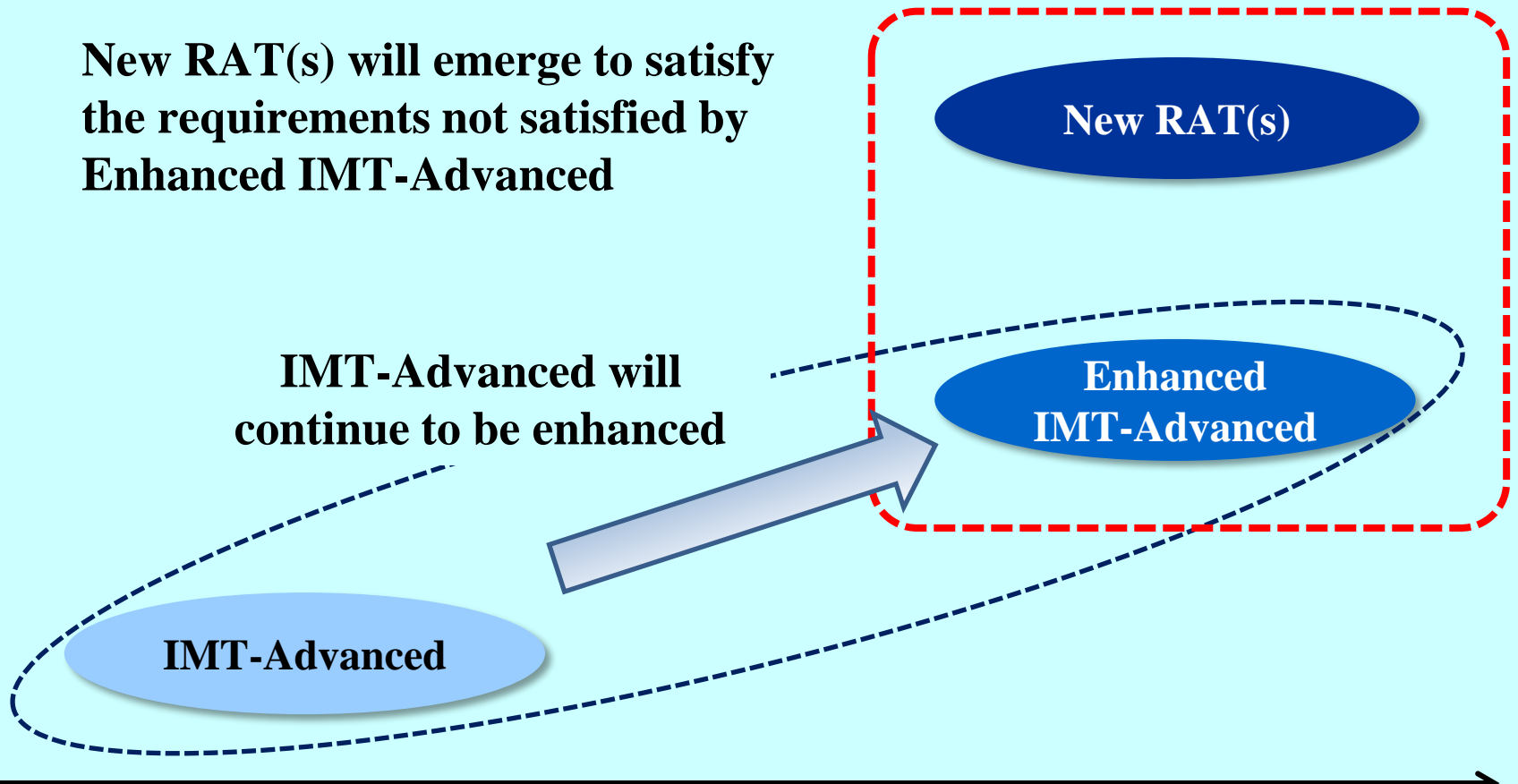
Evolution

# ROAD TO 5G

5G RAN

New RAT(s) will emerge to satisfy the requirements not satisfied by Enhanced IMT-Advanced

IMT-Advanced will continue to be enhanced



IMT-Advanced

New RAT(s)

