World Class Standards

# a connected world

## Annual Report

april 2017

# ETSI's Vision of a Connected World


**ETSI is** a producer of technical standards intended for global use for digital technologies, products and services. The high quality of our work and our open approach to standardisation has seen our reach extend from European roots to the entire world.

**ETSI is** officially recognised by the European Union as a European Standardisation Organisation (ESO). Our activities are driven by time to market and our standards help ensure the free movement of goods within the single European market, allowing enterprises in the EU to be more competitive.

**ETSI is** a not-for-profit organisation created in 1988. We have over 800 member organisations worldwide, drawn from 67 countries and five continents. Our diverse membership includes some of the world's leading companies from the manufacturing and service sectors, regulatory authorities and government ministries, as well as Small and Medium-sized Enterprises and innovative start-ups, working alongside universities, R&D organisations and societal interest groups.

**ETSI is** a world-renowned organisation with a solid reputation for technical excellence. Our standards are produced by our members, through active participation, co-operation and consensus in an atmosphere of openness and transparency, where all contribute as equals. We work in partnership with all relevant worldwide Standards Developing Organisations, particularly the other ESOs, as well as communities, fora and consortia. This ensures that our standards are aligned with those produced elsewhere and avoids the duplication of effort.

**ETSI is** at the forefront of emerging technologies. We have close relationships with research communities and other innovative organisations, addressing the technical issues that will drive the economy of the future and improve life for the next generation.

Our 'clusters' (above) provide a simplified, yet comprehensive, way of identifying our different areas of expertise based on business relevance or application domain rather than our committee structure.

Each cluster represents a major component of the global Information and Communications Technologies architecture and brings together the work of those Technical Committees and other groups which share a common technological scope and vision. It is this joint scope and vision that gives each cluster its own identity; collectively the clusters represent the totality of ETSI's work, and demonstrate the way that technologies are converging into a connected world.

# Annual Report 2016 (published April 2017)

**Simon Hicks**
*Chairman of the General Assembly*

**Dirk Weiler**
*Chairman of the Board*

**Luis Jorge Romero**
*Director-General*

5G was one of the hot topics of 2016, not least for the part it will play in supporting the Internet of Things (IoT). We contribute to the development of 5G, both as a founding partner of the Third Generation Partnership Project (3GPP™) and through the work of our own committees.

We are producing specifications for Network Functions Virtualisation (NFV), Millimetre Wave Transmission and Multi-access Edge Computing – technologies which will form the potential building blocks for a 5G system. We are looking into our future requirements for Internet Protocols to support developments in local access networks.

Since spectrum is a major issue for 5G, we are working to ensure compatibility between the different uses which may occupy adjacent spectrum and looking at advanced techniques for sharing spectrum. And we are investigating possible new metrics for energy efficiency within 5G systems.

In 2016 we also focussed on the security of the technologies we are standardising, as well as cyber security and the protection of critical infrastructures, and we are developing trusted platforms on which to run the new virtualisation technologies and networked digital systems such as the IoT, Industry 4.0 and eHealth.

5G and security are but two topics in our diverse work programme. Together the various achievements described in this report will help to create a more connected world. They will also ensure that it is a safer place to live.

In 2016 we invested heavily in support of the European Union, publishing over 100 new and revised Harmonised Standards required for the new Radio Equipment Directive.

But we also looked to our future, anticipating the technologies which will dominate our work in coming years. In November 2016, we approved our new Long-Term Strategy for 2016-2021. It includes two key technical themes, the IoT and supporting 5G communications systems, as well as involvement in Horizon 2020, attracting innovative new work and exploring the potential of Open Source. In 2016 we made excellent progress towards our targets in all these areas.

For example, as a partner in the oneM2M initiative, we are developing technical specifications for IoT technologies. oneM2M Release 2 was published in September, enabling one common core interworking platform technology for the IoT. In our own committees, we are addressing the needs of smart cities, eHealth and Intelligent Transport Systems. To encourage energy efficiency in the IoT, we are also producing standards for Low Throughput Networks, the new ultra narrowband radio technology which is ideal for connecting objects in the IoT which need only low throughput connectivity.

As technologies increasingly interconnect and all sectors become more ICT-intensive, the need for improved communication between them becomes crucial, both technologically and economically. Perhaps this is one reason why in 2016 we saw rising membership and participation from a wider industrial base.

The way that telecommunications systems are designed and operated is changing. 'Softwarisation', including the use of Software Defined Networks, NFV and Cloud computing, is expected to deliver services and applications in an agile and cost effective way. 5G networks, in particular, are forecast to make significant use of virtualisation.

ETSI is playing its part in this technological revolution through the work of our Industry Specification Group (ISG) on NFV and, in September, the virtualisation of telecommunication networks came a step closer with the publication of our second release of NFV specifications.

One of the key lessons to come from this 'software' world is the potential of engaging in Open Source-like projects, and we have begun not only to involve new communities but also to consider new processes for our standards development. With our Open Source MANO (OSM) initiative, we have made a significant foray into these new processes; our standards can be implemented quickly so that we can identify inconsistencies, and the results are fed back into our standards-making in ISG NFV in a process we call 'implementation driven standardisation'. Our members continue a very active discussion about the various ways Open Source software and ETSI standards can and should interact.

There is also a new component emerging in this technological revolution – Artificial Intelligence, systems that learn from their environment and take action to maximise their success. This is something we expect to develop in 2017.

The following pages describe our work in 2016. For what we plan to do next, please see our Work Programme 2017-18.

# Past and Future – an Overview of 2016

In line with our new Long-Term Strategy for 2016-2021, 5G and the Internet of Things (IoT), and work in support of their development, dominated our activities in 2016 – but not exclusively. We continued to work in areas of traditional expertise, and we also looked to the future.

## Nurturing New Technologies

For example, we cultivated our links with the research community and academia, and we organised numerous workshops to disseminate research results and identify standardisation opportunities.

Our Industry Specification Groups (ISGs) continued to prove an effective mechanism for bringing together key stakeholders, including non-members of ETSI, to kick-start new technologies. In 2016, we set up a new ISG on Mobile and Broadcast Convergence to define the requirements for media delivery over converged networks.

## Building the Internet of Things

In September, oneM2M Release 2 was published, providing a common core interworking platform technology for the IoT. Within ETSI, we also worked on smart cities, Body Area Networks, wireless industrial automation, eHealth and Intelligent Transport Systems.

On the radio side, we are producing standards for Low Throughput Networks. We further enhanced the Digital Enhanced Cordless Telecommunications (DECT™) Ultra Low Energy specification, which is primarily driven by a low power requirement for battery-operated devices, and we began to consider the future of DECT, particularly with regard to ultra-reliable and low latency communications.

## Towards 5G Mobile Communications

While significant work is still being undertaken to evolve the 4G system, planning for the development of 5G is well under way, both within the Third Generation Partnership Project (3GPP™) and through the work of our own committees.

In 2016 3GPP agreed a detailed work plan for Release 15, the first release of 5G specifications, and began work on the standardisation of the Next Generation architecture. Good progress was made with various studies into possible new radio technologies capable of meeting the evolving and disparate demands of the IoT.

### The Building Blocks for 5G

5G networks will consist of large elements of virtualisation, a topic addressed by our ISG on Network Functions Virtualisation (NFV), which in 2016 produced its second release of ETSI NFV specifications. 5G will need very high performance and high availability – and much more spectrum to achieve those objectives. Our work on millimetre wave transmission will provide a valuable knowledge base for 5G systems. Our ISG on Multi-access Edge Computing is looking into placing computational functionality as close as possible to the end-user to achieve the very low latency which 5G will require.

### 5G Energy Efficiency

Energy efficiency will acquire far greater significance with 5G than it did with previous mobile communication technologies. In 2016 we embarked on an investigation into possible new metrics for energy efficiency within 5G systems. At the same time, 3GPP was involved in a study of the energy efficiency of mobile networks.

### Maximising the Use of Spectrum

Spectrum resources are struggling to meet the growing demands of the Internet and mobile communications and this problem will become even more pronounced in the light of 5G. As well as ensuring compatibility between the different uses in adjacent spectrum, we are looking for ways to improve spectral efficiency by using modern methodology and advanced techniques for sharing spectrum. In 2016 we completed our work on Licensed Shared Access, and began looking at the possible extension of software reconfiguration technology to other network entities.

## Security

Security standards are crucial to a modern connected world. We produce standards for the security of individual technologies, as well as for specific security topics – Lawful Interception, Quantum Key Distribution and security algorithms, for example. We are addressing the security of critical infrastructures, the privacy of users and other aspects of cyber security, and we are looking at the new challenges of security in virtualisation. In 2016 we completed our first specification on quantum-safe cryptography. We began work

on a next generation Secure Element, and we completed our work in response to the European Commission (EC) mandate on Electronic Signature Standardisation (M/460), publishing all the outstanding specifications required.

## Creating a Better Life

### Energy Efficiency for ICT

In 2016 we continued to develop standards to help reduce the eco-environmental impact of Information and Communications Technologies (ICT) equipment and to monitor the energy management of deployed broadband. We made good progress on the ecodesign requirements for network standby mode for household and office equipment, and we began new work on the energy efficiency of smart cities.

### Increasing Digital Inclusion

We continued to address the needs of users with cognitive disabilities when interacting with ICT systems, and we began work on the human factors aspects of the services in smart, accessible, sustainable cities and communities. Other topics included emergency calling and alerting messages for users with special needs and improving the listening quality for people with impaired hearing.

### Public Safety

In addressing the needs of Public Protection and Disaster Relief and other mission-critical services, we are looking at methods of enabling migration from Terrestrial Trunked Radio (TETRA) to broadband by enhancing existing standards for technologies such as LTE™ and 5G. In 2016 3GPP completed the first set of mission-critical specifications covering voice communication, Push-to-Talk (PTT).

We began new work on the Quality of Service of mission-critical applications, and we continued to address eCall, the in-vehicle emergency call service.

### Transportation

In preparation for our second release of standards for Co-operative-ITS (C-ITS) and automated driving, we made good progress with initial studies into Co-operative Adaptive Cruise Control, platooning and the use of C-ITS to protect vulnerable road users. We began looking into the possible use of the C-ITS architecture and vehicle-to-everything communication technology to improve pollution control.

We also addressed rail, aeronautical and maritime transportation, and the use of satellite communications standards for high speed Internet access to fixed terminals or terminals on the move, in an aircraft, on board a ship or in a vehicle.

### Broadcasting and Content Delivery

In 2016 the Joint Technical Committee on Broadcasting continued to focus on digital broadcasting and was particularly active in Ultra High Definition TV and related areas, interactive TV and radio.

