An air-ground integrated network (AGIN) architecture for 6G

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1 **Multi-scenario 6G cloud-network architecture**

2 A4N：Enrich 6G networks with Air platforms

3 N4A：3D coverage with terrestrial IMT systems

Vision & requirements

6G Network Architecture

①多More function②省more sustainable
③快More flexible④好More better performance

ITU-R《Framework and overall objectives of the future development of IMT for 2030 and beyond》

This marks a fundamental consensus on the 6G vision research

Requirements driven

New Service
- Metaverse,
- 3D coverage

New Scenarios
- 2C
- 2B
- Temporary Networks

Technology driven

Network AI
- Federated learning knowledge graphs
- LLM

ISAC
- Integrated Sensing And communication

Space Communication
- Satellites
- HAPS
- LAPS

Problem driven

Complex architecture
- Too many NF and interface
- complex procedure

Robustness
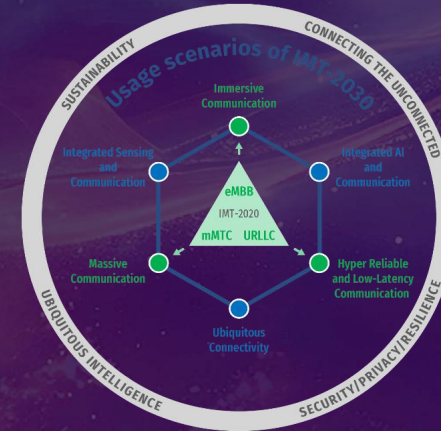- Long fault recovery time
- Frequent network disaster

Flexibility
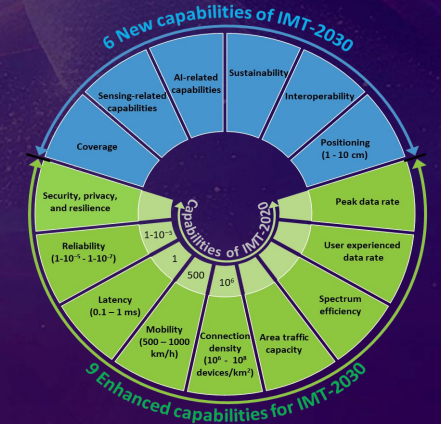- Customized demand in the 2B field

Usage Scenarios of 6G

5G Scenarios + New Scenarios

- Ubiquitous Connectivity
- Integrated AI and Communication
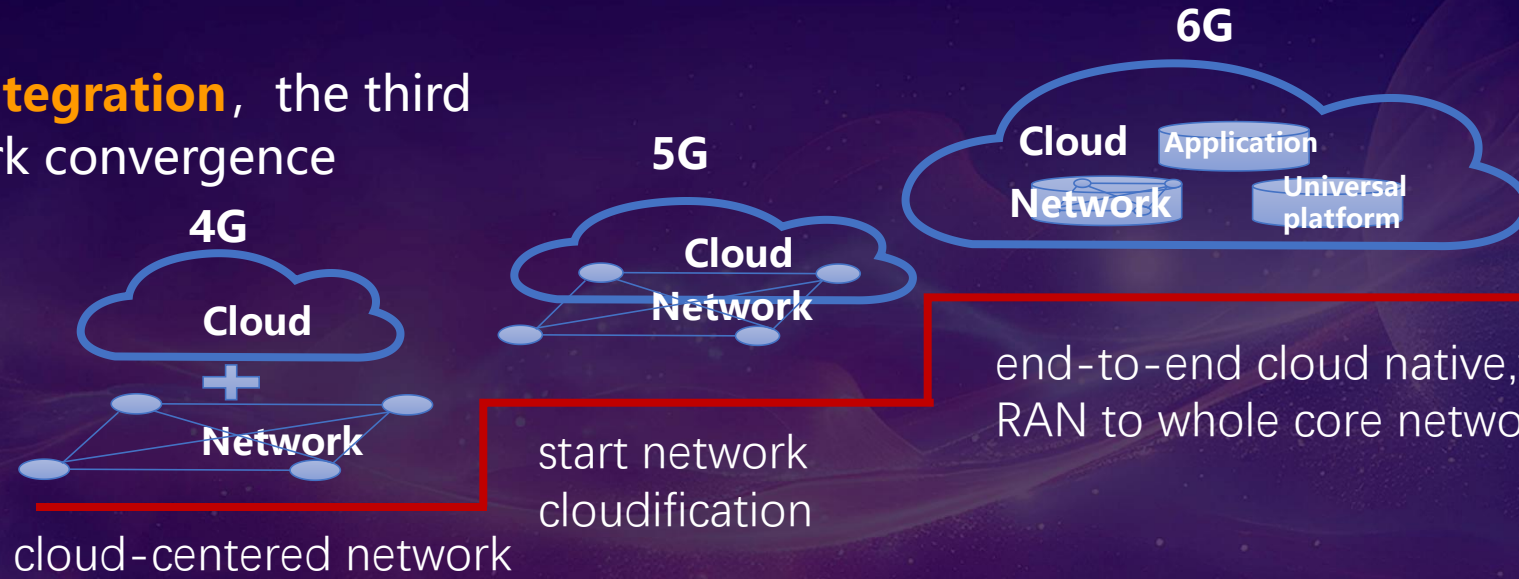- Integrated Sensing and Communication