Enhanced IMT-Advanced

2014

2020

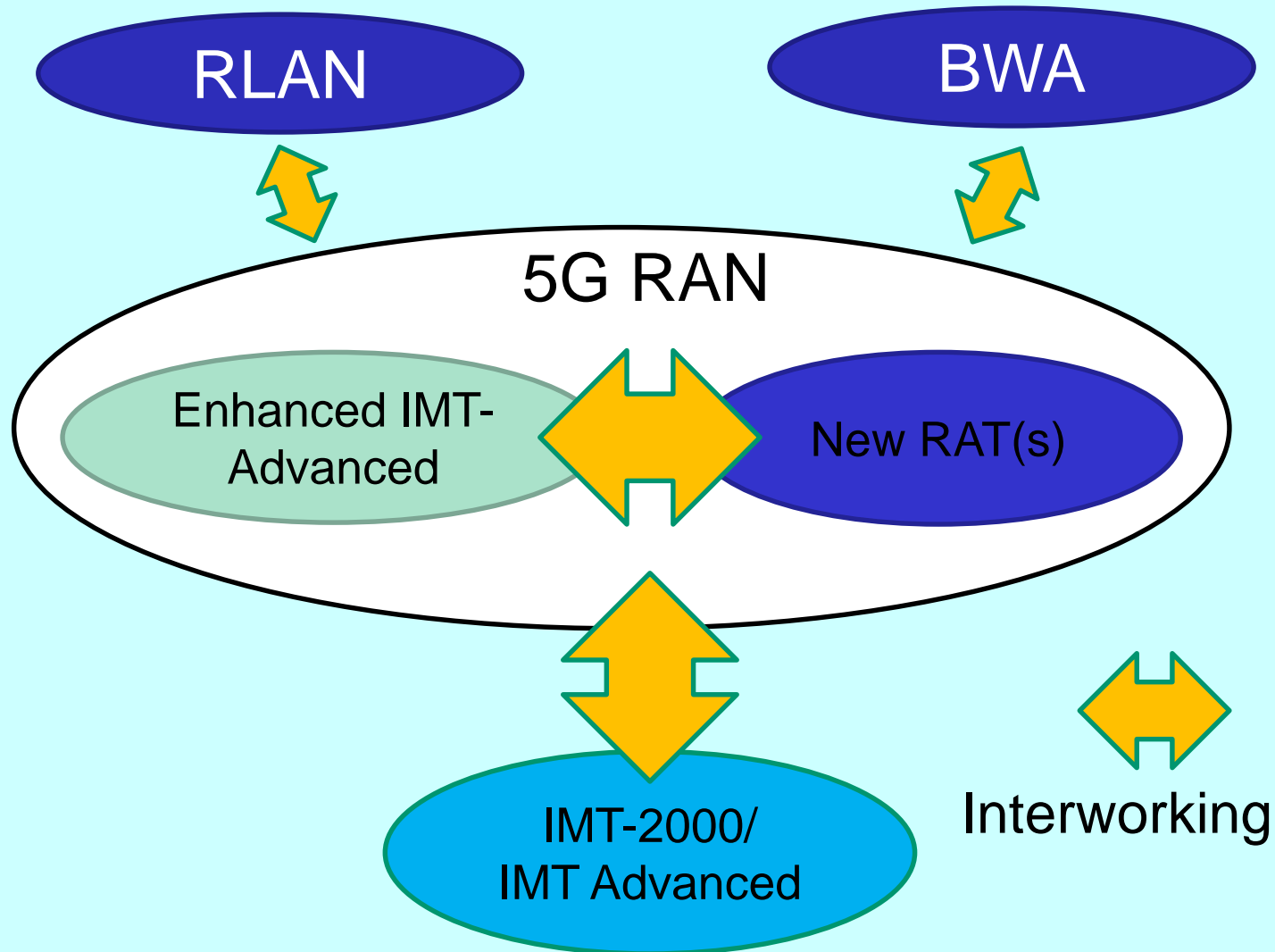
Year

- 5G RAN, which satisfies all the requirements identified in this white paper for 2020 and beyond, consists of *New RAT(s)* and *Enhanced IMT-Advanced*.

- *New RAT(s)* need to be developed in order to satisfy the requirements not satisfied by *Enhanced IMT-Advanced*

- *Enhanced IMT-Advanced* is a further enhancement of *IMT-Advanced*.

