

Field Trials of Use Cases in High Mobility Environment toward Social Implementation of 5G

Yukihiko Okumura, Satoshi Suyama, and Jun Mashino

Abstract

Experimental trials of use cases of fifth-generation mobile communications systems (5G) in high mobility environments exceeding 90 km/h were carried out as part of the 5G Field Trials initiated by the Ministry of Internal Affairs and Communications of Japan. These trials were conducted to evaluate the transmission and distribution of high-presence, high-resolution video and audio content of sightseeing information, news, advertisements, and entertainment content by 5G for passengers in cars traveling on highways and in trains traveling on a conventional line.

Keywords: 5G, field trials, high mobility environment

1. Introduction

Experimental trials were conducted as part of a project to examine the technical specifications for fifth-generation mobile communications systems (5G) that can achieve a data communication speed exceeding 2 Gbit/s in high mobility environments (study group GII). The trials were contracted to NTT Communications by the Ministry of Internal Affairs and Communications (MIC) as the main implementing entity and conducted in cooperation with NTT DOCOMO (Table 1). In this article, we describe an overview of the trials and introduce some experiments to transmit entertainment content for vehicle passengers as a potential application area. The roles of the organizations participating in the experimental trials are listed in Table 2.

2. 5G wireless transmission tests in high mobility environment exceeding 90 km/h

Two transmission tests were conducted to evaluate the transmission characteristics of 5G radio access in mobile environments consisting of a bus or private car traveling on a highway and a high-speed train traveling on a railway line. One test was conducted

with a car at Fuji Speedway and one was done with a train on the Tobu Railway Nikko Line.

2.1 Transmission test with car at Fuji Speedway

At Fuji Speedway (Shizuoka Prefecture) from February 7 to 9, 2018, a 5G communication area was constructed near the grandstand, and an experimental trial—assuming 5G radio transmission to a car moving at high speed—was conducted (Fig. 1).

The base station (BS) was installed near the grandstand of the home straight, set at an azimuth angle of 45° to the track, and the user equipment (UE) was mounted on the roof of the measurement car. The specifications of the transmission equipment consisted of a center frequency of 27.9 GHz, bandwidth of 700 MHz, and 96 (BS) and 64 (UE) antenna elements. A maximum throughput of 2.24 Gbit/s was obtained as the result when the car was traveling at a speed of 90 km/h.

2.2 Transmission test with a train on Tobu Railway Nikko Line

From February 19 to 23, 2018, in cooperation with Tobu Railway Co., Ltd., 5G communication areas were set up near Ienaka Station and Niregi Station (Tochigi Prefecture) on the Tobu Railway Nikko

Table 1. Study groups conducting the 5G Field Trials initiated by MIC.

Study group	GI	GII	GIII	GIV	GV	GVI
Outline of trials	<ul style="list-style-type: none"> • Ultra-high-resolution video streaming • Advanced city security • Remote medical services 	<ul style="list-style-type: none"> • Entertainment for high mobility transportation 	Remote operation for construction machinery	<ul style="list-style-type: none"> • Entertainment in stadiums • Ultra-high-resolution video streaming 	Platooning vehicles and remote operation for trucks	<ul style="list-style-type: none"> • Logistics • Smart office
Technological target	eMBB (enhanced mobile broadband) <ul style="list-style-type: none"> • 5 Gbit/s/UE; over 10 Gbit/s/BS 	eMBB <ul style="list-style-type: none"> • 2 Gbit/s in high mobility environments 	URLLC (ultra reliable and low latency communication) <ul style="list-style-type: none"> • Low latency communication within 1 ms (radio frame) 	eMBB <ul style="list-style-type: none"> • 5 Gbit/s/UE; over 10 Gbit/s/BS 	URLLC <ul style="list-style-type: none"> • Low latency communication within 1 ms (radio frame) 	mMTC (massive machine type communication) <ul style="list-style-type: none"> • 1 million UE/km²
Mobile velocity	Up to 30 km/h	More than 90 km/h	Up to 60 km/h		Up to 90 km/h	
Experimental environment	Densely populated urban environment	Urban or rural environment	Urban or rural environment	Indoor/closed-space environment	Urban or rural environment	Indoor/closed-space environment
Radio frequency	<ul style="list-style-type: none"> • 3.7-GHz band etc. • 28-GHz band 	<ul style="list-style-type: none"> • 28-GHz band 	<ul style="list-style-type: none"> • 3.7-GHz band etc. • 28-GHz band 	<ul style="list-style-type: none"> • 28-GHz band 	<ul style="list-style-type: none"> • 3.7-GHz band etc. • 28-GHz band 	<ul style="list-style-type: none"> • 3.7-GHz band, etc., 28-GHz band, less than 1-GHz band, and unlicensed band (920-MHz and 2.4-GHz bands, etc.)