KPI of 6G

5G Capability + New Capability

- Connection Density
- Latency
- Reliability

- Sensing-related
- AI related
- Sustainability
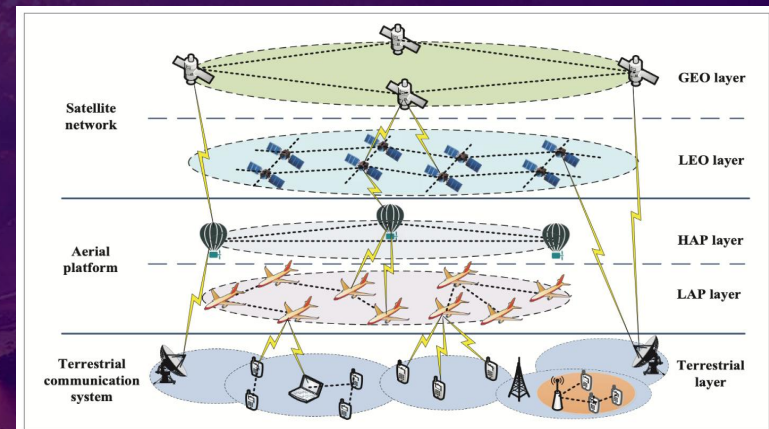- Coverage

Overall design principles for 6G networks

① **Cloud Network Integration**，the third stage of cloud network convergence

6G

Cloud Network
Application
Universal platform

5G

Cloud Network

4G

Cloud
+
Network

end-to-end cloud native,from RAN to whole core network

start network cloudification

cloud-centered network

② **Deep Convergence:**
Integrated AI and Communication、Integrated Sensing and Communication and other DOICT Convergence