# Interwork of 5G RAN



# 6. CONCLUSION

# Conclusion

- ◆ Overviews of ARIB 20B AH and its interim study results for “5G” are shown;
  - Market and user trends
  - Typical use cases
  - Framework and capabilities of “5G”
  - “5G” definition
  - “5G” Radio Access Technologies
- ◆ The interim study results may not be exhaustive and yet self-contained;
- ◆ ARIB 20B AH continues necessary investigations towards “5G”;
- ◆ ARIB 20B AH will develop a White Paper to capture our investigation results. Target completion date of the White Paper is the end of August 2014; and
- ◆ ARIB 20B AH is willing to establish collaborations with “5G” research related industrial organizations and academic institutes in order to share our technical activities as well as the investigation results.

*The term “5G” denotes the mobile communications system to be commercialized in 2020 and beyond. Tentatively used throughout this presentation for the sake of simplicity.*

**Thank you for your kind attention!**

**ARIB**

Association of Radio Industries and Businesses

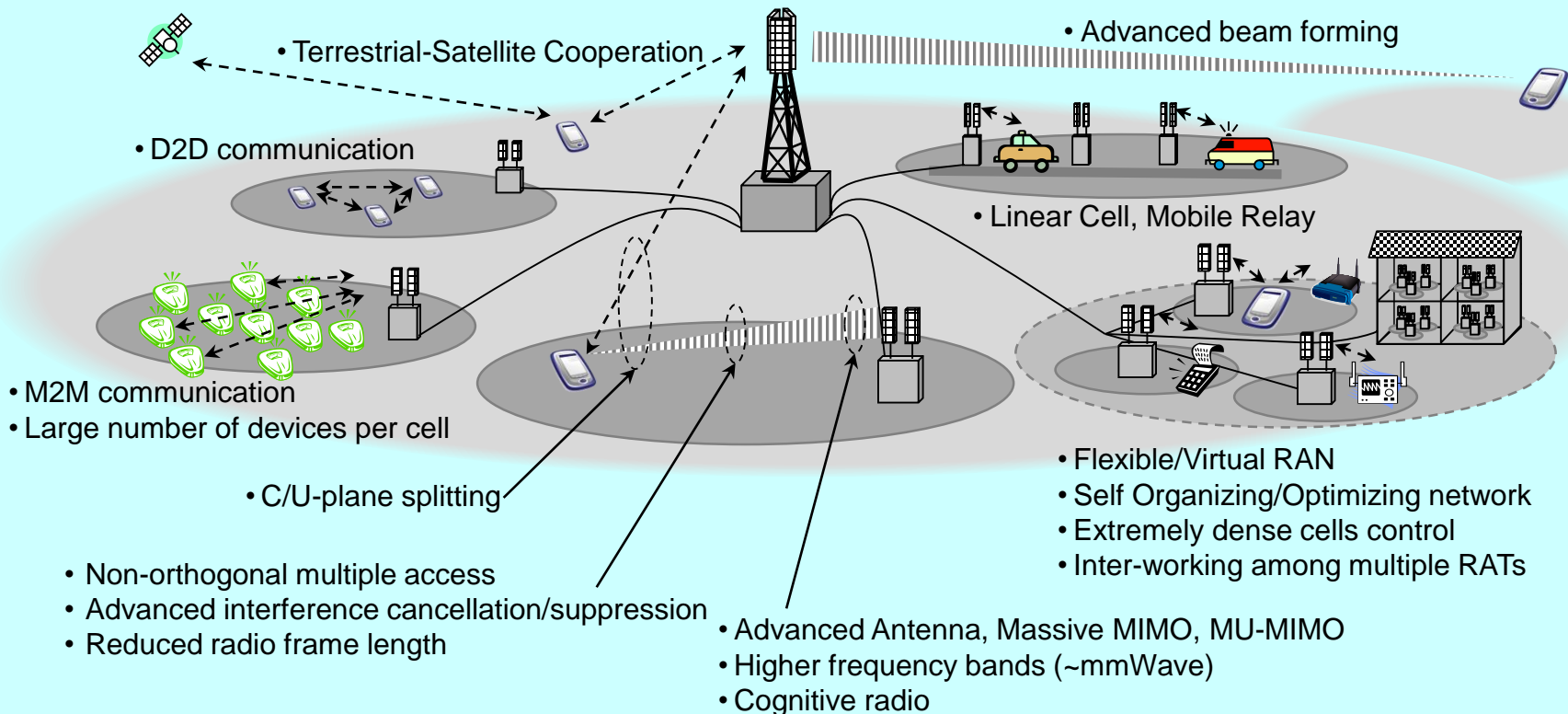
<http://www.arib.or.jp/english/index.html>

