IEC Standardization Activities for Distributed Network Sensor Technology

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IEC-ITU-T Workshop *“Standardization Roadmap for Cabled Multi-Core Fibre and Optical Network Sensing Technologies”*

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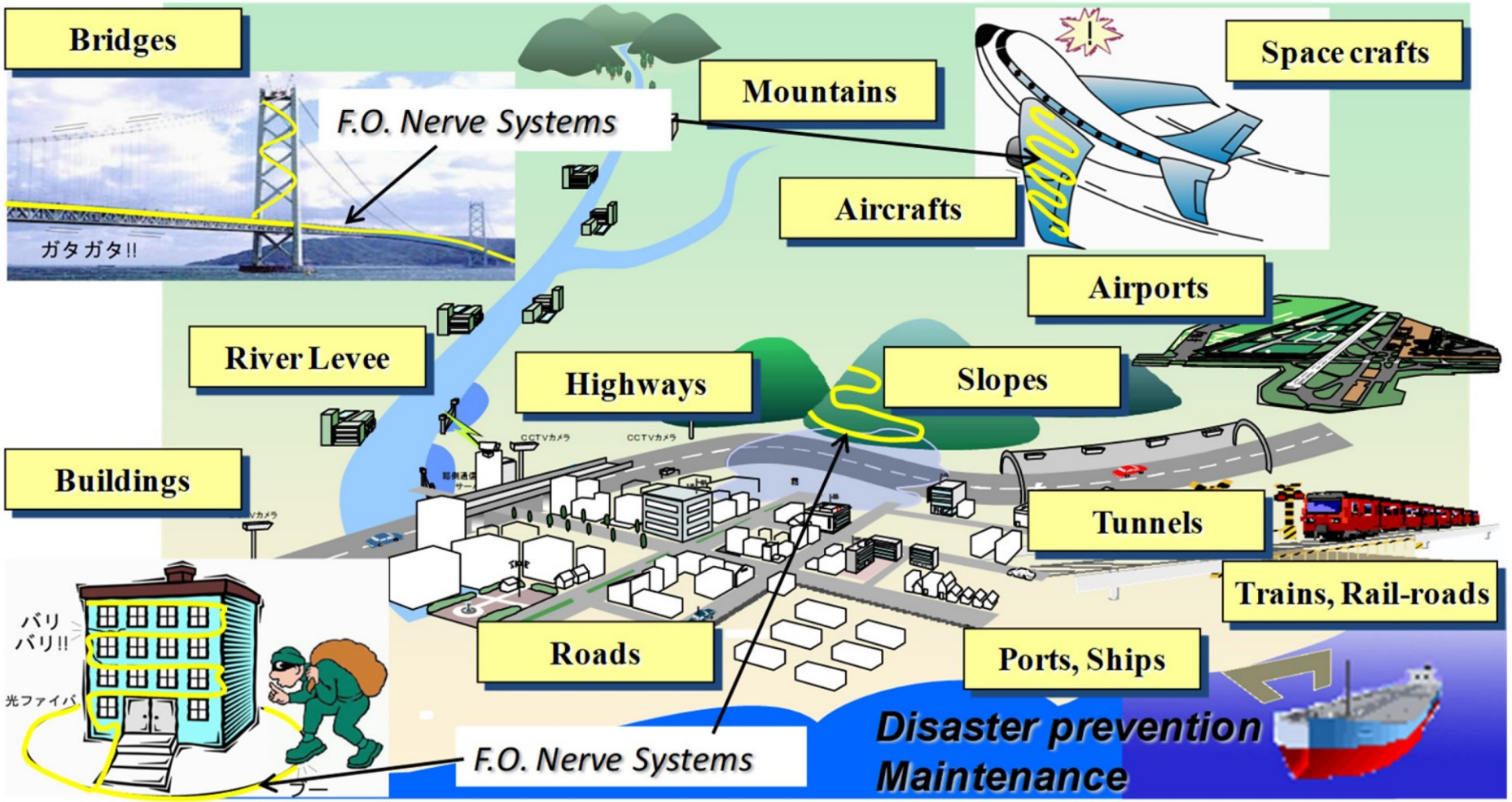
Geneva (Switzerland)

Fibre Optic “Nerves” for Safety, Security, and Smart Cities



Hotate, K. Brillouin Optical Correlation-Domain Technologies Based on Synthesis of Optical Coherence Function as Fiber Optic Nerve Systems for Structural Health Monitoring. Appl. Sci. 2019, 9, 187. https://doi.org/10.3390/app9010187

Market Ready Technologies

Distributed Temperature Sensing (DTS)

- Distributed Temperature Sensing (DTS) is based on Raman or Brillouin backscattering.
- Provides continuous temperature profiles along an optical fibre across ≥ 70 km with temperature resolution of 0.1 °C to 1 °C and spatial resolution of 0.5 m to 2 m.