Sensing built-in
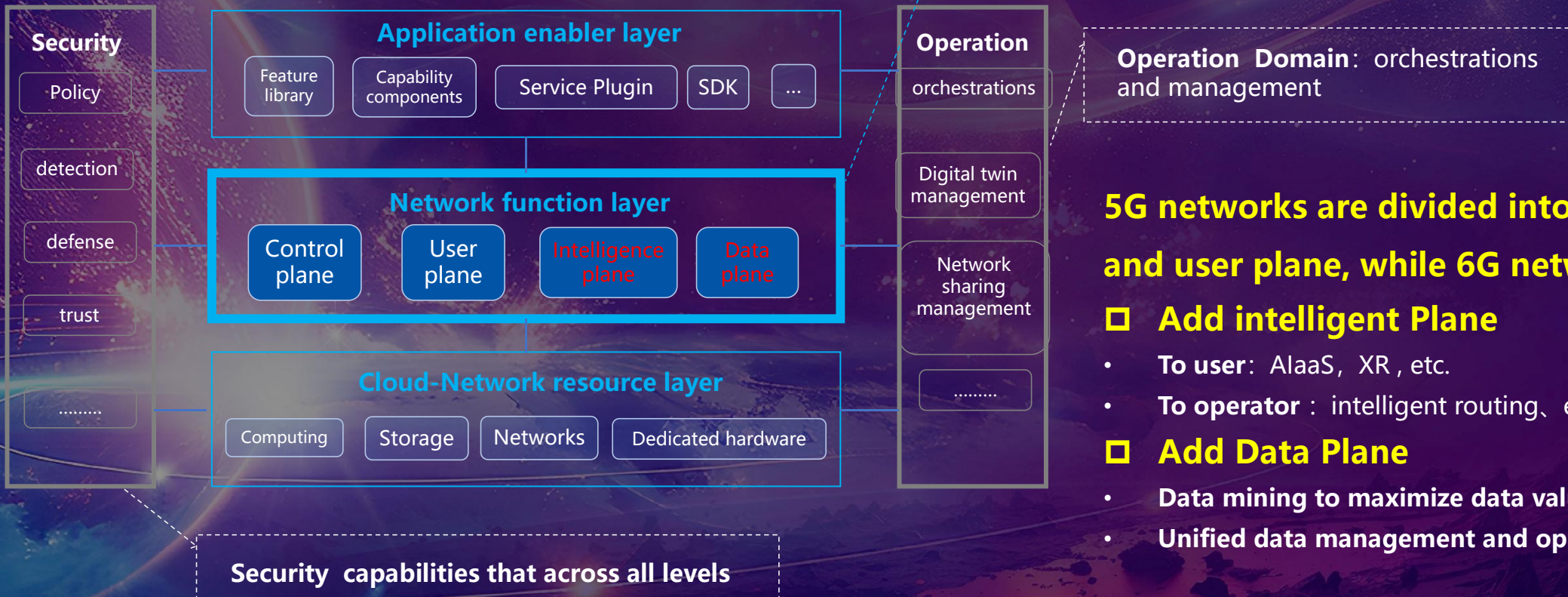
Computing Native

AI built-in

Trust built-in

Wide Convergence: Space、air、ground and sea，3D coverage

GEO layer

Satellite network

LEO layer

Aerial platform

HAP layer

LAP layer

Terrestrial communication system

Terrestrial layer

4

Framework of 6G network：Evolution from 5G

6G will continue the "three layers" of cloud/virtualization architecture ,and expand to "four Planes" based on the 5G specification

Framework of 6G

Security
- Policy
- detection
- defense
- trust
- ....

Application enabler layer
- Feature library
- Capability components
- Service Plugin
- SDK
- ...

Network function layer
- Control plane
- User plane
- Intelligence plane
- Data plane

Cloud-Network resource layer
- Computing
- Storage
- Networks
- Dedicated hardware

Operation
- orchestrations
- Digital twin management
- Network sharing management
- ....

Security capabilities that across all levels

Network Domain：focus on 3GPP , 6G network architecture

Operation Domain：orchestrations and management

5G networks are divided into control plane and user plane, while 6G networks will:

☐ **Add intelligent Plane**
- **To user**：AIaaS，XR , etc.
- **To operator** ：intelligent routing、energy saving , etc.

☐ **Add Data Plane**
- **Data mining to maximize data value**
- **Unified data management and openness**

6G cloud-network architecture : Add at the functional level and subtract at the architectural level

Finding a balance between "feature enhancement" and "architecture simplification"

- **Trend**：6G will support the integration of communication, sensing and AI, so the network features need to be enhanced.
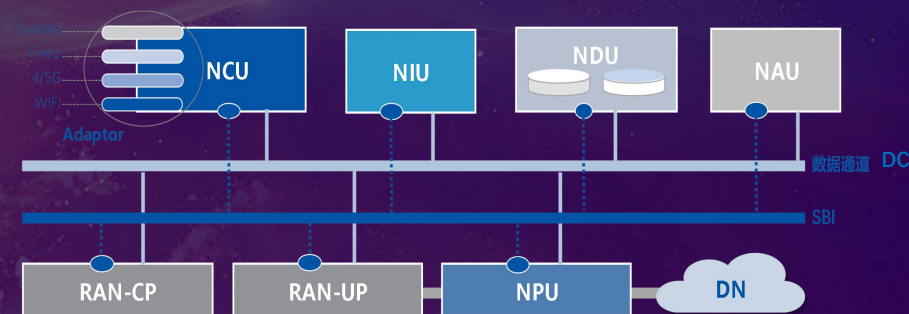- **Challenge**：Designing by adding features to existing networks will increase the complexity of 6G networks.

5G

6G proposal

Polymerization & optimization
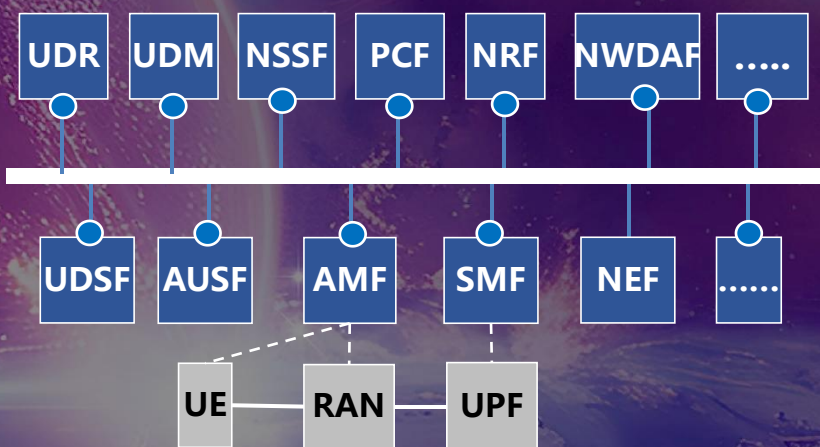
- Now ,5G network have 40+ NFs, 80+ logical interfaces
- OAM is complex and failure localization is difficult