Table 2. Companies participating in GII and their roles.

Company participating in GII	Role
NTT Communications	<ul style="list-style-type: none"> • Supervision of experimental trials in GII
NTT DOCOMO	<ul style="list-style-type: none"> • Overall implementation of experimental trials • Provision of test environment in advance (DOCOMO R&D Center) and test measurement vehicles
NEC	<ul style="list-style-type: none"> • Transmission test of high-speed mobile communication at Fuji Speedway and on Tobu Railway Nikko Line • Provision of 5G wireless devices
Ericsson	<ul style="list-style-type: none"> • Transmission test of high-speed mobile communication on Tobu Railway Nikko Line • Provision of 5G wireless devices
Tobu Railway	<ul style="list-style-type: none"> • Promotion of experimental trial on Tobu Railway Nikko Line • Operation of Skytree Train for test and site adjustment of test environment
Japan Display	<ul style="list-style-type: none"> • Experimental trial of 8K high-resolution display in train cars • Provision of 17-inch 8K display
INFOCITY	<ul style="list-style-type: none"> • Experimental trial of high-quality video distribution service for high-speed moving vehicles • Provision of video distribution server, vehicle-mounted application server, and 4K display equipment
Dandelion	<ul style="list-style-type: none"> • Management of experimental trial at Fuji Speedway

R&D: research and development

Line. Experimental trials in those areas were conducted with a 634-series Skytree Train running at high speed under the assumption of 5G wireless transmission for a high-speed railway (**Fig. 2**).

The BS baseband equipment #1 (subordinate to the core-network equipment) was installed at the north-

ern end of the platform of Ienaka Station, and the BS baseband equipment #2 was installed on vacant land on the south side of the station building. This equipment configuration enabled handover testing across the BS. Two antenna units (for transmission diversity) were connected to BS baseband equipment #1 and

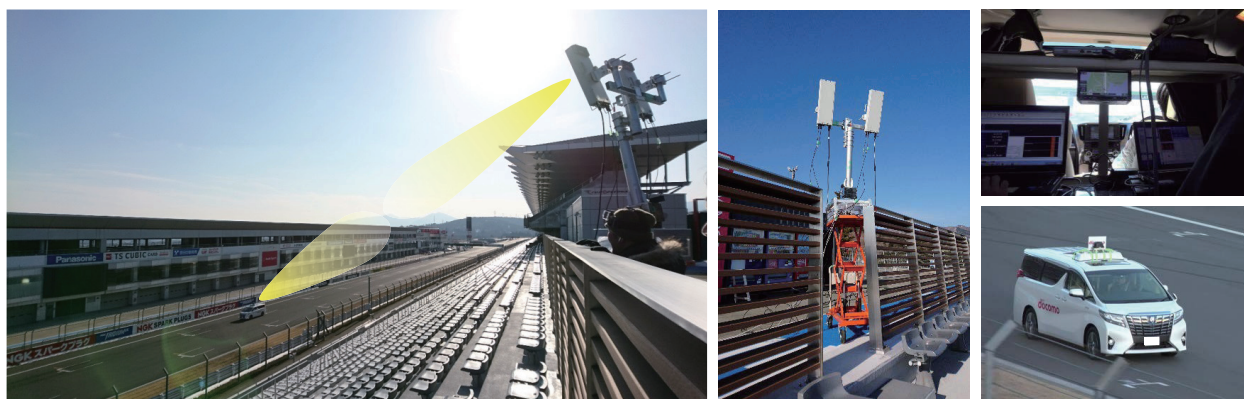


Fig. 1. Wireless transmission test on high-speed mobile communication conducted at Fuji Speedway.



(a) 5G BS near Ienaka Station

(b) 5G BS near Niregi Station



(c) 5G UE onboard 634-series Skytree Train

Fig. 2. Wireless transmission test of high-speed mobile communication on Tobu Railway Nikko Line.

#2. The antenna unit of the UE was fixed in the crew cabin of the Skytree Train to ensure line-of-sight (LOS) between the BSs and UE. The major specifications of the transmission equipment included a center frequency of 27.9 GHz, bandwidth of 700 MHz, and 96 (BS) and 64 (UE) antenna elements. The test result indicated that when the train was traveling at a speed of 90 km/h, a maximum throughput of 2.08 Gbit/s was obtained, and handover between BSs was suc-

cessful.