# Supplementary Slides

# **7. 5G RADIO ACCESS TECHNOLOGIES**

# Radio Access Technologies for 5G system

Technologies shown here may not be exhaustive and subject to further investigations in ARIB 20B AH



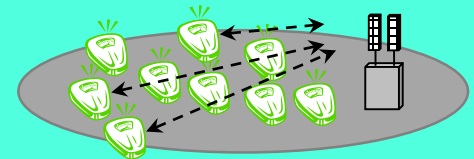
# 5G RAN technologies (1/3)

## - Network Architecture(s) [1/2]-

Novel mobile network architecture will need to be structured to achieve below:

1. Massive capacity and massive device accommodation
2. Intelligent control virtual network to provide scalability and resource management
3. Integrated cloud network computing and the aggregation to backhaul
4. Interworking with multiple RATs including data offload

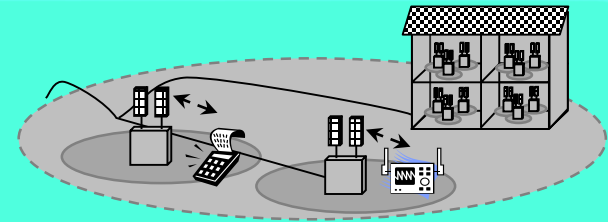
- M2M communication
- Large number of devices per cell



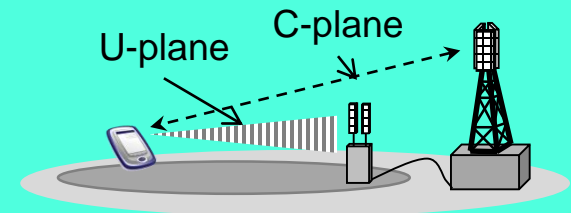
# 5G RAN technologies (1/3)

## (Network architecture related [2/2])

- Flexible/Virtual RAN
- Self Organizing/Optimizing network
- Extremely dense cells control



- C/U-plane splitting



- Inter-working among multiple RATs
  - With terrestrial IMT RATs
  - With other terrestrial RATs, e.g. RLAN, BWA



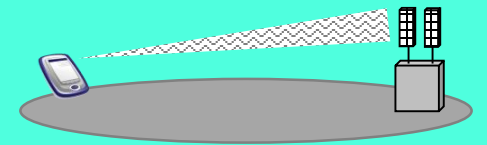
## 5G RAN technologies (2/3)

### - Radio spectrum aspect -

One of the ways to achieve higher network capacity to cope with demanding growing traffic is to take advantage of higher frequency bands.

- Advantages of the millimeter/centimeter waves
  1. System densification due to shorter range with less interference
  2. Bandwidth due to overwhelmingly broader bands
  3. Spectral efficiency enabled by advanced beam steering and massive MIMO.

• Higher frequency bands (~mmWave)



# 5G RAN technologies (3/3)

## - Some highlights [1/6]-

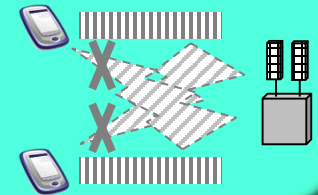
### 1. Technologies to enhance the radio interface

1. Advanced modulation, coding and multiple access schemes  
Non-orthogonal multiple access: NOMA  
Sparse code multiple access (SCMA)
2. Multi-antenna and multi-site technologies  
Narrow beamforming in rural area  
Nonlinear precoding MU-MIMO  
Enhanced MIMO for interference cancellation
3. Network densification
4. Flexible spectrum usage
5. Simultaneous transmission and reception (STR)