- Architecture Simplification: Logic Function Refactoring, Interface and Protocol Optimization
- Message flow simplification: Preliminary calculations show that some signaling processes can be reduced by about 50%
- Dual Bus：SBI and DCI Collaborate to Improve Data Interaction Efficiency

6G distributed networking: connect +

■ **Rich 6G application scenarios and increasing demand for customization require more flexible and robust networking methods**

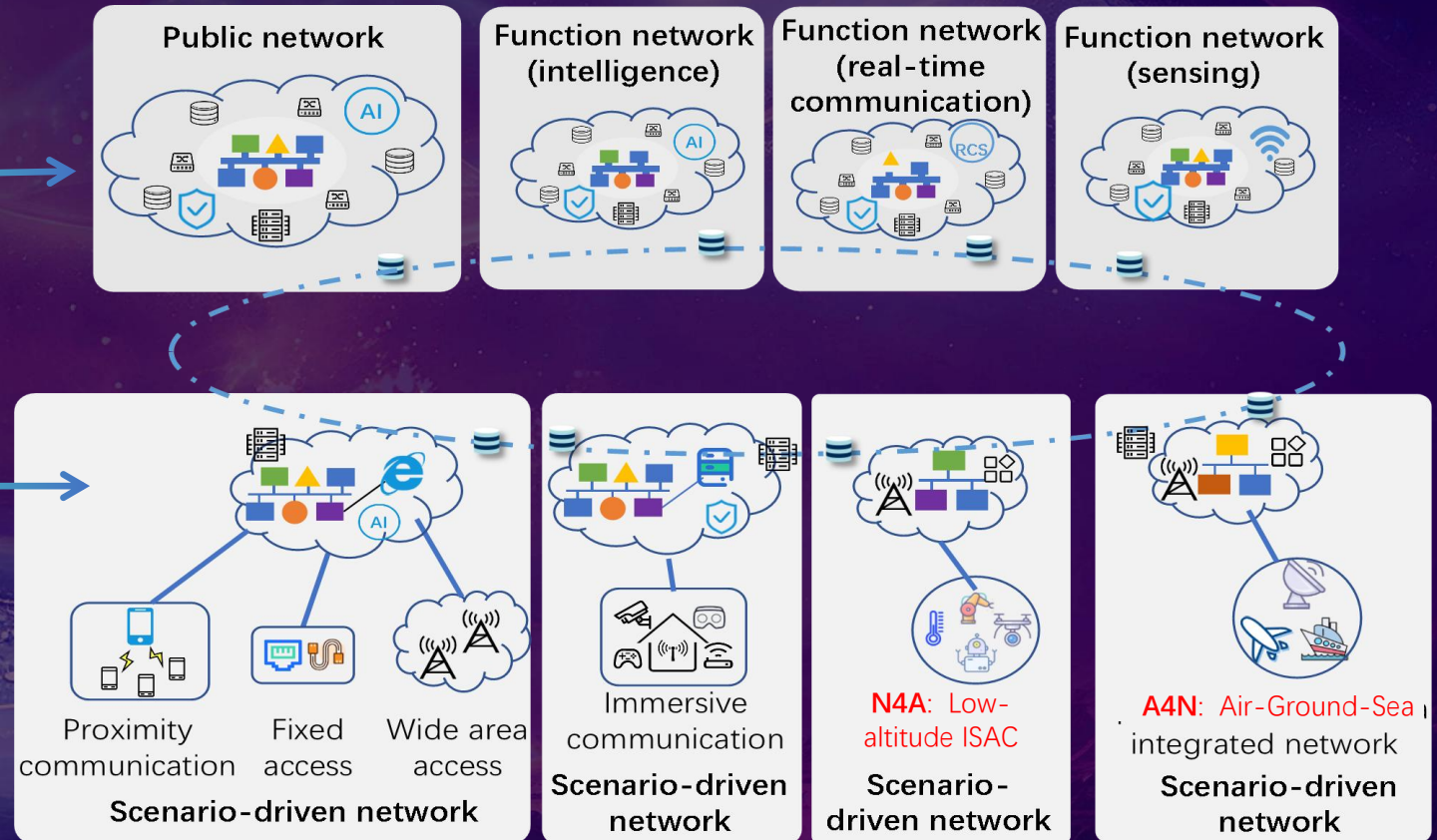■ **Centralized + distributed networking is a possible solution**