Near Niregi Station, the BS was configured as distributed antennas. The major specifications were as follows: the center frequency was 27.9 GHz, bandwidth was 730.5 MHz, and there were 128×2 units (BS) and 8 (UE) antenna elements. The UE was installed inside the train, and its antenna was attached to the front window of the driver's seat (via an acrylic panel) to ensure the best-possible LOS. The test result

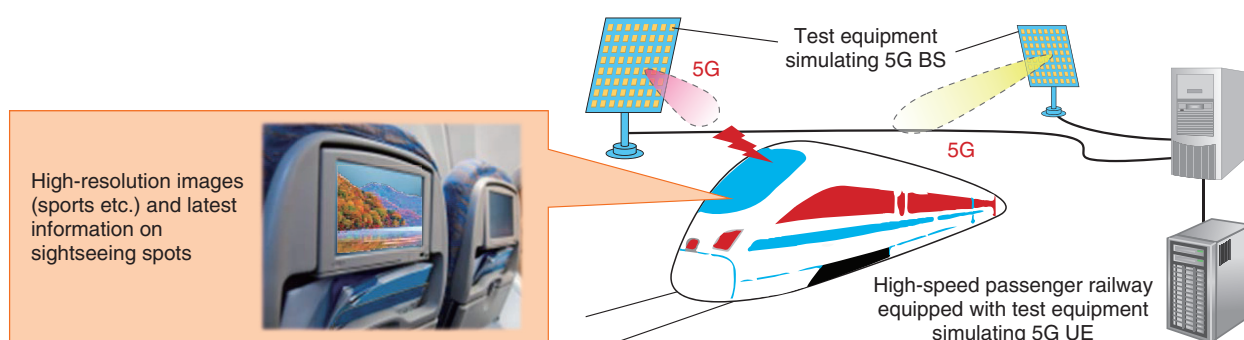


Fig. 3. Experimental trial of high-speed transmission of entertainment content.

revealed that a maximum throughput of 2.90 Gbit/s was obtained when the train was traveling at a speed of 90 km/h.

3. Experimental trial to transmit entertainment content

With public transport, the longer the distance traveled, the more time is taken traveling, and high mobility is required. Under those circumstances, it is important for passengers spending time traveling at high speed to have entertainment, and it should be provided with high quality such as having high-resolution images. Therefore, to evaluate a service utilizing 5G during high-speed transit, an experimental trial was conducted of a high-resolution video service for passengers carried by passenger transport operators such as railways, buses, and taxis at speeds of over 90 km/h (**Fig. 3**).

One of the main forms of usage of 5G services by passengers traveling in trains or passenger cars (traveling vehicles) is expected to be Internet-connected services, and it is assumed that such services will be included as a basic feature. This trial was carried out in order to visualize and evaluate 5G-specific services, specifically, a high-resolution video service providing information and entertainment content for passengers traveling at high speed. For a 5G video delivery service for passengers in vehicles, it is anticipated that information-provision services with higher-resolution video information, more channels, and better timeliness (such as live distribution of video) will be possible thanks to the large capacity of 5G services compared to services using conventional transmission methods.

Video distribution services are roughly categorized as either linear-delivery type (programming type)

services or on-demand distribution type services. In this experimental trial, only a limited number of BSs could be prepared, so the time to communicate in the high mobility environment was also limited. Consequently, our aim was to obtain the advantages of both the linear-delivery service (timeliness) and the on-demand delivery service (convenience), so a hybrid delivery service was implemented and experimentally verified (**Fig. 4**).

In cooperation with INFOCITY, INC., a cache server was installed between a video distribution server (master server) installed on the BS side and the UE devices in the train, and the network was separated into two networks: a server-to-server network (from the master server to the cache server) and an end-user network (from the cache server to the UE devices). The server-to-server synchronization function enables the service operator to add content of the master server, and even if the cache server cannot use 5G communication at the time of the updating, the content of the cache server can be appropriately updated at a later time when 5G communication becomes available, and users can be provided with instantaneous services similar to live distribution.

From February 19 to 23, 2018, this hybrid-type video delivery system was used to conduct an experimental trial to download multiple 4K and 8K video files simultaneously in the 5G area set up near Tobu Railway's Ienaka Station (**Fig. 5**).

During the 21-s period in which the train passes through the 5G area, a 4K and 8K video file with a total size of 1.2 GB was transferred, and video images were displayed on a 4K display and a 17-inch 8K display (provided by Japan Display Inc.) installed in the train.