Distributed Temperature and Strain Sensing (DTSS, DSS)

- DTSS / DSS is based on Rayleigh (DSS), spontaneous or stimulated Brillouin scattering (DTSS / DSS).
- Provides a Brillouin frequency shift on strain (≤ 2 με) and temperature (≤ 0.1 °C). Uses Brillouin scattering for simultaneous detection of strain and temperature over long distances (≥ 80 km), with meter-scale resolution (≤ 2.5 m). Rayleigh-DTSS provide at ≤ 100 m temperature resolution of ≤ 0.1 °C and strain resolution of ±1 με with mm spatial resolution.

Distributed Acoustic Sensing (DAS)

- Uses Rayleigh scattering via Coherent Optical Time Domain Reflectometry (COTDR) or Phase-Sensitive Optical Time Domain Reflectometry (Φ-OTDR).
- Turns fibre into a continuous acoustic sensor listening to vibration, intrusion, trains, seismic events in the 2 kHz range over ≥ 100 km.

IEC Fibre Optic Sensor Standards Development

Technical Committee 86 *Fibre optics*

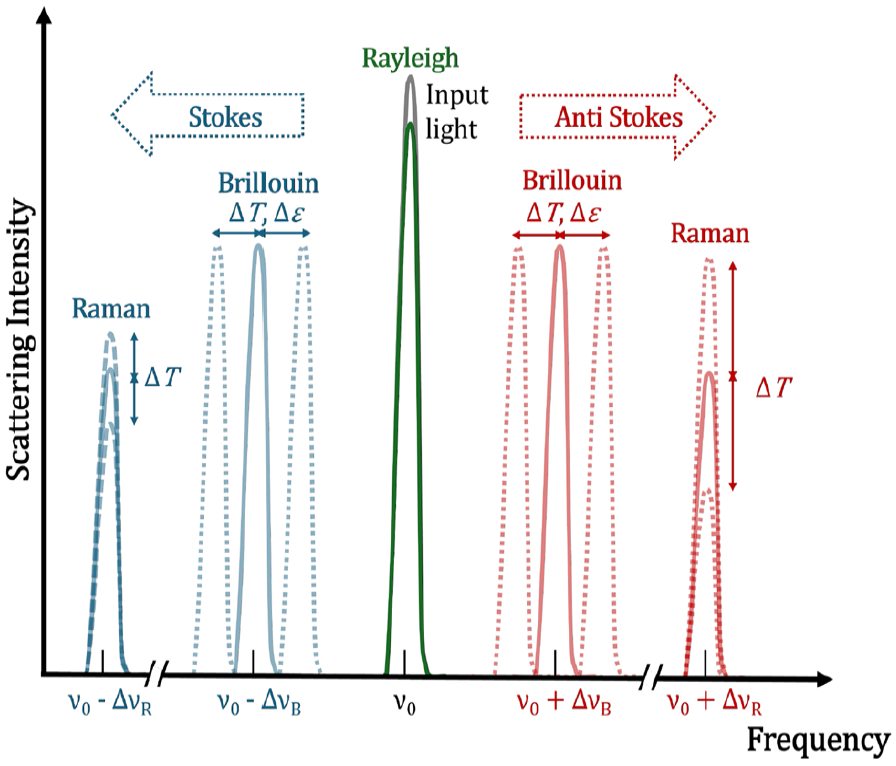
- **Sub-Committee 86C *Fibre optic systems, sensing and active devices***
  - **SC 86C Working Group 2 *Fibre optic sensors***
    - To prepare international standards and specifications for optical sensors based on fibre optics, covering performance and interface characteristics, as well as other standardization aspects including terminology, test methods, reliability and environmental attributes
    - Established in 1989
    - 1st edition of the “Generic Specification on Fibre Optic Sensors” published in 1998
    - WG closed in 1998 for lack of contributions
    - Re-established in 2011
    - 73 members from 18 member countries (2025)
    - Regular active ~20 members from 10 member countries