6G distributed networking

Centralized Network:

• **The public network** : basic coverage and the scheduling of intelligence

• **Functional network** is a dedicated network that meets specific new functions

Distributed subnetwork:

Specific needs in **various scenarios**, including 2C network sinking nodes, 2B localized access and customized subnets, AGINs

Public network

Function network (intelligence)

Function network (real-time communication)

Function network (sensing)

Proximity communication

Fixed access

Wide area access

Scenario-driven network

Immersive communication

Scenario-driven network

N4A: Low-altitude ISAC

Scenario-driven network

A4N: Air-Ground-Sea integrated network

Scenario-driven network

| 1	**Multi-scenario 6G cloud-network architecture**
2	**A4N：Enrich 6G networks with Air platforms**
3	**N4A：3D coverage with terrestrial IMT systems**

A4N: Airborne for Network

- The coverage of ground-based IMT network is less than 7% of the earth's surface, which is insufficient to meet the demands of emergency communications and Internet of Things communications.
- To achieve full coverage of the earth's surface, such as Remote areas, mountains, deserts, and oceans, the broad coverage methods from space-based and air-based platforms (HAPS: high attitude platforms, LAPS: lower attitude platforms,)are needed.
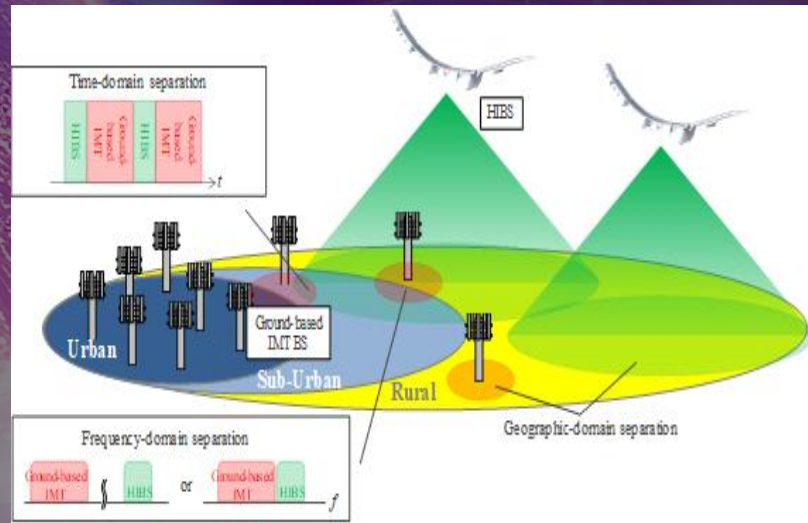
HAPS: a station located on an object at an altitude of 20 to 50 km and at a specified, nominal, fixed point relative to the Earth.

----RR 1.66A

From the 3GPP considerations, the air-based RAN system assists in 2D coverage of the ground surface, based on the ground-based cloud network step by step.

HAPS enhance wide coverage and meet 6G scenarios

- HIBS enhances ground IMT networks. The so-called "super macro cells" (umbrella coverage) can supplement the existing ground deployment methods
- Deploying HIBS in remote areas where ground IMT base stations have not yet been deployed, which can help bridge the digital divide in rural, oceans and remote areas.
- HIBS also provides emergency communication in areas where ground communication has been interrupted due to natural disasters.