We are specifying a new compound content solution for consumer electronic devices to provide backwards compatibility with today's display devices while ensuring a full quality signal is available for the next generation of televisions.

We also addressed protection and rights mechanisms and the transportation of video over powerlines.

## Networks

We continued to work on small cells microwave backhauling, Digital Subscriber Line technologies and optical fibre systems. We are leading work globally on the standardisation of Reverse Power Feeding. We made good progress with specifications to enable the transition from IPv4 to IPv6, and we are addressing future networks and the need for next generation protocols.

### Virtualisation and the Cloud

Our ground-breaking work on NFV will help simplify the roll-out of network services, reduce deployment and operational costs and encourage innovation.

In 2016 we completed our work on the Cloud Standards Co-ordination (CSC).

## Testing and Interoperability

Highlights of 2016 included new work on oneM2M conformance testing, and the promotion and evolution of Test Description Language (TDL).

### Open Source

We worked with Open Source communities, examining the potential benefits of collaboration, and we continued to apply Open Source-like software development approaches to the production of test specifications and platforms.

We established a new project to develop an Open Source NFV Management and Orchestration (MANO) software stack.

## Working in Partnership

We continued to collaborate with partners all over the world, including the other two European Standardisation Organisations, CEN and CENELEC, and we worked closely with the EC in support of its policies and goals.

### Harmonised Standards for the Single European Market

We play an important part in helping to create a large, unified European market by providing the Harmonised Standards by which manufacturers can demonstrate that their products comply with an EC Directive. This allows them to be placed on the market or put into service. By the end of 2016, we had delivered 121 of the new or revised Harmonised Standards required to support the new Radio Equipment Directive, and work was well advanced on the others.

This annual report looks back at our achievements in the last 12 months. But, since so much of our work in 2016 involved exploring new possibilities, there is a very real sense in which it looks forward to the future too.

# New Beginnings

## Long-Term Strategy 2016-2021

In November 2016, the General Assembly approved our new Long-Term Strategy 2016-2021, aimed at expanding our portfolio, improving the visibility of our work and positioning ETSI within a European and global context.

We aim to maintain and strengthen our strategic position at the heart of digital standardisation, as an enabler of standards, with a global reach, a versatile approach and involving all stakeholders in our work.

## From Research to Standards

Early standardisation in the development of a technology or a product can be crucial to its market success. Standards activities can help bridge the gap between research and industrial development of products and services by facilitating the commercialisation of research results. At the same time, R&D can also trigger new standardisation activities and enable us to ensure that standards are in place when they are needed.

In 2016 we therefore continued to cultivate close relationships with academic institutions, we took part in relevant conferences and other events where project results were presented and we supported the exchange of information between researchers and the standardisation community. We maintained contact with European Technology Platforms, Public Private Partnerships and Joint Technology Initiatives, as appropriate, and we participated in European Commission (EC) funded projects. Our aim is to identify candidate technologies for standardisation and to support stakeholders in standards-related activities in areas within our scope.

We defined and implemented new mechanisms to foster close relationships with researchers, so that we could identify new trends and establish appropriate groups to undertake work in new areas. We also set up methods for our technical committees to request support from the research community, for example by expressing a need for pre-/co-normative research. We developed specific publicity material, and we collaborated with National Standards Organisations and Small and Medium-sized enterprises, which are often well-placed to advance specific technologies.

## Facilitating Interaction with Researchers

### Horizon 2020

We continued to monitor activity related to Horizon 2020 (H2020), the EU research funding programme. We participated in relevant projects, as our resources allowed.

In May 2016 we organised a workshop entitled 'From Research to Standardisation' in support of the H2020 research programme. The event provided a platform for researchers to disseminate their project results to our members, and for industrial representatives to gain first-hand access to state-of-the-art knowledge and to identify future trends. Together delegates were able to identify common areas of interest and candidate technologies for further exploitation through standardisation. The main focus was on enabling technology for 5G mobile systems, future network architecture and virtualisation techniques for 5G. The development of four ETSI White Papers was agreed, focusing on topics identified for potential new activities in ETSI: Fog computing, cross-domain orchestration, cross-hauling and tactile networking.

### White Papers

In 2016 we produced four White Papers, on Cyber Security, the Generic Autonomic Networking Architecture, Millimetre Wave Semiconductor Industry Technologies and Next Generation Protocols.

### Workshops

Throughout 2016 we organised numerous workshops, designed to bring communities together, inform about our work and invite input for future activities. Our workshops provide a platform for researchers to share their results and to identify next steps for standardisation. These events also facilitate early consensus-building, stimulate new standardisation activities and fertilise our ongoing technical work.

In 2016 globally recognised annual events included our Intelligent Transport Systems workshop and the seventh annual Machine-to-Machine communications workshop which once again incorporated a oneM2M Showcase. This year, the ETSI Security Week in June comprised an Internet of Things (IoT) Security Workshop, an open meeting of our Cyber committee (TC CYBER) and the Alliance for IoT Innovation (AIOTI) Security and Privacy Workshop. In January, we held a workshop on 'Future Radio Technologies: Air Interfaces', and in March about 120 people attended our workshop on the IoT in the Smart Home.

Other highlights included workshops on Public Protection and Disaster Relief, the fourth Quantum-Safe Cryptography workshop co-organised by ETSI and the Institute for Quantum Computing in Toronto, Canada, and the ETSI International User Conference on Advanced Automated Testing (UCAAT). Our first workshop on next generation radio

for rail, 'Managing Rail Mobile Communications Evolution: On Track for Future Challenges', took place in November. In January, we convened a unique industry information modelling workshop in Louisville, USA, bringing standards bodies and Open Source communities together to accelerate the alignment of their Network Functions Virtualisation (NFV) activities.

## Supporting the Development of New Technologies

### Industry Specification Groups

Our Industry Specification Groups (ISGs) have proved to be a flexible platform to bring together key stakeholders, including non-members of ETSI, to shape the industry. We have already nurtured a number of innovations in our ISGs and the output of some of our earliest groups is now being built upon in other ETSI committees.

In 2016 we established a new ISG on Mobile and Broadcast Convergence to deliver the requirements for media delivery over converged networks.

### Developing the Building Blocks for 5G

We are working to support the development of 5G, both as a partner in the Third Generation Partnership Project (3GPP™) and oneM2M as well as in our own committees. We are also helping to define the requirements for 5G. In 2016, we conducted a comprehensive survey to collect information on all 5G-related activities in ETSI. Some of these activities, such as NFV, Millimetre Wave Transmission and Multi-access Edge Computing, will form the potential building blocks for a 5G system and are considered key components of the next generation of ICT platforms.

Spectrum is a major issue for 5G. We are helping to ensure compatibility between the different uses which may occupy adjacent spectrum and we are looking for ways to improve spectral efficiency by using the latest methodology and advanced techniques for sharing spectrum.

We have already started work on monitoring and controlling power consumption in 5G networks. This will be a crucial factor in the viability of 5G in both economic and environmental terms.

### 5G: From Myth to Reality

In April, we held our annual ETSI Summit on the subject of '5G: From Myth to Reality'. Around 240 participants gathered to discuss the 5G priority use cases of mobile broadband, supporting massive connectivity for the IoT and ultra-reliable/low latency communications.

## Open Source

Open innovation is a major trend in technology development. Working across traditional borders, for example with Open Source communities and foundations, can accelerate the development of new and innovative digital technologies. In 2016 we continued to analyse the differences and similarities between traditional telecommunication standardisation and Open Source, and to examine possible co-operation models, with a view to establishing whether and how our work and our members might benefit from the use of Open Source approaches, methodologies and frameworks in ETSI.

Our Centre for Testing and Interoperability is already making use of Open Source-like software development approaches in the production of test specifications and platforms.

We considered the legal implications of Open Source at a workshop in September.

### ETSI Open Source MANO group

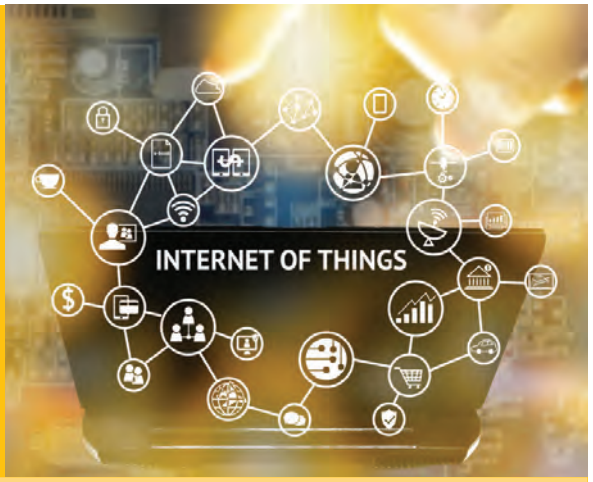
In February we created a new group to develop a software reference implementation (code) for the Management and Orchestration (MANO) of NFV. The ETSI Open Source MANO group (ETSI OSM) uses Open Source working procedures and a software development platform hosted and managed by ETSI.

## Education on Standardisation

We kicked-off an EC-funded project on the design and development of teaching materials for education on ICT standardisation. We conducted interviews about standardisation with standardisation professionals, university academics and researchers in order to identify topics to be taught. The results provided the basis for a table of contents for the teaching materials under development. By the end of the project in June 2018, the plan is to be able to offer several teaching modules to be integrated flexibly as part of curricula for engineers, MBA students and law students.

## Integrating Objects to Create New Networked Services

An ever increasing number of everyday machines and objects are now embedded with sensors or actuators and have the ability to communicate over the Internet. Collectively they make up the Internet of Things (IoT). The IoT draws together various technologies including Radio Frequency Identification (RFID), Machine-to-Machine (M2M) service platforms and Wireless Sensor Networks. Potential applications and services include smart devices, smart cities, smart grids, the connected car, eHealth, home automation and energy management, public safety and remote industrial process control.




Industry analysts estimate that, during 2016, over 6 billion IoT devices were in use worldwide, with that figure set to reach 20,8 billion by 2020. The IoT is changing the way we live and work through new and innovative services. As a result, it offers unprecedented opportunities for creating and commercialising new devices and applications. As IoT devices continue to saturate society, standardisation is key to achieving universally accepted specifications and protocols for true interoperability between devices and applications.

## oneM2M

### ETSI and oneM2M

ETSI is one of the founding partners in oneM2M, the global standards initiative for M2M and the IoT. oneM2M brings together 14 partners including eight of the world's leading Information and Communications Technologies Standards Developing Organisations, as well as representatives of different industry sectors. The European Committee for Standardisation (CEN) and the European Committee for Electrotechnical Standardisation (CENELEC) joined in June, increasing oneM2M's European presence. By the end of the year, membership numbered over 200 companies.

