SNS Research

Market Intelligence & Consultancy Solutions

The 5G Wireless Ecosystem: 2015 – 2025

Technologies, Applications, Verticals, Strategies & Forecasts

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1 Chapter 1: Introduction

1.1 Executive Summary

While LTE and LTE-Advanced deployments are still underway, wireless carriers and vendors have already embarked on R&D initiatives to develop so-called "5G" technology, with a vision of commercialization by 2020.

5G is essentially a revolutionary paradigm shift in wireless networking to support the throughput, latency, and scalability requirements of future use cases such as extreme bandwidth augmented reality applications and connectivity management for billions of M2M (Machine to Machine) devices.

Although 5G is yet to be standardized, some of the collectively accepted attributes of the technology include new air interface transmission schemes, new spectrum bands, spectrum aggregation, Massive MIMO, beamforming, D2D (Device to Device) communications and self-backhauling, among others.

Driven by regional, national government, wireless carrier and vendor initiatives, we expect 5G R&D and trial investments will account for nearly $5 Billion by 2020, following a CAGR of nearly 40% over the next 5 years.

The "**5G Wireless Ecosystem: 2015 – 2025 – Technologies, Applications, Verticals, Strategies & Forecasts**" report presents an in-depth assessment of the emerging 5G ecosystem including key market drivers, challenges, enabling technologies, use cases, vertical market applications, spectrum bands, wireless

carrier deployment commitments and vendor strategies. The report also presents forecasts for both 5G investments and subscriptions.

The report comes with an associated Excel datasheet suite covering quantitative data from all numeric forecasts presented in the report.

1.2 Topics Covered

The report covers the following topics:

- 5G requirements, use cases & vertical market applications
- 5G market drivers and barriers
- Air interface & antenna technologies: *Massive MIMO, waveforms, phased array antennas & beamforming*
- Spectrum technologies: *Cognitive radio, spectrum sensing, aggregation & LSA (Licensed Shared Access)*
- D2D communications & self-backhauling networks
- Complimentary technologies for 5G: *NFV (Network Functions Virtualization), SDN (Software Defined Networking), HetNet (Heterogeneous Networking), C-RAN (Cloud RAN), drones & satellites*
- Spectrum options for 5G
- Standardization & research initiatives
- Competitive assessment of vendor strategies & commitments to 5G
- 5G investment and subscription forecasts from 2015 till 2025

1.3 Forecast Segmentation

- Market forecasts are provided for each of the following regional submarkets:
  - Asia Pacific
  - Eastern Europe
  - Latin & Central America
  - Middle East & Africa
  - North America
  - Western Europe

1.4 Key Questions Answered

The report provides answers to the following key questions:

- How much will vendors and operators invest in 5G R&D and trial commitments?
- What will the number of 5G subscriptions in 2025 and at what rate will it grow?
- What will be the key applications of 5G networks?
- What trends, challenges and barriers will influence the development and adoption of 5G?
- Which regions and countries will be the first to adopt 5G?
- Will 5G networks utilize new spectrum bands?
- Who are the key 5G vendors and what are their strategies?
- Will 5G be a C-RAN centric network?
- What will be the impact of 5G on the M2M and IoT ecosystem?
- Will drone and satellite based communication platforms play a wider role in 5G networks?

1.5 Key Findings

The report has the following key findings:

- Driven by regional, national government, wireless carrier and vendor initiatives, we expect 5G R&D and trial investments will account for nearly $5 Billion by 2020, following a CAGR of nearly 40% over the next 5 years
- Nearly 70% of these investments will target large scale commercial trial networks in Japan, South Korea and other early pioneering countries
- Despite a lack of standardization, vendors are aggressively investing in 5G development efforts with a principal focus on new transmission schemes, antenna technologies, and higher frequency bands
- 5G networks are expected to utilize a variety of spectrum bands, ranging from established cellular bands to millimeter wave frequencies
- 5G standardization activities are expected to commence between 2015 and 2016

1.6 Methodology

The contents of this report have been accumulated by combining information attained from a range of primary and secondary research sources. In addition to analyzing official corporate announcements, policy documents, media reports, and industry statements, SNS Research sought opinions from leading industry players within the 5G ecosystem to derive an unbiased, accurate and objective mix of market trends, forecasts and the future prospects of the industry between 2015 and 2025.