HiBS: HAPS as an IMT Base Station, which can fully utilize the benefits of the IMT industry chain
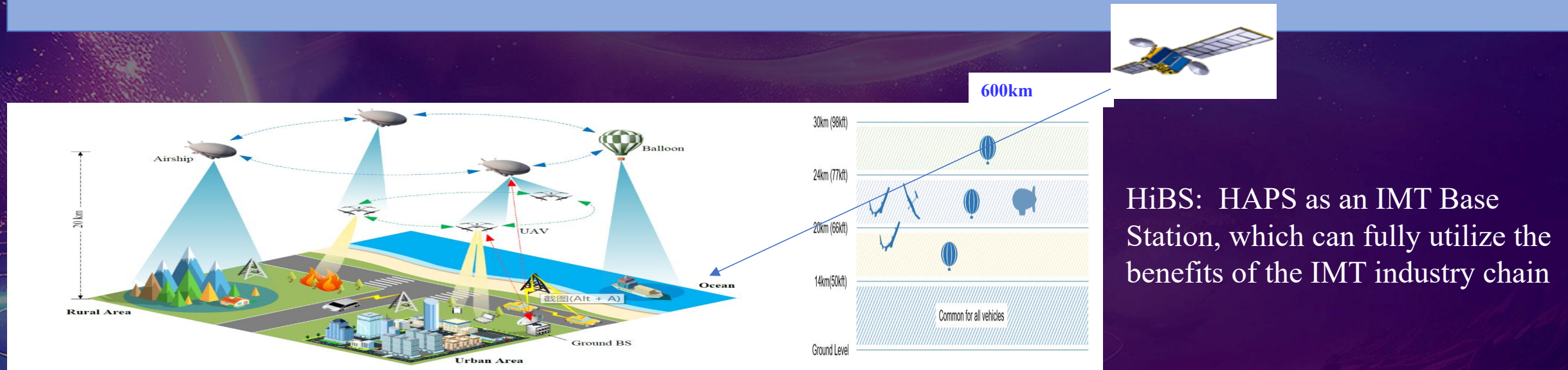
WRC2023 has formulated frequency rules for HiBS at the frequencies of 694-960 MHz, 1710-1980MHz, 2010-2170MHz, and 2500-2690MHz.

1   **Multi-scenario 6G cloud-network architecture**

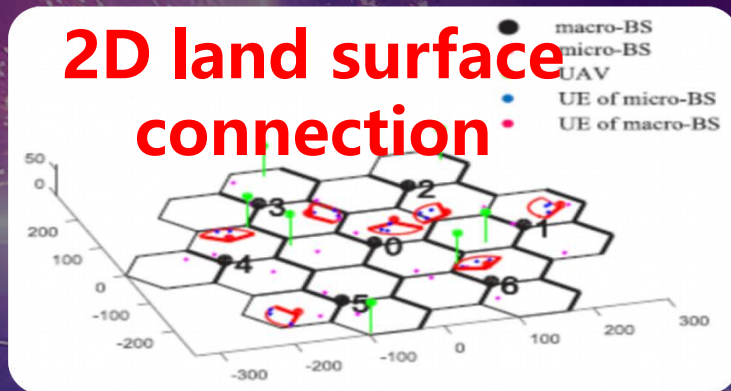**2**   **A4N: Enrich 6G networks with Air platforms**