IEC Distributed Fibre Optic Sensor Standards

- IEC 61757 Fibre optic sensors - Generic specification

The individual parts of the IEC 61757 series are numbered as IEC 61757-M-T, where M denotes the measurand and T the technology. Distributed sensing standards are marked by M-2 and M-4:

- IEC 61757-1-2 Fibre optic sensors - Part 1-2: Strain measurement - Distributed sensing based on Brillouin scattering
- IEC 61757-2-2 Fibre optic sensors - Part 2-2: Temperature measurement - Distributed sensing
- IEC 61757-3-2 Fibre optic sensors - Part 3-2: Acoustic sensing - Distributed sensing
- IEC 61757-1-4 Fibre optic sensors - Part 1-4: Strain measurement - Distributed sensing based on Rayleigh scattering



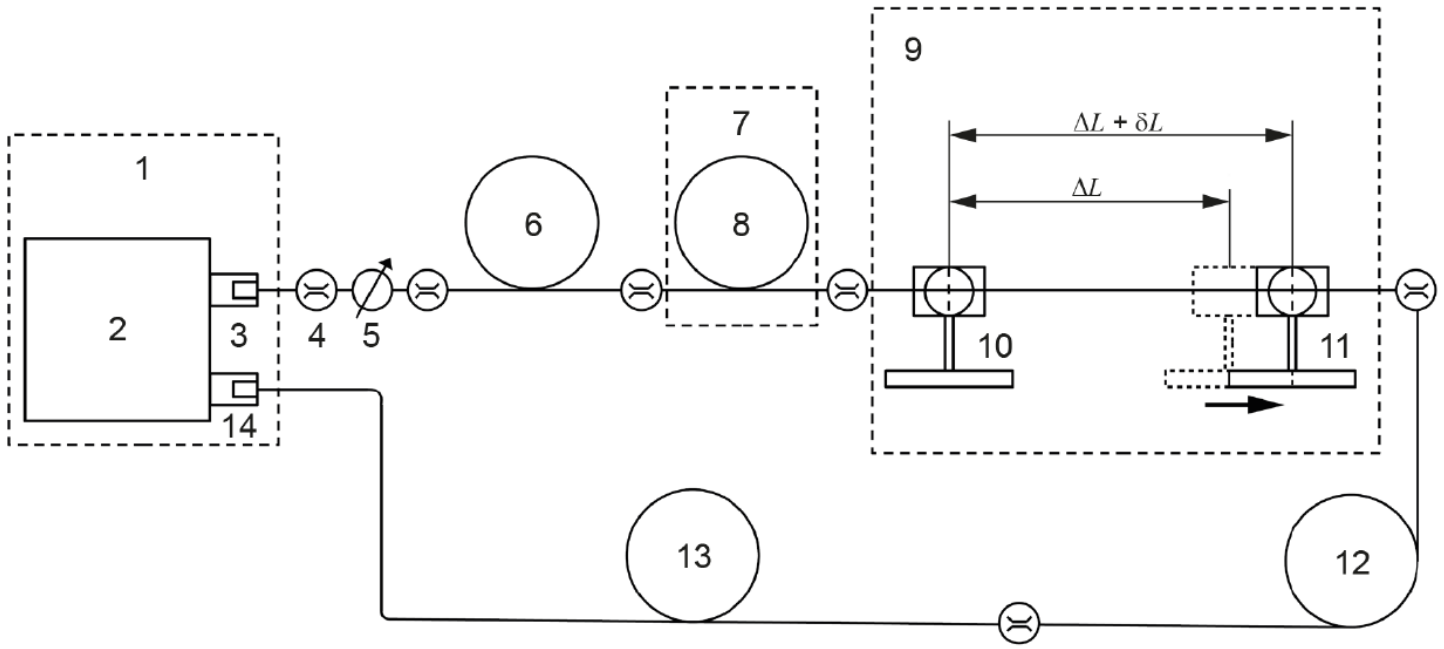
S. Krenek et al: Fibre-optic thermometry to support the clean energy transition; tm–Technisches Messen 2025; 92(9–10): 392–405; https://doi.org/10.1515/teme-2025-0044