*Further information at: www.oneM2M.org*

oneM2M draws together the many diverse IoT-related business domains including telematics and intelligent transportation, healthcare, utilities, industrial automation and smart homes. The initiative is developing specifications that will enable users to build platforms by which devices and services can be connected, regardless of the underlying technology used, thus enabling interoperability across IoT applications. oneM2M's specifications will thus reduce complexity for the application developer and lower costs for service providers.

Each oneM2M partner standards body publishes oneM2M specifications as its own local specifications, thereby ensuring there is one global set of specifications, recognised in each region. In March 2016, we published the complete set of updated oneM2M Release 1 specifications as ETSI Technical Specifications (TSs). These specifications cover the requirements, the architecture, Application Programming Interfaces (APIs), security and mapping to common industry protocols. The updated specifications incorporate improvements based on early implementation experience as well as the first oneM2M interoperability test specifications. Most importantly, however, the updated standard presents the industry with the first scalable and future-proof platform upon which it can invest and develop IoT applications, without fear of vendor lock-in or the need to commit to one connectivity technology.

By the end of 2016, oneM2M's specifications were being used by a number of independent Open Source foundations and projects, in addition to commercial deployments in Europe, South Korea and elsewhere in Asia, particularly for smart cities and transport systems. oneM2M has made various resources available to support developers implementing oneM2M specifications, including XML code, the oneM2M Application ID registry and an email list to answer technical questions and provide a direct link to the experts who wrote the oneM2M specifications.

Release 2 was published in September. Its 17 new specifications include enhanced security, features for home and industrial deployment and semantic interoperability. They also include interworking with popular IoT device ecosystems, thus greatly increasing the number of devices that can connect seamlessly with one another. In addition, oneM2M provided user-friendly APIs and guidelines for application developers.

Work then began on Release 3 which was expected to be issued towards the end of 2017. This will focus on the use of oneM2M for industrial IoT and will include interworking support for industrial technologies and improved support for 3GPP-standardised mobile IoT technologies such as Narrowband IoT. Smart cities will also be addressed. In addition, Release 3 will include support documentation and tools to assist developers.

oneM2M held two interoperability events in 2016, organised by ETSI and the Telecommunications Technology Association (TTA) of Korea: one in Seongnam, South Korea, in May, based on Release 1 specifications, and the other in November/

December in Kobe, Japan, referencing both Release 1 and Release 2 specifications. They included conformance testing to help participants debug their products.

Promotion of oneM2M's achievements remained an important aspect of its work. Members of oneM2M therefore took part in numerous international conferences and exhibitions throughout 2016. Other communications activities included executive briefings, interviews with key figures in the industry and continuation of the highly successful programme of webinars on the business and technical aspects of oneM2M.

### The ETSI IoT and M2M Workshop

The ETSI IoT and M2M workshop took place in November 2016, focusing on the smart world and smart cities.

The workshop included a one-day tutorial on oneM2M for developers. Various showcases demonstrated oneM2M in action, with commercially available products and services which had already been deployed from across a wide range of IoT application domains. The latest developments in oneM2M Release 2 were also presented, with a particular focus on its support for security and semantic interoperability.

## Smart Appliances

In the future, domestic and industrial appliances will be intelligent, networked smart devices, forming complete energy consuming, producing and managing systems. They will need open interfaces so that they can communicate with service platforms from different energy service providers and allow the addition of new appliances from different vendors, using 'plug and play' connectivity.

In 2016, our Smart M2M committee (TC SmartM2M) extended its specification for SAREF, the smart appliances reference ontology that runs with oneM2M-compliant communication platforms, with input from the energy, the environmental and the buildings domains. SAREF will allow devices in the home to exchange information with any energy management system, whether located in the home itself or in the Cloud. We also completed an investigation into the possible evolution of SAREF, potentially to include non-energy aspects and expanding it in response to feedback received from industry.

In addition, we are developing a complete set of testing specifications for smart appliances.

## Building Smart Cities

We are heavily committed to the development of standards which will form the technology building blocks for smart cities, both as a partner in oneM2M, as well as in our own committees. For example, our Human Factors committee (TC HF) has begun work on a pre-study of the human factors aspects of the services in smart, accessible, sustainable cities and communities.

We are also developing specifications for energy efficiency in smart cities. We have created a working group for sustainable digital multiservice cities to develop standards to support the deployment and roll-out of smart city infrastructures.

An international group was established to develop a consensus framework for smart city architectures. The group, in which we join the National Institute of Standards and Technology (NIST), the American National Standards Institute (ANSI) and the Green Building Council in the U.S., the Republic of Korea's Ministry of Science, ICT and Future Planning, the Italian Energy and Innovation Agency and the FIWARE Foundation, will build upon existing standards and specifications, including the work of oneM2M and TC SmartM2M.

Following the World Smart City Forum in July, representatives of relevant Standards Developing Organisations, including ETSI, met together in August to consider how to align their work to accelerate the deployment of smart cities.

## Other Aspects of M2M

Following the closure of the Home Gateway Initiative (HGI) in June, TC SmartM2M handled the conversion of three HGI specifications into ETSI TSs, using the Publicly Available Specification (PAS) procedure. Published in November, these three TSs cover the requirements specifications for linking SmartM2M devices with Home Gateways.

We also completed a gap analysis, publishing the results in two Technical Reports (TRs). One TR identifies where new standards are needed to support the IoT standards landscape, covering requirements, architecture, protocols, tests and relevant Open Source projects. The other describes use cases and standardisation gaps in relation to European Large Scale Pilots (LSPs).

In November we published a new TR on smart grid systems suitable for utility operations and spectrum requirements, which forms the basis for the development of a System Reference document (SRdoc) on critical infrastructure utility operations.

We joined two new EC-funded projects as a partner when they kicked off in January 2016: UNIFY-IoT, aimed at developing a healthy IoT eco-system, and the ESPRESSO (systEmic Standardisation apPRoach to Empower Smart citieS and cOmmunities) project, where we support standardised integrated communication and data processing for a sector-independent ICT platform in a smart city.

## Wireless Industrial Automation

As part of work to exploit the 5 GHz band, we continued with the development of a Harmonised Standard for radio equipment to be used in the 5,8 GHz band for Wireless Industrial Automation (WIA). We published a new TS on the methods and concepts for a WIA system approach in June.

## eHealth

eHealth offers numerous potential benefits but the success of its implementation relies on the widespread digitalisation of all sectors of society. By ensuring interoperability, standards can assist the development of new eHealth products and the growth of Telemedicine.

In 2016 our eHealth Project (EP eHEALTH) continued to work on a TR describing typical use cases in the eHealth domain and identifying gaps in standardisation. We are also compiling a glossary of terms to clarify the vocabulary used for eHealth issues.

### Body Area Networks

Body Area Networks (BAN) technology uses small, low power devices for health and wellness monitoring, sports training, personalised medicine (e.g. heart monitors) and personal safety (e.g. fall detection). Our Smart BAN committee (TC SmartBAN) is addressing the need for a dedicated technology optimised for BAN.

Work began in May on the updating of our TS on Smart BAN unified data representation formats, a semantic open data model and corresponding ontology, by adding extensions for semantic interoperability. We made good progress with a TR on data representation and transfer, service and application and we began revising our TS on low complexity MAC and routing for Smart BANs, addressing relay and hub-hub communications. Other ongoing work included a new TR to provide a system description for Smart BANs. We verified the performance of the Smart BAN communication system, publishing a new TR on measurements and modelling of the Smart BAN RF environment.

### Medical Devices

Our Electromagnetic Compatibility and Radio Spectrum Matters committee (TC ERM) made good progress revising our Harmonised Standards for wireless medical devices (including ultra low power active implants and medical BAN systems) to address the changes required by the Radio Equipment Directive. Five out of seven of the required Harmonised Standards were published in 2016; the other two were expected to be available early in 2017.

We also began work on a new SRdoc on wideband Ultra Low Power wireless medical capsule endoscopy in the UHF band, finalising the document in November.


## Enabling the IoT

Low Throughput Networks (LTN) is an ultra narrowband radio technology for very low data rates for ultra long autonomy devices. This makes it ideal for connecting objects in M2M and the IoT which need only low throughput connectivity. In 2016 we made good progress with a TR on LTN use cases and system requirements, along with two TSs for the LTN architecture and the protocols for LTN interfaces.

We also continued to enhance the Digital Enhanced Cordless Telecommunications (DECT™) Ultra Low Energy specification, which has been developed specifically for M2M communications.

## Towards a Fully Connected Wireless World

Radio technology is an integral part of our daily lives. We use it for mobile phones, for broadcast radio and television, in Wireless Local Area Network and cordless technology, Global Navigation Satellite Systems (GNSS), Radio Frequency Identification (RFID) and short range devices (SRDs). ETSI creates the standards which define many of these radio technologies and systems.

We also provide the standards which the regulatory authorities in Europe – and elsewhere – use to manage the radio spectrum environment and to ensure safe co-existence between all the systems which compete for use of limited spectrum resources.

## Harmonised Standards and the Radio Equipment Directive

We provide a wide range of Harmonised Standards by which manufacturers are able to demonstrate that their products comply with a European Commission (EC) Directive, allowing them to be placed on the market or put into service. In this way, we play an important part in helping to create a large, unified European market.

The new Radio Equipment Directive (RED), which replaces the Radio and Telecommunications Terminal Equipment (R&TTE) Directive, was applied throughout the European Union (EU) from June 2016. Manufacturers may take advantage of the single European market by complying voluntarily; compliance will become mandatory in June 2017. The RED covers all products that deliberately use radio waves for communication or for determining their position, regardless of primary function. This means, for example, any product which includes a satellite positioning system (e.g. GPS, Galileo), Bluetooth, RFID, Radio Local Area Networks (RLANs) or Near Field Communication functions.

The RED puts specific requirements on the performance of radio receivers that they do not use more of the spectrum than is necessary. For the first time broadcast receivers, equipment operating at frequencies below 9 kHz and radio determination equipment (including GNSS equipment) are included. We provided the EC with an initial work programme listing the new standards and revisions required. It includes revising existing standards and developing new ones for aeronautical, maritime and meteorological radar. (Our work also takes account of the evolving use of the radio spectrum, with increasingly dense use of the SRD bands at 863 - 870 MHz, 2,45 GHz and 5,8 GHz, and work to liberate spectrum for mobile broadband and 5G developments.)

The RED work programme is updated on an ongoing basis and the EC has introduced additional requirements to ensure our Harmonised Standards integrate smoothly with the Standardisation Regulation. This took the total work programme at the end of 2016 to 238 Harmonised Standards. Throughout the year we were heavily engaged in this work and, by December, we had delivered 121 of the new and revised Harmonised Standards required, and work was well advanced on the others.