3   **N4A: 3D coverage with terrestrial IMT systems**

N4A: Network for Air information services

Worry-free network: 3D full coverage includes the ground, sea surface, low altitude, aviation, near space, and outer space
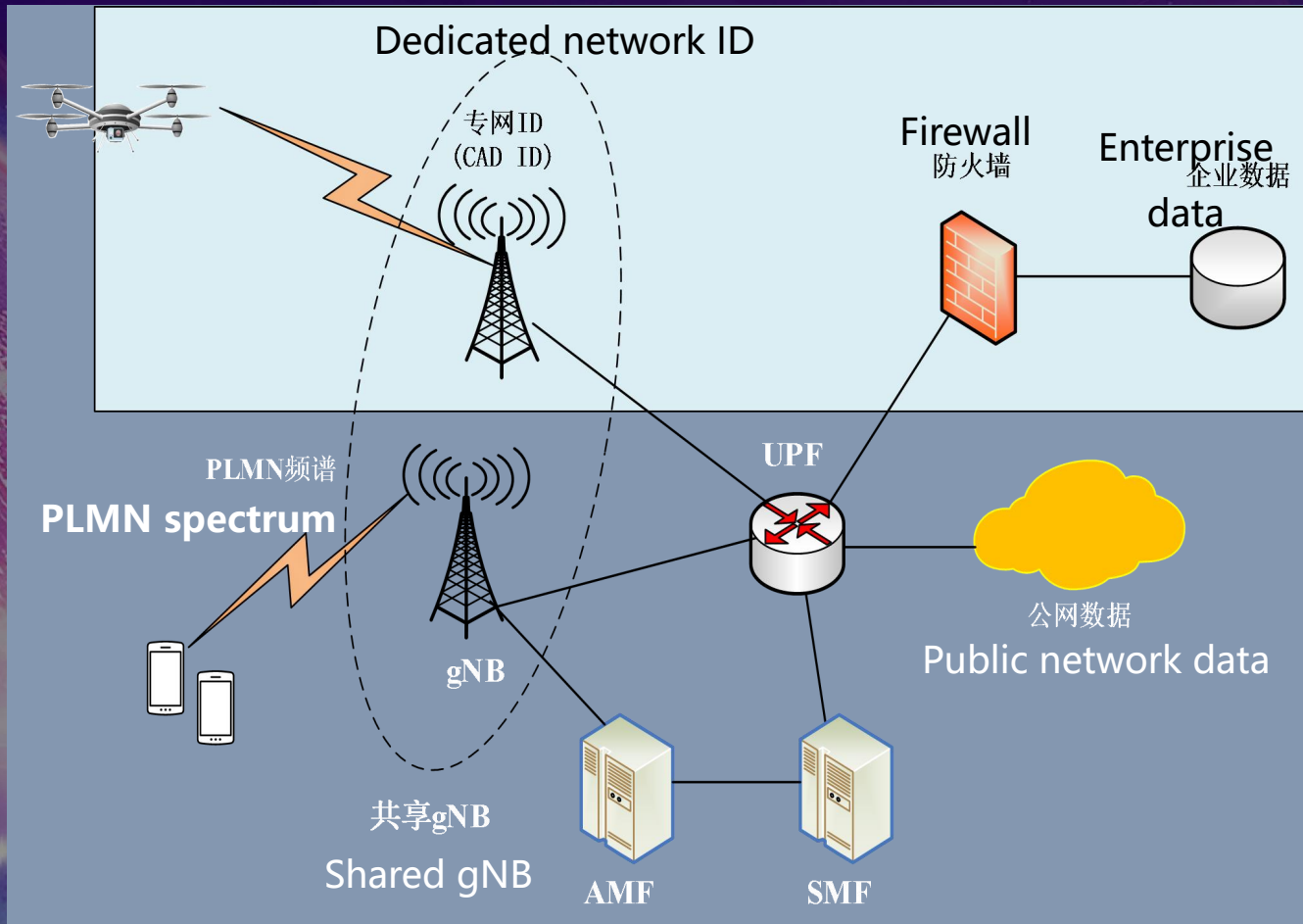
- 3D coverage requires ground-based, air-based access methods for the control and utilization of intellegent body in the air, and on the sea.

- Like airborne subnet, N4A network should be also accessed to the 6G Centralized network for the connection+ sensing+control+computing.

3D Intelligent connection+

2D land surface connection

- macro-BS
- micro-BS
- UAV
- UE of micro-BS
- UE of macro-BS

空天地一体

宏基站
Macro Base Station

毫米波基站
Millimeter Wave Base Station

中继节点
Relay Node

无线蜂窝网
Wireless Cellular Network

传输网
Transmission Network

云网自智
Cloud network autonomy

节能
Energy Saving

算力中心
Computing Power Center

5G

6G

Use case：Low altitude dedicated network

Dedicated network ID

专网ID
（CAD ID）

Firewall
防火墙

Enterprise data
企业数据

PLMN频谱
PLMN spectrum

UPF

公网数据
Public network data

gNB

共享gNB
Shared gNB

AMF

SMF

Information infrastructure for the low attitude economy: **Fly as service**

➢ **Manage drone customers with independent network logic to form a logical private network;**

➢ **Provide differentiated services for different drone groups through slicing;**