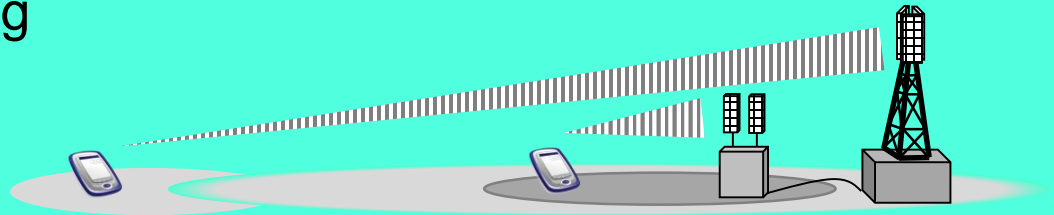
# 5G RAN technologies (3/3)

## Technologies to enhance the radio interface [2/6]

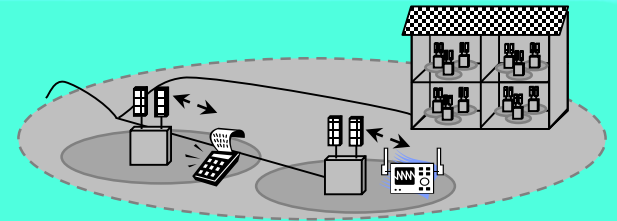
- Non-orthogonal multiple access
- Advanced interference cancellation/suppression
- Reduced radio frame length



- Advanced Antenna Technologies, e.g. Massive MIMO, MU-MIMO
- Advanced beam forming



- Flexible/Virtual RAN
- Self Organizing/Optimizing network
- Extremely dense cells control



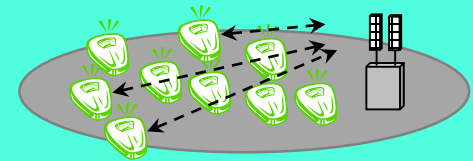
## 5G RAN technologies (3/3)

- Some highlights [3/6]-

### 2. Technologies to support wide range of emerging services

1. Proximity services
2. Machine to machine communication

- M2M communication
- Large number of devices per cell



### 3. Technologies to improve energy efficiency

1. Network-level power management
2. Energy-efficient network deployment

## 5G RAN technologies (3/3)

### - Some highlights [4/6]-

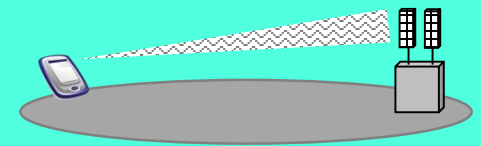
#### 4. Technologies utilizing frequency bands in millimeter waves or centimeter waves:

- The door to an abundance of spectrum.
- But the very different propagation properties from UHF band.

##### Observations:

- Transmission should be done through a few selected paths (without relying on scattered energy), i.e. the strongest line-of-sight (LOS) path.
- Noise limited due to its large path loss.
- Sizes of antenna modules is expected very small.

- Higher frequency bands (~mmWave)



# 5G RAN technologies (3/3)

## - Some highlights [5/6]-

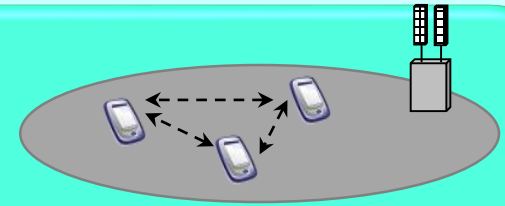
### 5. Network Technologies

- Technologies to simplify management and improve network reliability
- NFV based network virtualization
- Technologies to support ease of deployment and increase network reach
  - Multi-radio access and multi-mode
  - Mesh and Grouping : Mobile relay
- Novel RAN architecture
  - Multi-layer / Multi-band cells
  - Cloud-RAN (C-RAN)

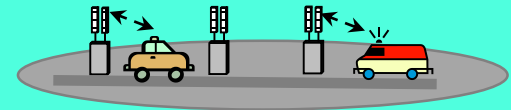
# 5G RAN technologies (3/3)

- Few more highlights [6/6]-

- D2D communication



- Linear Cell, Mobile Relay



- Terrestrial-Satellite Cooperation

