News Release

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The University of L'Aquila
Sumitomo Electric Industries, Ltd.
Optoscribe Ltd.

The World's First Field Deployed Multi-Core Fiber Testbed for Optical Communications Installed in L'Aquila, Italy

The University of L'Aquila, Sumitomo Electric Industries, Ltd. and Optoscribe Ltd. have jointly deployed the world's first testbed for multi-core fiber communications in a field deployed environment in the city of L'Aquila, in Italy.

The University of L'Aquila, Sumitomo Electric, and Optoscribe have jointly deployed the world's first multi-core fiber (MCF) testbed for space-division multiplexed*1 (SDM) fiber-optic communications in a real-field environment in the city of L'Aquila, as part of INCIPICT project.[1,2] An MCF is an optical fiber with multiple cores in a glass cladding and is considered one of the most promising SDM transmission technologies to overcome the limitations of conventional single-core fiber communication systems. For INCIPICT, Sumitomo Electric fabricated two types*2 [3–5] of uncoupled MCFs and one type*3 of coupled MCFs with a standard glass diameter of 125 μm*4 (details in Table 1). The standard glass diameter enabled the use of conventional optical fiber cable and connector technologies. The MCFs were cabled into conventional loose-tube jelly-filled cables (Fig. 1) widely used in Europe. Optoscribe manufactured fan-in/fan-out (FIFO) devices*5 3D OptoFan™[6] for the conversion between MCFs and multiple standard single-mode fibers (SMFs). The MCF cable was installed in a microduct placed on INCIPICT's rack in the walkable multi-service underground tunnel sketched in Fig. 1. Figure 2 shows the experimental fiber-optic network of INCIPICT, in the city of L'Aquila. The MCF testbed was installed as a part of it. The total length of the installed MCF cable is 6.3 km, of which 5.6 km in the tunnel and 0.7 km in the laboratory that gives access to the fibers. The optical properties of the MCFs were evaluated before and after the installation, and no significant degradations due to the installation were observed.

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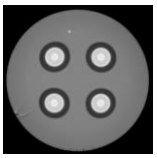
Table 1: MCFs installed in the testbed

	(a)	(b)	(c)
Type	Uncoupled	Uncoupled	Coupled
Fiber cross section			
# of cores in a fiber	8	4	4
# of fibers in a cable	2	4	12
Transmission suitable wavelength band	O band 1260 to 1360 nm	O, C, L bands 1260 to 1625 nm	C, L band 1530 to 1625 nm
Reference	[3,4]	[5]	n/a

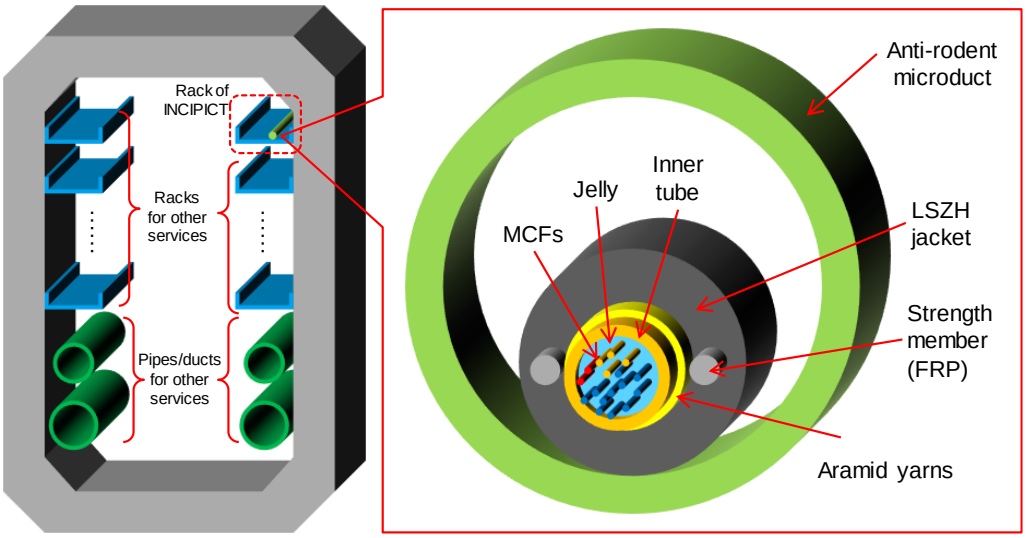


Figure 1: Schematics of the walkable underground tunnel with INCIPICT's rack (left), and the installed MCF cable in a microduct (right)

*The images are shown for illustrative purposes, and rack/pipe/duct counts/positions may differ from the actual ones.