Achieving Gbit/s-grade ultrahigh-speed communication in high mobility environments will make it

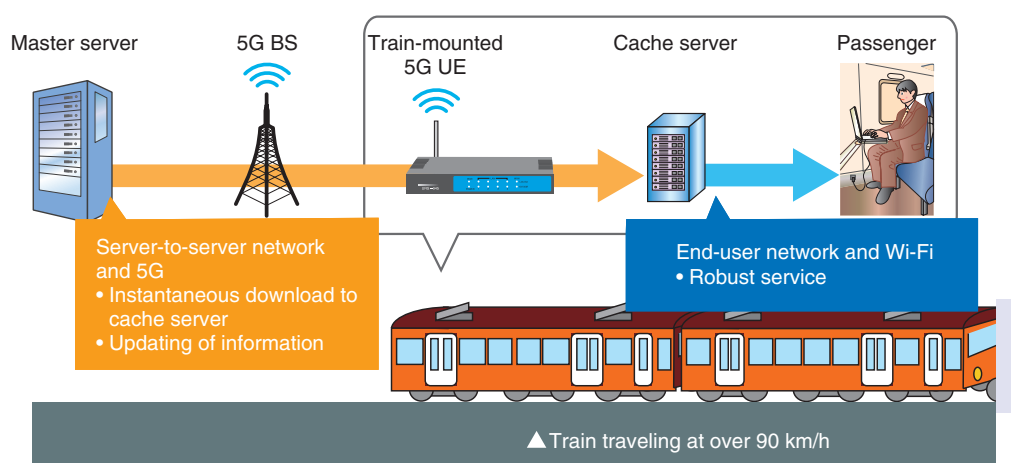


Fig. 4. Hybrid-type video delivery system.

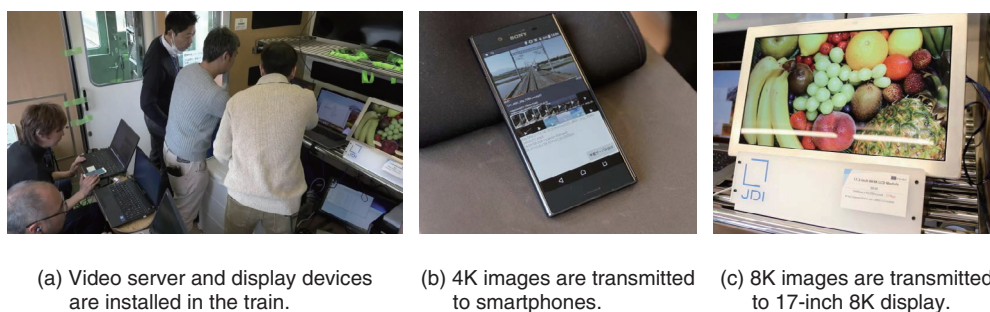


Fig. 5. High-resolution video transmission test for high mobility environment on Tobu Railway Nikko Line.

possible to deliver high-resolution video clips (such as the latest news) to passengers of high-speed rail services in a timely manner.

Trademark notes

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Yukihiko Okumura

Senior Manager, 5G Laboratories, NTT DOCOMO, INC.

He received a B.S. and M.S. in electrical engineering from Tokyo University of Science in 1989 and 1991, and a Ph.D. in engineering from Tohoku University, Miyagi, in 2006. In 1991, he joined NTT Radio Communication Systems Laboratories. Since 1992, he has been engaged in the research, standardization, and development of wideband/broadband mobile radio communication technologies, terminals, and systems at NTT Mobile Communications Network, Inc. (now NTT DOCOMO, INC.). He is currently involved in researching 5G system technologies. He is a senior member of the Institute of Electrical and Electronics Engineers (IEEE).



Satoshi Suyama

Manager, 5G Laboratories, NTT DOCOMO, INC.

He received a B.S. in electrical and electronic engineering, an M.S. in information processing, and a Dr. Eng. in communications and integrated systems, all from Tokyo Institute of Technology, in 1999, 2001, and 2010. From 2001 to 2013, he was an Assistant Professor in the Department of Communications and Integrated Systems at Tokyo Institute of Technology. He has been engaged in research on OFDM (orthogonal frequency division multiplexing) mobile communications systems and applications of adaptive signal processing, including turbo equalization, interference cancellation, and channel estimation. In April 2013, he joined NTT DOCOMO and has been involved in research and development of 5G systems. He received the Young Researchers' Award from the Institute of Electronics, Information and Communication Engineers (IEICE) in 2005, the Best Paper Prize from the European Wireless Technology Conference (EuWiT) in 2009, the Paper Award from IEICE in 2012, and the Best Paper Award from International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC) in 2016. Dr. Suyama is a member of IEEE and IEICE.



Jun Mashino

Manager, 5G Laboratories, NTT DOCOMO, INC.

He received a B.E. in electrical and electronic engineering and an M.E. in communications and computer engineering from Kyoto University in 2003 and 2005. He joined NTT Access Network Service Systems Laboratories in 2005. He has been engaged in the research and development of intelligent interference compensation technologies and signal processing for future wireless communications systems. Since 2016, he has been working as a research engineer at NTT DOCOMO 5G Laboratories. His current interests include wireless transmission technologies for 5G systems. He received the IEICE Young Researchers' Award in 2009 and the APMC 2014 Prize at the Asia-Pacific Microwave Conference in 2014. He is a member of IEEE and IEICE.