We are co-operating closely with the European Committee for Electrotechnical Standardisation (CENELEC), in particular in the area of 'smart' or 'connected' devices where the electromagnetic compatibility (EMC) requirements for the base machine need to be reconciled with EMC requirements for the radio elements providing the connectivity. This affects, for example, smart washing machines and other domestic appliances, radio-controlled light bulbs and some industrial machinery. In June 2016 we published a new 'combined equipment' guide, which forms the basis for a new multipart Harmonised Standard which we are developing.

We organised various events to ensure our members – and others – understand the implications of the RED. These included a follow-up '53 shades of RED' workshop in December, on how to place compliant radio equipment on the European market. We also contributed to the development of the draft EC Guide to the RED.

## Managing Radio Spectrum

Our standards also enable administrations to ensure that users can use spectrum as widely as possible. We help the EC and the European Conference of Postal and Telecommunications Administrations (CEPT) to harmonise the use of spectrum throughout the EU and beyond (usually by producing System Reference documents (SRdocs)). In 2016 we produced a set of standards for Reconfigurable Radio Systems (RRS) which have enabled an entire mobile device reconfiguration ecosystem covering technical, security and certification solutions. We assisted the EC in setting up a group to integrate this new technology into the framework of the RED.

We participate in CEPT, the Radio Spectrum Committee and the Radio Spectrum Policy Group (RSPG) to ensure full coherence between radio standardisation and the developing policy framework. In 2016 we contributed specifically to RSPG Opinions on Intelligent Transport Systems, the Internet of Things (IoT) and Programme-Making and Special Events (PMSE).

We continued to maintain our Technical Report (TR) which includes detailed information on spectrum use and an overview of ETSI standards, reports and specifications, together with their applications and relevant frequency bands.

A dominant theme of much of our work on wireless communications involved exploring new ways to meet growing spectrum demand.

## Reconfigurable Radio Systems

RRS – intelligent radio devices which can characterise and act upon their environment – offer an opportunity for the sharing of unused spectrum among multiple services and radio networks. RRS are thus expected to become a key driver in the evolution of wireless communications. Other potential benefits include reconfigurable, flexible and cost effective architectures for wireless devices and the exploitation of synergies between different domains.

In 2016 our RRS committee (TC RRS) completed its work on Licensed Shared Access (LSA), the technology which allows for the co-existence of the original incumbent with a new cellular operator in the same frequency band. We produced a Technical Specification (TS) on information elements and protocols for the LSA1 interface, finalising our work in response to EC Mandate M/512 on RRS.

The RED includes new features such as the use of RRS that affect device certification which were not addressed by the R&TTE Directive. Work progressed well in 2016 with a TS which will define the requirements for the introduction of dynamic recertification mechanisms for reconfigurable radio equipment, thus supporting its reconfiguration after its initial certification and deployment.

With the finalisation of a new multipart European Standard (EN) on mobile device information models and protocols, we completed the framework for mobile device reconfiguration. This framework enables the installation on a device of radio applications which provide modifications to its radio connectivity capabilities (for example, adding LTE™ or Wi-Fi modes). The framework also allows for installed radio applications to be updated, or for new applications to be installed on the device, thus enabling RRS-compatible devices to support future radio access technologies. Such enhanced flexibility makes RRS a critical enabler for next generation Software Defined Radio and Cognitive Radio networks, since it will be possible to upgrade devices with new features on a regular basis.

However, these new capabilities bring new security challenges. A TR on security-related use cases and threats in RRS was therefore published in June, and followed in August by a TS defining the security requirements for RRS and identifying available and required countermeasures to security threats. We began completing our previous security analysis, taking into account additional use cases to produce revised versions of both the TR and the TS. We started mapping existing radio access technologies to the RRS model in order to identify missing security requirements and we began to revise our two ENs on the radio reconfiguration architecture and requirements for mobile devices by adding new security elements.

Building on our work on Radio Environment Maps for intra-operator scenarios, we published a TS on the system requirements for RRS operating in International Mobile Telecommunications-2000 (IMT-2000) and GSM™ bands.

We began to plan for new activities in the area of information management in the heterogeneous environment, including the possible extension of software reconfiguration technology to other network entities such as from mobile to, for example, Mobile-Edge Computing nodes or small cells. We made good progress with a feasibility study into a Radio Interface Engine which will address the efficient acquisition and management of context information and suitable equipment configuration in a heterogeneous radio environment including, for example, satellite, mobile broadband and the IoT.

We also began considering extending our work on LSA to vertical applications such as PMSE, eHealth, factory and process automation and public safety, embarking on a feasibility study into temporary spectrum access for local high-quality wireless networks.

## Broadband Radio Access Networks

In 2016 our Broadband Radio Access Networks committee (TC BRAN) completed two Harmonised Standards for direct air-to-ground communications systems. We revised our Harmonised Standard for RLANs operating in the 5 GHz frequency band, including new technologies and addressing the need for a common sharing mechanism to achieve equal and fair access between various RLAN technologies. We updated our Harmonised Standard on Wireless Access Systems (WAS)/RLAN equipment operating in the 60 GHz band, adding a Listen Before Talk mechanism to ensure co-existence with other WAS/RLAN equipment operating in the same band. We made good progress with a new version of the Harmonised Standard on the use of White Space devices for WAS operating in the 470 - 790 MHz TV broadcast band, which will include improved test methods and updated emission classes.

We began updating our Harmonised Standard on WAS 5,8 GHz fixed broadband data transmitting systems, including receiver parameters and Dynamic Frequency Selection user access restrictions. Work continued on the preparation of three new TRs to support the possible extension of the current 5 GHz frequency allocation for RLANs. We initiated a study into the central co-ordination of RLANs operating in the 5 GHz frequency band.

## Ultra Wide Band

We completed our investigation into the technical requirements, parameters and measurement procedures now required under the RED, in preparation for updating our Harmonised Standards on Ultra Wide Band (UWB), and a TS was published at the beginning of 2016. Based on this work, we produced a new standard on measurement techniques.

We completed new versions of our two Harmonised Standards on tank level probing radar and local positioning radar, and produced two additional TSs on time domain-based peak power for UWB and the RF conformance testing of radar level gauging applications in still pipes.

Four parts of the five-part Harmonised Standard for UWB were completed in 2016; good progress was made with the final part, on UWB on board aircraft. In August we published the third part of a multipart TR on UWB signal characteristics, describing the various UWB regulations in place in different parts of the world.

Work progressed well with two new SRdocs, on UWB in medical applications and on amended mitigation techniques for UWB. Work on an SRdoc on UWB-based vehicular access systems was completed in June.

## Satellite Communications

Satellite technology is an important delivery platform for diverse services such as direct-to-home TV and mobile, high-speed Internet access and location services. It is particularly useful for rural and outlying regions, where it is difficult to deploy other systems on a commercial basis, and therefore plays a key role in ensuring that all European citizens are able to access high quality information services.

In addition to finalising 26 new or revised ENs for compliance with the RED, the primary focus of our Satellite Earth Stations and Systems committee (TC SES) in 2016 was on standards to enable high speed Internet access to fixed terminals or terminals on the move, whether in an aircraft, on board a ship or in a vehicle. We revised our Harmonised Standard for mobile earth stations operating in the 1 980 - 2 010 MHz (earth-to-space) and 2 170 - 2 200 MHz (space-to-earth) frequency bands. Good progress was made with a new EN on GNSS receivers, and we began revising our EN on radio frequency and modulation for the Telemetry, Command and Ranging (TCR) of geostationary communications satellites.

We published guidelines for the use of the Satellite Independent Service Access Point in Broadband Satellite Multimedia and made good progress defining a multi-link routing scheme in hybrid access networks with heterogeneous links, with the aim of delivering a high speed broadband service.

Other work addressed Single-Carrier Frequency-Division Multiple Access based radio waveform technology for the Ku/Ka band satellite service and updating of our technical analysis of spread spectrum solutions for the TCR of geostationary communications satellites.

We also continued with the updating of our TS on GNSS-based location systems, and published new parts related to performance testing and the requirements for location data exchange protocols.

We began to update our multipart TS on geostationary satellite-mobile radio interface specifications for the Third Generation Satellite Packet Radio Service. A TR on the characterisation of antenna performance for geostationary satellite mobile applications was published in April.

We completed an early draft of a TR on the seamless integration of satellite and/or High Altitude Platform Station systems into 5G systems.

## Advanced Mobile Communications Technologies – 3GPP™

### ETSI and 3GPP

ETSI is one of the founding partners of the Third Generation Partnership Project (3GPP), in which we come together with six other regional standardisation organisations worldwide, plus market associations and several hundred individual companies, to develop specifications for advanced mobile communications technologies. Based on the evolution of GSM, which was defined by ETSI, 3GPP has developed the Universal Mobile Telecommunications System (UMTS™), LTE and LTE-Advanced/LTE-Advanced Pro technologies.

3GPP is supported by ETSI's Mobile Competence Centre (MCC).

*Further information at: www.3gpp.org*

Release 13 of the 3GPP Specifications was finalised in March 2016 and the focus then shifted to Release 14. All in all, Release 14 is composed of almost 150 top-level studies and features. Release 14 will benefit from the results of the first concentrated 5G studies. Unlike previous 3GPP technologies, where the radio access specifications have, to some extent, dominated, 5G is likely to be much broader in its scope and will not necessarily be restricted to further developments of 'conventional' cellular telecommunications.

There has been much greater emphasis in recent years on communications between machines than between human beings, which has resulted in the development of different radio technologies for wireless IoT to suit different needs. Some IoT applications require stand-alone, autonomous operation, with very little data transfer and with many minutes, hours or even days between transactions; for these applications, battery life of the order of ten years is sought, so the electronics must be as efficient as possible. Transmission speed is not critical. But for other applications, such as vehicle-to-vehicle automatic collision avoidance systems, very much higher throughput and vastly faster responsiveness is required – perhaps beyond the capabilities of the latest LTE-Advanced Pro technology.

To meet these different requirements, a great deal of research has been conducted into possible new radio ('NR', or 'NextGen') technologies. A study into channel models for frequency spectrum above 6 GHz was completed in June, followed in September by a study into scenarios and requirements for next generation access technologies. Work continued on a study of NR access technology.

By the end of 2016, a number of 3GPP-internal studies were also well advanced, examining layer 1 and higher issues, novel access network architecture, and the co-existence of NR with previous radio technologies, both in 3GPP-licensed bands and in unlicensed bands around 60 GHz.