1.7 Target Audience

The report targets the following audience:

- Wireless carriers/MNOs (Mobile Network Operators)
- MVNOs (Mobile Virtual Network Operators)
- Mobile infrastructure (RAN, Core, Backhaul) OEMs
- Mobile device OEMs
- Chipset manufacturers
- Gateway vendors
- Mobile chipset OEMs
- Investors
- Application & software providers

1.8 Companies & Organizations Mentioned

The following companies and organizations have been reviewed, discussed or mentioned in the report:

3GPP (Third Generation Partnership Project)	Facebook	Ofcom
Aalborg University	Fraunhofer-Gesellschaft	Orange
Aalto-University	Fujitsu	Poznan University of Technology
Aeroflex	Fujitsu Laboratories of Europe	Qualcomm
Aircom International	Google	Rohde & Schwarz
Alcatel-Lucent	GSMA (GSM Association)	Roke Manor
Alpental Technologies	Huawei	RWTH Aachen
Anite	IBM	Samsung
ARIB (Association of Radio Industries and Businesses, Japan)	Institut Mines-Télécom	SES S.A.
Ascenta	Intel	SingTel
Ascom International	ITRI (Industrial Technology Research Institute)	SK Telecom
BBC	ITU (International Telecommunication Union)	Telecom Italia
BMW	KTH - Royal Institute of Technology	Telefónica
BT	MegaFon	TIA (Telecommunications Industry Association)
Chalmers University of Technology	Ministry of Industry, Development and Reform Commission, China	Titan Aerospace
China Mobile	MOST (Ministry of Science & Technology, China)	Universitaet Bremen
Connected Digital Catapult	MSIP (Ministry of Science, ICT and Future Planning, Korea)	Universitat Politècnica de València
DoCoMo Euro-Labs	National and Kapodistrian University of Athens	University of Kaiserslautern
DT (Deutsche Telekom)	NEC	University of Oulu
EE	New York University	University of Surrey

EM3 (Enterprise M3)	NGMN (Next Generation Mobile Networks) Alliance	Vodafone
Ericsson	Nokia	ZTE
Etisalat	Nokia Networks	
European Commission	NTT DoCoMo	

3 Chapter 3: Enabling Technologies for 5G

This chapter presents an overview of essential and complementary technologies for 5G networks.

3.1 Key Technologies & Concepts

Discussed below are some of the key technologies and concepts that will empower future 5G networks.

3.1.1 Air Interface: Waveform Options

It is a common consensus among most vendors and wireless carriers that 5G will need to accommodate a variety of requirements including delivery of asynchronous M2M traffic, provisioning of heterogeneous network elements and utilizing fragmented spectrum resources. Given the aggressive dynamics of ongoing 5G R&D activities, numerous waveform options have been proposed to fulfill these requirements.

Transmission Scheme	Key Benefits
OFDM (Orthogonal Frequency Division Multiplexing)	Widespread commercialization
UFMC (Universal Filtered Multi Carrier)	Improved spectrum utilization and efficiency for short-burst communications
FBMC (Filter Bank Multi Carrier)	Efficient for transmitting long sequences and multi-carrier based spectrum pooling
GFDM (Generalized Frequency Division Multiplexing)	Well suited for asynchronous low duty cycle transmission and non-continuous bandwidths
BFDM (Bi-Orthogonal Frequency Division Multiplexing)	Well suited to sporadic traffic
NOMA (Non-Orthogonal Multiple Access)	Increased throughput and number of simultaneous users
SCMA (Sparse-Code Multiple Access)	Increased throughput and number of simultaneous users

Figure 2: Potential Waveform Options for 5G

Source: *SNS Research*

While OFDM, the transmission scheme utilized in LTE, remains a potential candidate for the 5G air interface, several other schemes offer promising

4 Chapter 4: 5G Investments & Future Forecast

This chapter reviews the status of ongoing 5G investments and provides 5G subscription forecasts up to 2025.