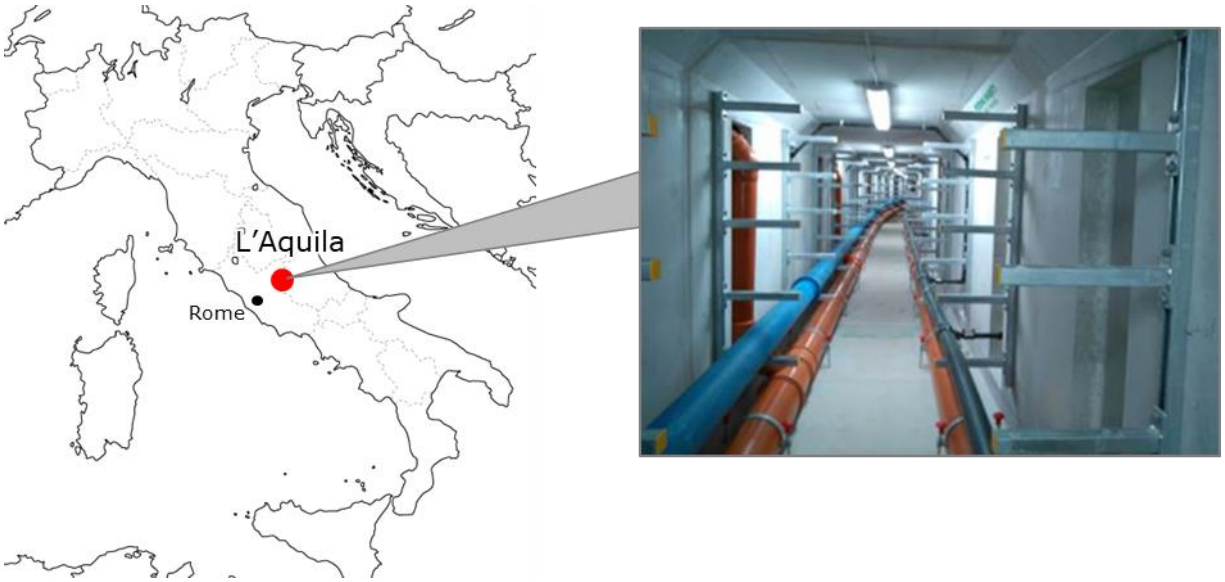


Figure 2: L'Aquila city and the tunnel where MCF cable was installed

[Future prospect]

The MCF testbed will be used to host various R&D activities in fiber optic communications, and specifically in the area of SDM transmission over MCFs. These include device testing, transmissions and software-defined networking, also in conjunction with the ongoing 5G trial (L'Aquila is one of the five Italian sites selected for trialing 5G technologies). The testbed will serve to assess problems and requirements for deployed MCFs, thereby contributing to the development of SDM transmission systems. The testbed will be available to the international research community under the jurisdiction of the University of L'Aquila.

[Acknowledgements]

The MCFs fabricated by Sumitomo Electric for INCIPICT was cabled by Opticable S.A., a joint venture of Nexans S.A. and Sumitomo Electric, in Belgium.

[About the city of L'Aquila, and INCIPICT Project]

The city of L'Aquila, the regional capital of Abruzzo, is located in central Italy. The city was struck by a high-magnitude earthquake on April 6, 2009, which destroyed most of the city center. Since the beginning of the reconstruction process, the city has been open to various

experimental projects based on a green-field approach, to which a fraction of the reconstruction funds has been dedicated. One of these projects is INCIPICT (Innovating City Planning through Information and Communications Technologies), proposed and led by the University of L'Aquila and funded by the Italian Government, in the spirit of supporting production and research activities in L'Aquila. Inspired by the concept of a living-lab, this project includes various research activities that ultimately rely on the fiber-optic infrastructure. Details can be found in [1,2].

*1 Space-division multiplexed transmission

A transmission method for multiplexing signals using multiple spatial channels in optical fiber. Various fiber structures have been proposed to this end, including MCFs, where the fiber cores are used as spatial channels, and few mode fibers, where the fiber modes are used as spatial channels.

*2 Uncoupled multi-core fiber

An MCF designed so as to suppress crosstalk (XT) between cores, so that an MCF with *N* cores is equivalent to *N* isolated single-core fibers with higher spatial density of cores.

*3 Coupled multi-core fiber

An MCF with smaller core-to-core pitch than uncoupled MCFs, intentionally designed to have random coupling between cores. Although multiple-input-multiple-output (MIMO) digital signal processing is necessary for extracting the signals transmitted in the various cores, random coupling reduces the accumulation of nonlinear propagation effects and modal dispersion (which has a considerable impact on the MIMO complexity). These advantages are significant in long-haul point-to-point links, such as submarine transmission systems.

*4 Standard glass diameter

The cladding diameter of a fiber is defined to be 125 ± 0.7 μm and the coating diameter to be 235-265 μm by international standards.

*5 Fan-in/fan-out device

A device that connects individual conventional SMFs to the cores of an MCF.

[References]

[1] http://incipict.univaq.it

[2] C. Antonelli et al., “The City of L’Aquila as a Living Lab: the INCIPICT Project and the 5G Trial,” in 2018 IEEE 5G World Forum (5GWF), 2018, pp. 410–415.

[3] T. Hayashi et al., in Opt. Fiber Commun. Conf. (OFC), Los Angeles, 2015, paper Th5C.6.

[4] T. Hayashi et al., in Int. Wire Cable Symp. (IWCS), Providence, 2018, paper P-6.

[5] T. Matsui et al., in Eur. Conf. Opt. Commun. (ECOC), Valencia, 2015, paper We.1.4.5.

[6] http://www.optoscribe.com/products/fiber-to-fiber-interconnects/

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