IEC Fibre Optic Sensor Standards Scheme

PUB IEC 61757 Fibre optic sensors – Generic specification			
IEC 61757 – Measurand (M) – Architecture / Technology (T)			
Technology (T) / Architecture / Measurand (M)	Sensing with fibre Bragg gratings T = 1	Distributed sensing based on scattering T = 2 T = 4	Polarimetry based sensing T = 3
Strain measurement M = 1	PUB IEC 61757-1-1	PUB IEC 61757-1-2 (Brillouin) APUB IEC 61757-1-4 (Rayleigh)	
Temperature measurement M = 2	PUB IEC 61757-2-1	PUB IEC 61757-2-2 (Brillouin, Raman, Rayleigh)	
Acoustic sensing and vibration measurement M = 3		PUB IEC 61757-3-2 (Rayleigh)	
Electric current measurement M = 4			PUB IEC 61757-4-3
Tilt measurement M = 5	PUB IEC 61757-5-1		
Displacement measurement M = 6	PUB IEC 61757-6-1		
Electric voltage measurement M = 7			PUP IEC 61757-7-3
Pressure Measurement M = 8	APUB IEC 61757-8-1		

IEC 61757-1-2 Fibre optic sensors - Part 1-2: Strain measurement - Distributed sensing based on Brillouin scattering

DSS performance parameter determination by defined and traceable fibre strain:

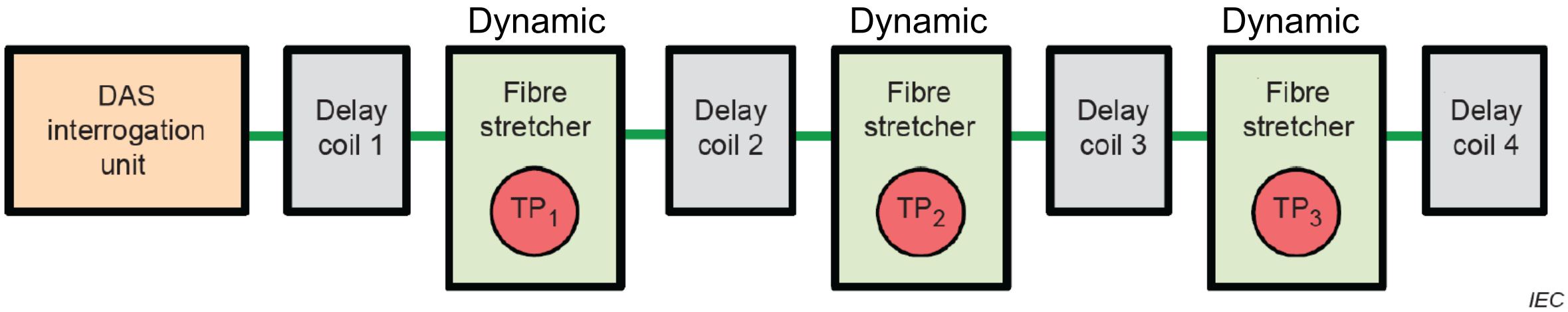


Key

1 Temperature-controlled encasement (e.g. temperature chamber)
2 DSS interrogation unit
3 DSS interrogation unit output connector
4 Fibre fusion splice
5 Optional variable optical attenuator
6 Optional long fibre length $L_{F,opt}$ (normal spool)
7 Temperature-controlled environment for stable ambient conditions
8 Long fibre length $L_{F,long}$ (loose and strain free wound)
9 Strain test section with temperature-controlled environment for stable ambient conditions
10 Fixed fibre clamping unit
11 Movable fibre clamping unit
12 Long fibre length $L_{F,short}$ (loose wound), longer than 5 times the spatial resolution
13 Long fibre length $L_{F,loop}$ (normal spool), with $L_{F,loop} > (L_{F,opt} + L_{F,long} + \Delta L + L_{F,short})$
14 DSS interrogation unit input connector

IEC 61757-3-2 Fibre optic sensors - Part 3-2: Acoustic sensing - Distributed sensing

DAS performance parameter determination by a simulated fibre sensor:



SOURCE: SEAFOM MSP-02 [1], reproduced with the permission of SEAFOM.

IEC Fibre Optic Sensor Standards Development

WG2 cooperation with other organizations that develop application standards:

- Subsea Fiber Optic Monitoring Group (Cat. C Liaison)
- ITU-T Study Group 15 - Scientific monitoring of the ocean using optical submarine cables
- SAE Aerospace - AS-3 Fiber Optics and Applied Photonics Committee
- ASTM - Subcommittee F36.10 on Optical Fiber Systems within Existing Infrastructure
- IEEE Photonics Standards Committee

WG2 involvement in research projects:

- Integrated European research, calibration and testing infrastructure for fibre-optic thermometry

INFOTherm

- Aircraft Photonic Interfaces Standardization for Sensing

APISS

Thank you for your kind attention.