Early 5G Pioneers

Japan: Japan's NTT DoCoMo plans to roll out a 5G network by 2020, envisioning 1,000 times the capacity and 100 times the speed of its current network. The wireless carrier aims to have the network up and running in time for the 2020 Olympic Games.

South Korea: South Korean authorities intend to invest over $1.5 Billion in 5G R&D, as part of an initiative to deploy commercial 5G services by 2020. A trial network deployment is planned for the Pyeongchang Winter Olympic Games in 2018.

Others: In Q4'2014, the Isle of Man announced its goal to become the first place in the world to launch a 5G network, with hopes for testing to begin as early as 2015. Russia's MegaFon has announced similar intentions with a plan to deploy a trial 5G network in time for the 2018 FIFA World Cup. China and the UK also hold similar ambitions.

4.1 How Much is Being Invested in 5G?

Driven by regional, national government, wireless carrier and vendor initiatives, we expect 5G R&D and trial investments will account for nearly $5 Billion by 2020, following a CAGR of nearly 40% over the next 5 years.

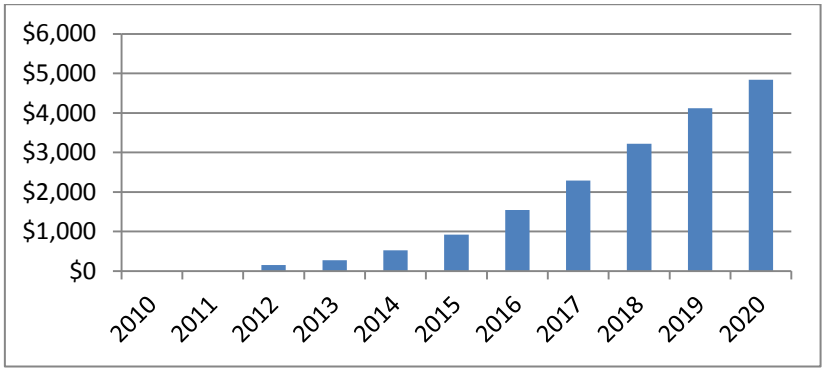

Figure 6: Global Investments in 5G R&D & Trials: 2010 – 2020 ($ Million)

Source: *SNS Research*

SNS Research expects nearly 70% of these investments will target large scale commercial trial networks in Japan, South Korea and other early pioneering countries.

7.2 Ericsson

7.2.1 5G Strategy

As part of its 5G strategy, Ericsson maintains a major focus on new frequency bands (15 GHz and above), Massive MIMO and antenna technology. The vendor envisions 5G to be combination of multiple well-integrated radio-interface solutions.

7.2.2 Demonstrations & Trial Commitments

Ericsson made headlines in Q2'2014, when NTT DoCoMo chose it as one of the six vendors for the wireless carrier's test run of 5G technologies. The trial engagement with Ericsson focuses on developing and demonstrating solutions related to new air interface concepts, new frequency bands (specifically 15 GHz) and new antenna technologies supporting Massive MIMO.

Ericsson was later (in Q3'2014) able to successfully demonstrate[3] an over-the-air speed of 5 Gbps in the 15 GHz band, at its lab in Kista, Sweden. The demonstration was witnessed by senior management teams from both NTT DoCoMo and SK Telecom. The demonstration was followed by the signing of a MoU between Ericsson and SK Telecom to collaborate on 5G research, with the aim of demonstrating 5G at the Pyeongchang 2018 Winter Olympic Games.

In Q4'2014, Ericsson announced that it is partnering with IBM to jointly research phased array antenna[4] designs for 5G networks. The vendor ultimately plans to be

[3] The 15 GHz pre-standard 5G solution (as the vendor terms it), reportedly utilized a new (undisclosed) air interface concept and Massive MIMO.
[4] Phased-array designs allow for more directional antennas that are electrically-steerable and have significant weight and flexibility advantages over existing mechanical antennas.