At the same time, the first set of LTE mission-critical specifications were completed covering voice communication (Push-to-Talk – PTT). The controversial debate over which codec or codecs to mandate was finally solved. New work was started addressing mission-critical video and data communications, which are regarded as vital for modern policing, security and rescue services.

## Mobile Standards Group

Our Mobile Standards Group (TC MSG) provides the regulatory standards needed to support the deployment of GSM, UMTS and LTE networks in Europe. As well as dealing with the transposition of Harmonised Standards from the R&TTE Directive to the new RED, we introduced new work to align our EN on IMT cellular networks with 3GPP Release 13, by adding new parts to cover features such as Narrowband IoT, machine-type communications and new bands for carrier aggregation. This will enable operators to introduce new features in mobile networks, paving the way for the future development of 5G technologies.

## Millimetre Wave Transmission

Millimetre-wave bands (30 - 300 GHz) offer enormous amounts of under-utilised bandwidth, as well as more spectrum for radio transmission than lower bands, and wider channel bandwidth, with fibre-like capacity. As a source of largely untapped spectrum resource, millimetre wave technologies are expected to be a major enabler of future mobile communications.

In 2016 our Industry Specification Group (ISG) on millimetre Wave Transmission (mWT) focused on licensing aspects, more innovative and holistic use of the spectrum (band and carrier aggregation), standardisation of new bands above 90 GHz (W-band and D-band) and the co-existence of different services in the V-band (57 - 66 GHz), with the aim of giving operators the confidence to deploy in an interference-safe environment. We also began work on the applications and use cases of Software Defined Networking as related to mWT.

In May, we organised a workshop on mWT in New Delhi, India. We also published a White Paper providing an overview of the semiconductor industry technologies available for mWT.

## Mobile-Edge Computing

Mobile-Edge Computing (MEC) technology offers IT service and Cloud computing capabilities at the edge of the mobile network, in an environment that is characterised by proximity and ultra-low latency, and provides exposure to real-time network and context information. It enables operators to open their networks to authorised third parties, allowing them to rapidly and easily deploy innovative applications and services for use by mobile subscribers, enterprises and vertical markets, creating a new value chain. However a standardised, open environment is needed to allow the efficient and seamless integration of applications across multi-vendor platforms.

MEC has been identified as a key enabler for the IoT and mission-critical, vertical solutions and is helping to advance the transformation of the mobile broadband network into a programmable environment. It helps to satisfy the demanding requirements for the 5G era in terms of expected throughput, latency, scalability and automation. It also offers additional privacy and security and ensures significant cost savings.

In 2016, our ISG on MEC continued to develop its first release of specifications. Release 1 will focus on the introduction of the concept of MEC, describe use cases, identify an MEC community and provide basic specifications. In March we achieved a major milestone with the publication of three new Group Specifications (GSs), providing a glossary of terms, the technical requirements to enable interoperability and deployment, and a framework and reference architecture to enable mobile-edge applications to run efficiently and seamlessly in a mobile network.

We then began nine new studies related to MEC Application Programming Interfaces (APIs), management interfaces and essential platform functionality, and we made significant progress with a study into MEC in a Network Functions Virtualisation environment. Work continued on end-to-end mobility.

We produced a specification which describes various metrics (e.g. latency, energy efficiency) that can potentially be improved by the use of MEC in both LTE-based and future mobile networks, and work continued on a GS specifying MEC market requirements for multi-vendor eco-systems.

We continued to use Proofs of Concept (PoCs) to demonstrate the viability of MEC implementations, with the results being channelled back into specification activities. By the end of 2016 there were eight approved MEC PoCs addressing different aspects of application.

During the course of 2016, we extended the scope of our work on Edge Computing to include Wi-Fi and fixed access technologies in addition to 3GPP access technologies.

## Standards for Secure, Reliable Communications

Information Security standards are essential to ensure interoperability among systems and networks, compliance with legislation and adequate levels of security. They provide a means for protecting the user and creating a more secure and profitable environment for the industrial sector.


## Cyber Security

The rapid evolution and growth in the complexity of new systems and networks, coupled with the sophistication of changing threats, present demanding challenges for maintaining the security of Information and Communications Technologies (ICT) systems and networks. Security solutions must include a reliable and secure network infrastructure, but they must also protect the privacy of individuals and organisations. Security standardisation, sometimes in support of legislative actions, has a key role to play in protecting the Internet and the communications and business it carries. Our Cyber Security committee (TC CYBER) is addressing many of these issues.

In 2016 we outlined the baseline security requirements for Network Functions Virtualisation (NFV) and related platforms in a Technical Report (TR) on Lawful Interception (LI) and Retained Data (RD) for NFV, and a Technical Specification (TS) on sensitive functions.

We published a TR on protection measures for ICT in critical infrastructures, which will form the basis of a new TS defining metrics for the identification of critical infrastructures.

We published a four-part TR describing the technical measures available to detect, prevent, respond and mitigate damage from different levels of cyber attack. We also began work on a TR on gateway cyber defence, aimed at increasing cyber security by improving technology standards, particularly technology protocols such as the Internet Protocol stack.

A new TS on the security aspects of LI and data retention interfaces was published in April and then updated in October with the inclusion of additional specifications.

We continued to address privacy, in response to European Commission (EC) Mandate M/530 on Privacy by Design. We began work on a practical introductory guide to privacy. Work continued on a new TS on mechanisms for privacy assurance and the verification of Personally Identifiable Information (PII) and we completed a TR on the protection and retention of PII in mobile and Cloud services. We began new work on a TS on the application of Attribute-Based Encryption (ABE) for data protection on smart devices, Cloud and mobile services, and a TS which will specify the standard features needed to use ABE as Attribute Based Access Control. Other ongoing work in this area included a TS on identity management and naming schema protection mechanisms, which will help prevent identity theft and resultant crime.

The most effective security is that which is built in from the beginning – 'security by design' – rather than just bolted on afterwards. We therefore published a TR which provides a high-level structured ecosystem of security design requirements for communication and IT networks and attached devices.

We completed a TR on methods for exchanging cyber-threat information in a standardised and structured manner, and began work on a new specification for an interface to enable a trusted domain to perform sensitive functions coming from another domain. Work continued on the updating of our two-part TS on methods and protocols for security, addressing countermeasures and Threat, Vulnerability and Risk Analysis methods.

We introduced new work on the implementation of the EU's Network and Information Security Directive, which was published in July 2016 with the intention of increasing consumer confidence and maintaining the smooth functioning of the European internal market.

## Smart Cards

In 2016 our Smart Card Platform committee (TC SCP) began work on use cases and requirements for a next generation Secure Element (SE). As part of our work, we will consider improvements to the existing physical/electrical interface, the logical interface and the potential definition of new interfaces for removable and non-removable SEs. New data structures capable of handling large amounts of data in a secure way will be required, as well as an optimised configuration for the Internet of Things (IoT).

We enhanced the requirement specification for the embedded UICC (eUICC) with the addition of local management for profiles.

We made good progress with the specification of a technical solution to meet the requirements identified for an eUICC, completing the first version of a TS on the physical, logical and electrical characteristics of the eUICC. To achieve interoperability between eUICCs issued by different providers, we approved a profile specification of the eUICC which specifies the format to be used for the Profile Package that is loaded into an eUICC. This means that the same structure is used on all eUICCs for data, including subscriptions, ensuring the interoperable management of such data.

We upgraded several existing test specifications to cover new releases of the respective core specifications and reviewed a large number of existing test descriptions to take into account experience gained in the field. This included updating of the test specifications for the support of the UICC as a mobile contactless SE.

To increase interoperability and avoid proprietary implementations, there is a need to standardise the interaction between the Near Field Communication (NFC) controller, the UICC and other (secure) elements, particularly the routing of data to a specific application (in any one of the secure elements) without user interaction being required at the time of the contactless transaction. The technical realisation of the requirements for the support of multiple contactless Host Controller Interface hosts was carried out in close co-operation with GlobalPlatform and the NFC Forum to achieve a harmonised approach. We completed our part of the work in 2016, ensuring that legacy UICC applications still work in a device implementing Host Card Emulation. The findings of the three organisations were expected to be published as a joint white paper early in 2017.

We continued to maintain the application identity register for smart card applications on behalf of various other organisations.

## Electronic Signatures

In 2016 our Electronic Signatures and Infrastructures committee (TC ESI) completed its work in response to the EC mandate on Electronic Signature Standardisation, M/460, publishing all the outstanding specifications required. M/460 aimed to achieve mutual recognition and the cross-border interoperability of electronic signatures throughout Europe by providing a Rationalised Framework for electronic signature standardisation.

Our European Standards (ENs) include a series of six new standards and four revised ENs on security and policy requirements which will be used by conformity assessment bodies to audit Trust Service Providers (TSPs) and assess their conformity with relevant requirements of the 'eIDAS Regulation' on electronic identification and trust services for electronic transactions in the internal market. These standards also form an audit scheme recognised by the CA/Browser Forum for certification authorities issuing certificates for website authentication.

The majority of the standards, however, relate to the creation and validation of digital signatures to support various types of electronic signatures and seals. The well-known signature formats, CAdES, XAdES, PAdES, and the signature container format, ASiC, have now become ENs.

We updated our TR which describes the general structure for the standardisation of digital signatures and outlines existing and potential standards for such signatures, and we provided guidance documents and test specifications for interoperability and conformance testing.

Other work in 2016 addressed cryptographic suites, long term preservation, and a signature validation policy for European qualified electronic signatures/seals using trusted lists.

Work was initiated on Electronic Registered Delivery Services and Registered EMail (REM) services.

We also began work on three new specifications related to signature validation reports and TSPs providing AdES digital signature validation services. We made good progress with enhancements to the CAdES and XAdES signature formats to support the Evidence Record (ERS and XMLERS).

A new TS on PAdES document time-stamp digital signatures was published which specifies a type of PDF digital signature using a document time-stamp to prove the integrity and existence of a PDF document.

We worked as a partner in the Electronic Simple European Networked Services (e-SENS) Large Scale Pilot Project, with the goal of developing a European solution for eJustice, eID, eDelivery and eSignatures.

## Lawful Interception and Data Retention

Lawful Interception and Retained Data (RD) play a crucial role in helping law enforcement agencies to investigate terrorism and serious criminal activity.

In 2016 our Lawful Interception committee (TC LI) continued to update our LI and RD standards, specifications and reports in line with the latest developments. This included our TS on the handover interface for the request and delivery of RD and the seven-part TS on the handover interface and service-specific details for Internet Protocol (IP) delivery.

We began new work on an interface for communication among Law Enforcement Monitoring Facilities to support (as a minimum) European Investigation Orders related to LI and/or RD, which will include the handling of real-time and stored data transfer.