➢ **The subnet can establish an interface with third-party customers**

The 6G is getting closer
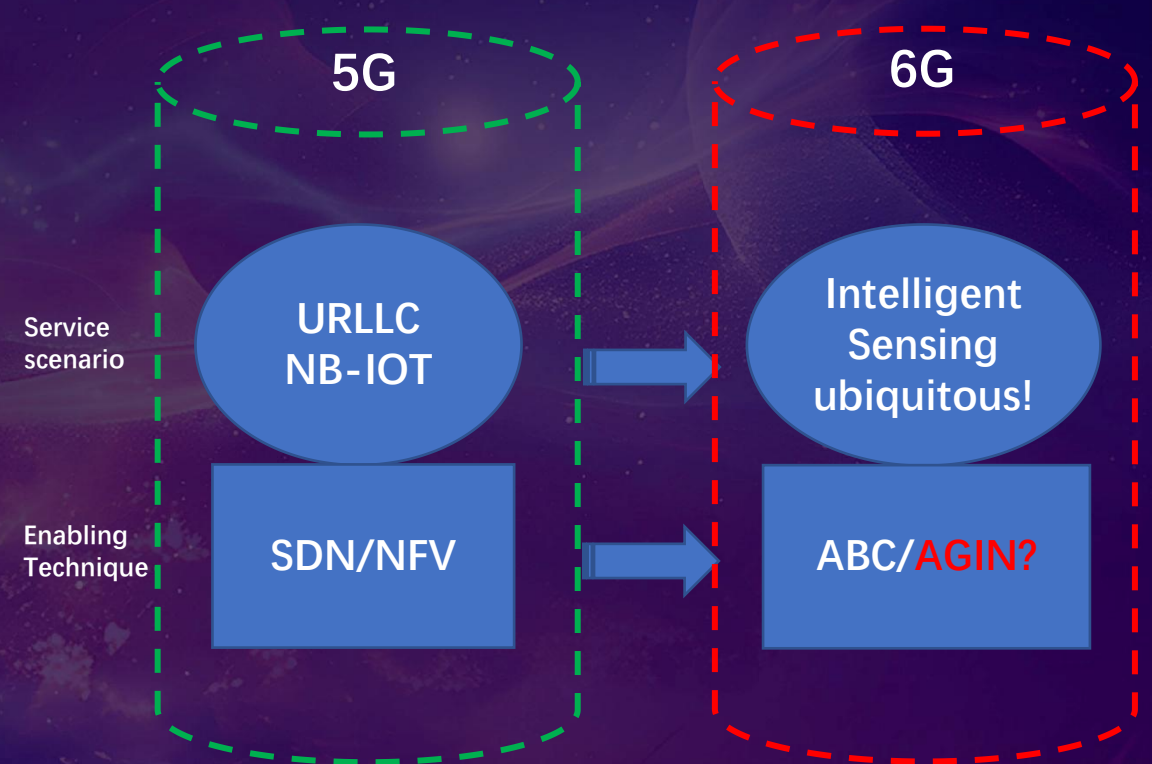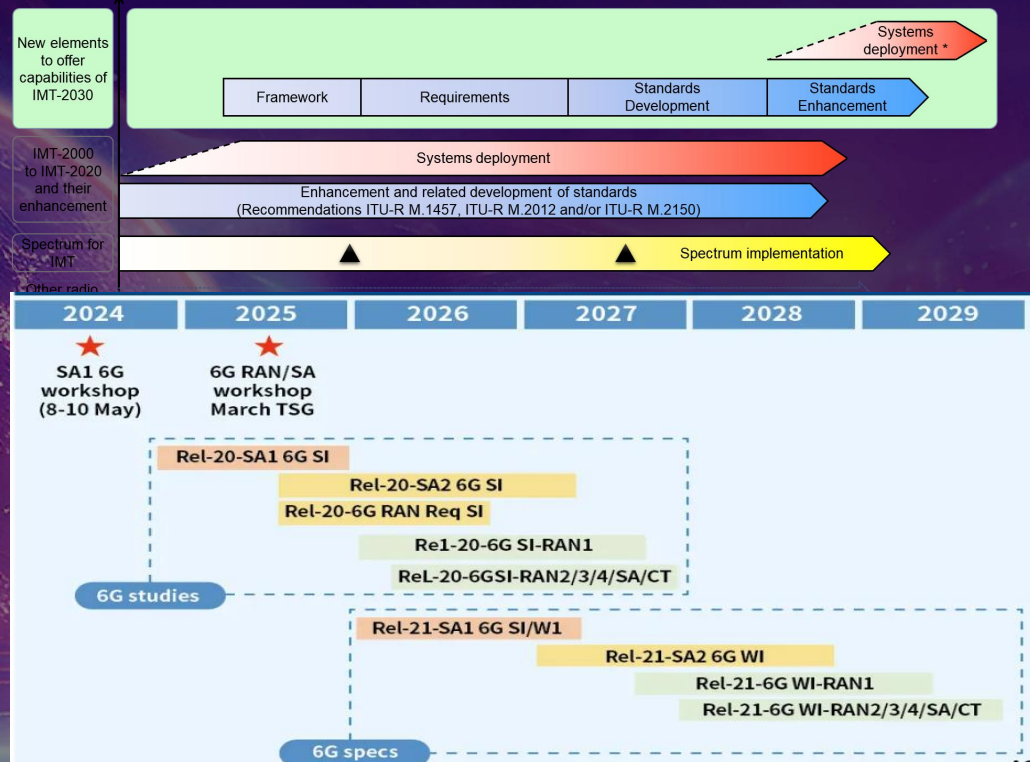
If you want to go fast, go alone, If you want to go far, together.

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