We produced, and later in the year revised, a new specification which defines a specific electronic interface between two systems for warrants for the exchange of information relating to the establishment and management of LI.

We made good progress with a new specification for an internal network interface X1 for LI-related messages over Handover Interface 1 (HI1), which will cover wide area connections between LI systems and, depending on the network, several network elements from different vendors. We began work on two new specifications for interfaces X2 and X3 for messages to HI2 and HI3 respectively.

We updated the specification defining a dictionary of common parameters. Other issues addressed in 2016 included the security of LI and data retention systems and the dynamic triggering of interception.

Work continued on the development of two new Special Reports: one will provide a guide to LI and RD standards and concepts and the other will offer guidance on LI for LTE™ in the form of Frequently Asked Questions. Other ongoing work included the LI requirements of NFV, and updating our specification for an LI interface for Terrestrial Trunked Radio (TETRA).

## Security Algorithms

Our Security Algorithms Group of Experts (SAGE) is universally recognised for its work on authentication and encryption mechanisms for different technologies. In 2016, SAGE developed new General Packet Radio Service (GPRS) algorithms to support 'Extended Coverage GSM' (an adaptation of 2G for more efficient service to the IoT). The new algorithms (GEA5 for encryption, and GIA4 and GIA5 for integrity protection) were delivered to the Third Generation Partnership Project (3GPP™), with publication anticipated early in 2017.

## Quantum-Safe Cryptography

The emergence of the quantum computer will present a serious challenge to current cryptographic techniques. Previously secure encrypted information, including, for example, bank account details, identity information and military security, will become subject to discovery and possible misuse. New 'quantum-safe' cryptographic techniques have emerged in recent years that provide protection against quantum threats. Our Industry Specification Group (ISG) on Quantum-Safe Cryptography (QSC) is assessing the current situation with regard to QSC and developing specifications for the transition to quantum-safe ICT applications.

In 2016, we completed our first Group Specification (GS) which describes a quantum-safe algorithmic framework. Good progress was also made on a Group Report (GR) which will provide a quantum-safe threat and risk assessment for real-world use cases. Work continued on QSC case studies and deployment scenarios, and on the limits of quantum computing. New work was introduced on quantum-safe key exchanges and quantum-safe signatures.

The fourth QSC workshop organised jointly by ETSI and the Institute for Quantum Computing of the University of Waterloo, Canada, was held in September in Toronto, Canada.

To help industry plan its investment in QSC, and governments and industry to decide their funding to academia, we began to explore the possibility of establishing a longer-term roadmap through a series of workshops where participants can share their ideas and devise a workable plan.

TC CYBER produced an ETSI Guide (EG) on the impact of quantum computing on ICT security. Interest in our QSC work has grown since ISG QSC was established and we now have sufficient support to justify the development of normative specifications. Discussions therefore began at the end of 2016 with a view to transferring the ISG's activities into mainstream ETSI standardisation in a new working group within TC CYBER.


## Other Aspects of Security

We contributed to the work of 3GPP on the requirements for critical communications security, and updated the management rules for TETRA algorithms.

Our ISG on Quantum Key Distribution (QKD) completed a specification on the characterisation of optical components for use in QKD systems and began to revise its specification on the properties of the components and internal interfaces of QKD systems. Other ongoing work included protection against Trojan horse attacks and QKD deployment parameters.

Our ISG on Information Security Indicators (ISG ISI) launched a second phase of work in 2016. This will involve developing an ISI-compliant measurement and event management architecture for cyber security and safety to enable communication between diversified detection tools, guidelines for building and operating a secured security operations centre, and a description of a comprehensive security information and event management approach involving all stakeholders. We also began updating our Key Performance Security Indicators for evaluating the maturity of security event detection, with the addition of application examples.

**The ETSI Security Week**

Now in its second year, the ETSI Security Week took place in June 2016 and attracted some 140 delegates. The week consisted of a three-day IoT Security Workshop followed by an open plenary meeting of TC CYBER and the Alliance for IoT Innovation (AIOTI) Security and Privacy Workshop.

## Technologies for a Better Life

While technological progress has improved the way we communicate for both social and business purposes and opened up exciting new opportunities, we are careful to minimise any adverse social consequences. Part of our work involves making products and services simpler to use, safer and more efficient.

We are also committed to identifying energy efficiency solutions that mitigate the impact on climate change of the growing use of Information and Communications Technologies (ICT). The ultimate goal is to ensure that ICT improve the quality of life for all.

## Energy Efficiency for ICT

Much of our work on energy efficiency supports European Commission (EC) policies, regulation or legislation and we work closely with the European Committee for Electrotechnical Standardisation (CENELEC) in the development of relevant standards.

For example, in 2016 we continued to develop standards for reducing the eco-environmental impact of ICT equipment, in support of EC Mandate M/462 on energy efficiency in fixed and mobile information and communication networks. Our Environmental Engineering committee (TC EE) made good progress with three new European Standards (ENs) for energy efficiency Key Performance Indicators (KPIs) for servers, for Radio Access Network equipment and for the application of Network Functions Virtualisation (NFV) in ICT networks.

Our Access, Terminals, Transmission and Multiplexing (TC ATTM) committee continued with its work on 'Global KPIs' to support the deployment of eco-efficient networks and sites and to monitor the energy management of deployed broadband. When completed, these KPIs (ETSI Standards (ESs) and Technical Specifications (TSs)) will describe the best practices, most efficient equipment and solutions to build sustainable operational networks, sites and data centres. They will provide ICT users with tools to monitor the energy management of networks and sites in full compliance with the Kyoto Protocol on climate change and the reduction of greenhouse gas emissions. We began work in September on a new TS in the series, which will define the main KPIs for green smart cities and outline the standards which will be needed to improve the efficiency and sustainability of the cities of the future. We also began upgrading our ESs and TSs, with the aim of publishing them as ENs by 2018, in time to support potential new European legislation related to the development of efficient ICT products and components.

We submitted to the EC our proposed programme of work in response to Mandate M/543 on material efficiency.

By the end of 2016, we had approved a new EN on the ecodesign requirements for network standby mode for household and office equipment, in support of EC Mandate M/544.

We continued to revise our two-part ES on the measuring of the energy efficiency of wireless access network equipment, completing the part on radio base stations in static traffic load; work continued on dynamic traffic loads. Revision of the ES on the energy efficiency of mobile networks continues on an ongoing basis to take account of the evolution of the network. We made good progress with a new Technical Report (TR) describing best practice in assessing the energy performance of future radio access network deployment. We also began work on two new TRs: one on studies into methods and metrics to evaluate energy efficiency for future 5G systems and the other on energy estimation methods for mobile networks based on a statistical approach.

Recognising that traditional measurement methods for energy efficiency are not suitable for NFV, work continued on an ES to define appropriate methods, and we began to extend our ES on the 'Green Abstraction Layer' to NFV applications.

By the end of 2016, we had completed a final draft of an ES defining standardisation terms and trends in energy efficiency. A new TR on the circular economy was also completed and we published a TR on testing methodology for equipment capable of dynamic performances adaptation. We began to revise our ES on measurement methods for the energy efficiency of router and switching equipment, including a new method to simplify testing.

Throughout 2016, we continued in discussion with the Alliance for Telecommunications Industry Solutions (ATIS) with the goal of aligning our respective methodologies for the measurement of energy efficiency in ICT products and networks.

Ongoing work included revisions of the ENs for environmental classification and tests for telecommunication equipment, and our multipart EN on test methods for storage, transportation and equipment installed in weather-protected and non-weather-protected locations.

We began work on liquid cooling for ICT equipment and we embarked on a study into test methods and the test severity of mechanical aspects for equipment installed on poles and towers.


Work progressed well on our series of standards on the alternating current interface for ICT equipment connected to a 400V DC source, and with revisions to the standards for equipment powered by 48V DC. We began work on a new ES on the management of the migration of telecommunication site installations from existing -48 V DC power distribution to the new 400 V DC, and on a TS on the impact on the ICT equipment architecture of multiple AC or 400 V DC power inputs.

In December we published a new ES on the colour and marking of DC cables and connecting devices – the first international standard on this subject – which will simplify the installation of equipment and improve both safety and efficiency.

We began work on three new TSs on the evolution of battery technology for use with stationary ICT and telecommunication equipment. This work will have implications for smart cities and other applications which rely on batteries used in conjunction with alternative power sources.

A position paper on the general rules for managing the end of life of ICT equipment, developed by our Industry Specification Group on Operational energy Efficiency for Users (ISG OEU), was published in January. Based on this, we began work on a new nine-part EN on broadband deployment and lifecycle resource management for the end of life of ICT equipment.

We continued to develop our multipart TS on broadband deployment and energy management. In particular, we completed the final draft of a new subpart on city individual terminals, which will ease the deployment of smart new services such as IP networks in digital multiservice cities.

Work continued on a series of TSs on the general engineering of networks and sites.

ISG OEU made good progress on the measurement of energy consumption in memory units, and we published a Group Specification (GS) on information technology servers. Work continued on the deployment of fire extinguishing and alarm systems in ICT sites.

We made good progress with a global KPI named Data processing Communication Energy Management (DCEM), which will be used for monitoring data centres. Work continued on a specification which will define global KPI modelling for green smart cities. We began new work aimed at defining useful ICT services for the management of sustainable intelligent cities and KPIs for smart cities. We started new work on KPIs for the level of ICT energy required for different industrial sectors, and on the operational sustainability management and monitoring of the ICT carbon footprint.

We initiated a report on functionalities in various domains including smart buildings, digital industry, the management of smart cities and smart connected vehicles in the city, in preparation for a forthcoming Plugtests™ event on Smart Energy Management Systems. We also began work on a position paper on the interoperability of networking equipment manufactured by different vendors, for use in the organisation of a Plugtests event on plastic optical fibre digital communications.

We published two TRs on the environmental impact of satellite broadband networks.

## Access for All

One of the goals of human factors research and development today is to find innovative approaches to extend digital inclusion. Increasing the uptake and use of new technologies can benefit both individual members of society and industry.

In 2016 our Human Factors committee (TC HF) finished its work in response to EC Mandate M/473 on the inclusion of 'Design for All' in relevant standardisation initiatives. Considerable effort went into implementing best practice in our creation and distribution of electronic documents and in making our meetings and minutes accessible to all.

We continued to address the needs of users with cognitive disabilities when interacting with ICT systems. We published a TR which identifies the functional needs of people with cognitive and learning disabilities (including dyslexia and dementia). We also published an ETSI Guide (EG) which contains recommendations for the design and development of applications, services and devices to enable the elderly and users with learning disabilities to exploit the potential of user interfaces and mobile technologies.

We initiated work on a new EG on device and service terminology.

We began a pre-study of the human factors aspects of the services in smart, accessible, sustainable cities and communities.

In December, we began to prepare a work programme in response to the European Union's new Directive on the accessibility of the websites and mobile applications of public sector bodies.

In 2016 our Special Committee on Emergency Telecommunications (SC EMTEL) worked on various aspects of emergency calling and alerting messages for users with special needs.

## Media Quality and the User Experience

Our Speech and Multimedia Transmission Quality committee (TC STQ) continues to address the growing demand for wideband and 'super-wideband' (bandwidth up to 14 kHz) speech communication and multimedia in hands-free and video phone applications. In 2016 we revised our TR on speech samples and their use for Quality of Service (QoS) testing, in order to include guidance on super-wideband.

Work progressed well on a revision of our four ESs on the transmission requirements for narrowband and wideband wireless terminals (hands-free/handset and headset), aimed at optimising end-to-end quality. We updated our ESs on the transmission requirements for narrowband Voice over Internet Protocol (VoIP) terminals.

We continued to revise our multipart TS on the QoS aspects of popular mobile services to reflect the latest developments in mobile telecommunications.

We updated various documents related to background noise, terminal testing and QoS parameters. We continued to develop a TR on bandwidth calculations and prioritisation in VoIP systems.

We continued work on a new TS aimed at improving listening quality for people with impaired hearing.

Work also continued on a new TS on evaluating the performance of wearable devices for speech communication, and we started work on a new TR on the status of technical aspects of net neutrality, including broadband access aspects.

We published a TS which defines the minimum requirements for detecting emotions in the measurement of telecommunication applications, with the aim of improving subjective testing.

We began new work on mobile communications which will include a specification on the QoS aspects of mission-critical applications, along with a framework for multi-service testing and reports on the QoS aspects of Wi-Fi off-loading and Voice over Wi-Fi and services related to the Internet of Things (IoT), 5G and video.

Our User Group works with our other committees to ensure the needs of users are considered. In 2016 the group continued its work on a Special Report (SR) on users' needs in relation to the IoT and a TR on the evaluation of reference values for the quality of ICT services, with the aim of helping users select the most appropriate supplier.

## Safety

Our Safety committee (TC SAFETY) continued to monitor developments in electromagnetic fields (EMF), electrical safety and safety in cable television systems, and continues to work with CENELEC on the updating of EMF standards for the Radio Equipment Directive.

## Connecting Devices in the Home and Office

The variety of devices that need to be interconnected is growing rapidly and most require broadband. The new services being developed are creating a 'Connected Home' and a 'Connected Office'.

Our standardisation for home and office focuses on three aspects: home and office wireless, home and office interconnection, and home and office requirements, including Quality of Service (QoS) and security.

## Cordless Voice and Broadband Communication

Our Digital Enhanced Cordless Telecommunications (DECT™) specification is still the leading standard globally for digital cordless telecommunications, with over 1 billion devices installed worldwide, but in 2016 the main focus of our DECT committee (TC DECT) was the continued enhancement of the specification to include Ultra Low Energy (ULE) products.

ULE is a new networking technology for residential and building applications. It enjoys all the advantages of the DECT spectrum and technology but has been developed specifically for the Internet of Things, with potential applications in home automation and energy control such as remote switches, the control of smart appliances, smart metering and temperature controls, security, alarms and eHealth applications. DECT ULE offers low power consumption, making it ideal for battery-operated devices and Personal Area Networks, as well as good QoS and wider coverage than competing technologies.

In 2016 we updated our two-part specification for Phase 1 and 2 of DECT ULE, adding the No-Emissions Mode (NEMo) and more functionality for operation with repeaters. A new version of the European Standard (EN) on repeaters, which now includes ULE, was completed.

Considerable effort went into revising our existing Harmonised Standards to take account of the introduction of the new Radio Equipment Directive.

We began new work on a Technical Report (TR) on the future of DECT, which will involve collecting requirements for the evolution of the technology and studying implementation possibilities, such as, for example, for low latency or higher bit rates, possibly using Orthogonal Frequency-Division Multiplexing and Multiple-Input Multiple-Output (MIMO).

In December we established a new working group to consider the use of Ultra-Reliable and Low Latency Communications for streaming and periodic as well as aperiodic traffic profiles.

## Powerline Communications

Our Powerline Telecommunications committee (TC PLT) has been addressing the co-existence of Digital Subscriber Line (DSL) modems and powerline telecommunications (PLT) at customers' premises to preserve the high throughputs of DSL technologies. In May we published a Technical Specification (TS) for co-existence processing recommendations to avoid interference between Very-high-bit-rate DSL 2 (VDSL2) and PLT. Work continued on a test specification for co-existence mechanisms between PLT and VDSL2/the G.Fast Recommendation.

To ensure continued protection for utility companies and customer information, we revised our TS on the Open Smart Grid Protocol to include updated security requirements.

### PLT and Premium TV Services

We have been addressing the transportation of video over powerlines, in response to the advent of 4K video streaming and video on demand services for Ultra High Definition (UHD) television and new advances in technology which rely on high performance PLT modems. We began work on a new TS which will define the transcoding of High Definition and UHD video over powerline networks, with the aim of improving network coverage.

# Transportation

## Bringing the Power of ICT to People on the Move

Information and Communication Technologies are revolutionising the transport sector, increasing efficiency, reliability and safety and reducing energy consumption. ETSI supports road, railways, aviation and maritime transportation with activities which are carried out by key industry players and therefore reflect true market demand.

## Road Transport

In the very near future, vehicles on our roads will interact directly with each other and with the road infrastructure through 'Co-operative Intelligent Transport Systems' (C-ITS). C-ITS allow road users and traffic managers to share and use information and to co-ordinate their actions. C-ITS are expected to significantly improve road safety, traffic efficiency and the comfort of driving. Communication between vehicles, infrastructure and other road users can also increase the safety of automated vehicles and their full integration into the overall transport system.

To achieve the target for the full-scale deployment of C-ITS-enabled vehicles in Europe in 2019, co-ordination is urgently needed at the European level, and standardisation has a key role to play in this. Our Intelligent Transport Systems committee (TC ITS) is leading the drive to achieve international standards to accelerate the introduction of ITS services and applications.

Security is central to C-ITS. In response to the findings of the European Commission (EC) C-ITS Deployment Platform, in 2016 we began new work on certification and security, updating our existing security standards to take into account ongoing work and developing EU policies and regulations. The change rate of ITS security credentials is a crucial parameter for the protection of privacy. We therefore began a pre-standardisation study into pseudonym change strategies. We also embarked on a pre-standardisation study into the detection of malicious behaviour.

We continued to fine-tune our C-ITS Release 1 standards in response to standards development and feedback from early deployments.

The major work of 2016, however, focused on initial studies for Release 2 and preparation for automated driving. Release 2 will address new features and functionalities anticipated in future C-ITS to deal with more complex use cases and the interests of a larger group of stakeholders. We made good progress with pre-standardisation studies into Co-operative Adaptive Cruise Control and the use of C-ITS to protect vulnerable road users such as cyclists and motor cycle riders. Work continued on additional studies into multi-channel operations and platooning.

Work continued throughout 2016 on a Technical Specification (TS) on the Collective Perception Service which will enable sensor information to be shared between road users. We published a new part for our TS on infrastructure-to-vehicle communications, to support communications for the Tyre Pressure Monitoring System, and we made good progress with a two-part TS on the facilities layer function.

We introduced new work on the possible use of the C-ITS architecture and vehicle-to-everything (V2X) communication technology to reduce the environmental impact of transport and improve pollution control.

We began new work to improve the radio characteristics of the Transport and Traffic Telematics Dedicated Short Range Communication link.

In response to EC Mandate M/453 on C-ITS, we continued to develop conformance tests and to update our existing specifications.

In November, in partnership with ERTICO, we organised the fifth C-ITS Plugtests™ event, in Livorno, Italy, at which ITS infrastructure vendors were able to test the interoperability of ITS equipment by deploying Roadside Units in the port and along the highway, connecting them to the highway control centre.

We organised the 8th ETSI ITS Workshop in March.

Our Electromagnetic Compatibility and Radio Spectrum Matters committee (TC ERM) addressed the spectrum needs of ITS and initiated work on a new System Reference document (SRdoc) on smart tachograph weight and dimension applications in the 5 GHz band.

### Automotive Radar

TC ERM also completed a new European Standard (EN) on measurement techniques for automotive and surveillance Short Range Radar equipment using the 24,05 - 24,5 GHz or 76 - 81 GHz bands.

### Wireless Power Transmission

We published an SRdoc on wireless power transmission for electric vehicles and began work on a new SRdoc on wireless power transmission. Work continued on a new Harmonised Standard on wireless power transmission.

## Aviation

Our main aeronautical work in 2016 related to the Radio Equipment Directive (RED) and the need to address the standardisation of communications, navigation and surveillance equipment, such as radar, aspects of which were not covered under the Radio and Telecommunications Terminal Equipment Directive. This work included updates to existing standards for meteorological aids, for Ground Based Augmentation System VHF ground-air data broadcast, and for ground-based VHF/UHF radio transmitters, receivers and transceivers for the aeronautical mobile service.

In addition, we published revised versions of our TS and our EN for mobile communication services on board an aircraft, which now include the Universal Mobile Telecommunications System (UMTS™) and LTE™ as well as the original GSM™.

We revised our Harmonised Standards on the Advanced Surface Movement Guidance and Control System for air traffic management equipment, and made good progress with a new part on multilateration equipment. We completed a new version of the Harmonised Standard for VHF Digital Link Modes 2 and 4.

Work progressed well with an EN for heli-borne obstacle detection radar equipment. Development of three new ENs on surveillance radar continued, and we started work on four Harmonised Standards for meteorological radars and air traffic control surveillance.

We also began work on a Technical Report (TR) on the use of professional unmanned aerial systems in Europe for civil use such as by film crews, for aerial surveys and by the police.

## Rail

In 2016, our Rail Telecommunications committee (TC RT) continued to maintain the GSM-R (GSM for railways) standard, and began to look at standards for the Next Generation of Radio for Rail (NG2R). We initiated new work to align the requirements for GSM operation on railways with 3GPP Release 99.

We published TSs related to General Packet Radio Service (GPRS)/Enhanced GPRS requirements for the European Train Control System, on the detailed requirements for GSM operation on railways, and on the commands necessary for the operation of mobile radio systems on railways. We continued to work on the incorporation of Internet Protocol into the core network and interface specifications, updating our TS on the use of Session Initiation Protocol (SIP). By the end of 2016, we had completed a stable draft of a new TS on the Short Message Service using Functional Addressing in a roaming environment.

We completed a study into the feasibility of operating C-ITS and Communication Based Train Control systems in the same frequency bands, publishing a TR in May. A revised version, taking account of further feedback from the ITS community, was published in September.

In the context of the Future Railway Mobile Communication System (FRMCS), we embarked on a study of the next generation end-to-end system architecture for rail transportation supporting multiple access technologies. At the same time, we collaborated with 3GPP and the International Union of Railways (UIC) on the definition of use cases for the FRMCS, and we completed an SRdoc on its spectrum requirements.

Other ongoing work included resolving interference issues with public systems and a feasibility study into radio performance enhancements and resource optimisation.

We organised a workshop on ‘Future Radio for Rail Transport’ in November.

In the spectrum area, work continued on an SRdoc on GSM-R networks evolution which will involve an investigation into the use of dedicated land-mobile spectrum in the 400 MHz or 700 MHz bands.

## Maritime

In addition to revising nine Harmonised Standards in the maritime area in line with the RED, TC ERM produced a new EN on fixed and portable VHF equipment operating on 121,5 MHz and 123,1 MHz.

Work continued on the use of Digital Selective Calling in the maritime mobile service, for low power personal survival locating devices, radar equipment used on non-SOLAS vessels, navigation radar for inland waterways, VHF coast stations, maritime VHF for Global Maritime Distress and Safety Systems, and UHF on-board communications systems and equipment.

We began new work on maritime mobile transmitters and receivers and radiotelex equipment.

## Satellite Communications

In 2016 our Satellite Earth Stations and Systems committee (TC SES) focused on standards to enable high speed Internet access to fixed terminals or terminals on the move, whether in an aircraft, on board a ship or in a vehicle. We completed a Harmonised EN for fixed and in-motion Earth stations communicating with non-geostationary orbiting systems in the Ku band.

## Facilitating Content Consumption Whatever the Platform

The Internet, mobile communications and broadcasting are converging. But the standardisation of these different areas has traditionally followed different paths, so they do not interoperate across the same platforms. We are addressing the urgent need to align the diverse specifications for content delivery in a converged environment supporting Internet Protocol Television (IPTV), Mobile TV and broadcast TV – for the benefit of both the industry and the consumer.

## Broadcasting

Our standardisation of broadcast systems, programme transmission and receiving equipment is dealt with in a Joint Technical Committee which brings us together with the European Broadcasting Union (EBU) and the European Committee for Electrotechnical Standardisation (CENELEC) – JTC Broadcast. More than 95% of inputs to JTC Broadcast are standardised by ETSI, with CENELEC responsible for the standardisation of the functional requirements of radio and television receivers.

In 2016 JTC Broadcast continued to focus on digital broadcasting and was particularly active in Ultra High Definition TV and related areas, interactive TV and radio.

In the audio area, the JTC produced a new Technical Specification (TS) which defines extensions to the Enhanced AC-3 codec to carry object audio in a manner that is backwards compatible with existing channel-based operation. In September a specification was published which defines a consumer object based audio renderer for use with the AC-4 codec in consumer set-ups.

In the area of interactive TV, the committee revised the Hybrid Broadcast Broadband TV (HbbTV) standard which allows the creation of TV services that combine broadcast and over-the-top content, introducing a global open platform as an alternative to proprietary technologies. The updated version of the specification, which corresponds to HbbTV 2.0.1, mainly addresses gaps relative to the ETSI Standard for the MHEG-5 Broadcast profile as used in the UK and the TS on DVB-MHP, as used in Italy. In a separate specification, HbbTV 2.0.1 was extended with broadband discovery, addressing situations in which broadcast signalling does not reach the HbbTV terminal.

The JTC also revised the MHEG-5 Broadcast Profile, mainly to improve understanding of the specification.

In the radio area, the JTC simplified the Digital Audio Broadcasting (DAB) system standard by removing obsolete features and adding clarifications to improve interoperability. Following the general move by broadcasters from the original DAB audio coding to the more efficient DAB+ audio coding, the JTC took the opportunity to remove DAB audio coding from the system standard into a separate TS. Other supporting TSs were revised to ensure consistency.

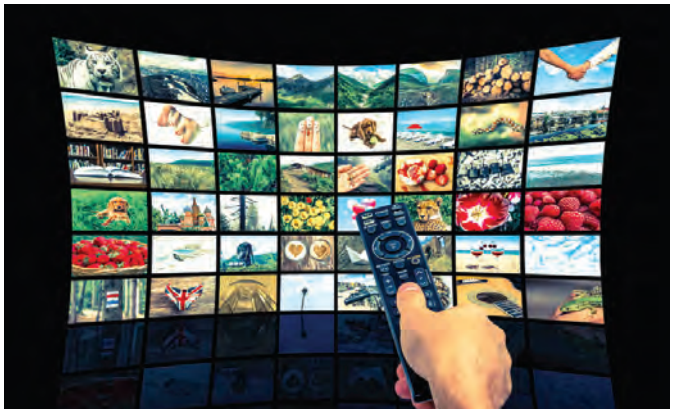
The JTC continued to update its popular Digital Video Broadcasting (DVB) Audio and Video coding specification which describes the necessary audio and video coding schemes to be used within DVB broadcast. The latest version, scheduled for publication in 2017, defines the implementation of the UHD-1 Phase-2 features: High Dynamic Range (HDR), Higher Frame Rates and Next Generation Audio. This specification will be complemented by a new version of the DVB Subtitle Specification and an update of the DVB Service Specification.

The revisions of all of the existing DVB IPTV standards to add support for Internet Protocol version 6 (IPv6) were published.

The JTC completed a new version of the specification for the modulator interface (T2-MI) for a second generation digital terrestrial television broadcasting system (DVB-T2) and implementation guidelines for a second generation digital cable transmission system (DVB-C2).

The JTC specification for Cross Platform Authentication for limited input hybrid consumer equipment was published in April. This allows personalised content on radio and television devices (limited input consumer equipment) to associate an online identity with media devices.

The maintenance of TV Anytime specifications continued in 2016 with an update of the part on metadata schemas.



## Mobile and Broadcast Convergence

Television delivery has traditionally been dependent on broadcasting (one-way, one-to-many delivery networks to fixed TV sets). Today, however, new forms of media consumption dramatically increase the load on mobile networks. Interest is growing in exploring the potential for developing future mobile and broadcasting standards in a more converged way.

Our new Industry Specification Group (ISG) on Mobile and Broadcast Convergence held its kick-off meeting in June 2016 and began work on a general report exploring the deployment and business models of converged networks. We will propose new solutions and use cases to enable future wireless networks to deliver mass market broadcast services to mobile devices more efficiently.

## Content Delivery

### Protection and Rights Mechanisms

Our ISG on the Embedded Common Interface (ECI) for exchangeable Conditional Access (CA)/Digital Rights Management (DRM) solutions (ISG ECI) is specifying a framework for software-based, easy-to-change protection and rights mechanisms for the delivery and consumption of media content on several types of user equipment. The core of the concept is the ECI software interface to which CA/DRM clients can be attached after being downloaded to the device. This will improve substantially the interoperability between services and devices, allowing consumers to continue using equipment and content they have previously paid for, after a move or a change of network provider, or to access content from multiple service providers from the same device.

Throughout 2016, we worked intensively on Part 3 of the core specification, which covers the CA/DRM container, loader, interfaces and revocation mechanisms. Work also continued on security aspects, and on the virtual machine (which will allow multiple clients to run in parallel on the same device).

### Compound Content Management

New production techniques for the creation of film and broadcast content, including HDR and Wider Colour Gamut (WCG), are expected to drive mass market sales of next generation Ultra-HD displays and equipment. However, legacy receivers, including tablets, will comprise the majority of installed receivers for many years to come. To ensure a smooth transition between today's television standards and tomorrow's, a system is needed which allows backwards compatibility while also providing full performance for the next generation of HDR and WCG televisions.

Our ISG on Intelligent Compound Content Management (ISG CCM) is defining a compound content system which allows two or more content qualities or grades to be sent simultaneously and permits the reconstruction of one or more of these in the receiver. This solution provides a scalable and flexible decoder post-processing system for consumer electronics devices to meet the needs of both existing and next generation receivers and set-top boxes without compromising the quality of either.

## Spectrum Aspects

Our Electromagnetic Compatibility and Radio Spectrum Matters committee (TC ERM) continued to address the spectrum aspects of broadcasting, including the needs of Programme-Making and Special Events devices (wireless microphones, in-ear monitors, talk-back links, audio links etc.).

Throughout 2016 we continued to develop Harmonised Standards to support the Radio Equipment Directive in the areas of radio and TV broadcast receivers and amplifiers for broadcast reception in domestic premises, as well as transmitting equipment for Digital Radio Mondiale broadcasting, Terrestrial - DAB (T-DAB), and the FM and AM sound broadcasting service. Work progressed well and a Harmonised Standard on digital terrestrial TV broadcast receivers was published in September; publication of the other standards was expected to follow in 2017.

We published the findings of an analysis of co-existence issues stemming from the European Commission (EC) Digital Dividend Decision, including co-existence between cable television and new LTE™ mobile phones operating in the 800 MHz band. The work was completed at the request of the EC and in co-operation with CENELEC and involved the creation and revision of the Harmonised Standards to control LTE interference with Short Range Devices.

## Fulfilling the Promise of Unlimited Bandwidth

Today's consumers expect communications services to be easily accessible and available everywhere, on whatever devices they are using. Technically, this means networks must converge. We provide a comprehensive set of standards for access network technologies.

## Network Functions Virtualisation

With Network Functions Virtualisation (NFV), standard IT virtualisation technology is adapted to consolidate many network equipment types onto industry standard high volume servers, switches and storage. This involves implementing network functions in software which can run on a range of industry-standard server hardware. This software can then be moved to, or introduced in, various locations in the network as required. The use of NFV simplifies the roll-out of network services, reduces deployment and operational costs and encourages innovation. The technology is being adopted increasingly for network planning, deployment and evolution and has become an essential element of modern network design. NFV promises to deliver significant benefits to service users and providers alike, particularly in the area of emerging 5G networks.

Our Industry Specification Group (ISG) on NFV is creating specifications to enable network functions to be deployed dynamically and on-demand, making organisations more agile in addressing customer needs and the new challenges facing network technologies. The importance of this work is demonstrated by the fact that membership of the group has grown from a small number of influential founders in 2012 to around 300 organisations.

In September 2016, the virtualisation of telecommunication networks moved a significant step closer with the publication of our second release of NFV specifications. Release 2 incorporates 11 new Group Specifications (GSs), in addition to the many NFV specifications already published, and includes our first normative specifications for NFV. Release 2 details the various requirements, interface descriptions and information models which will enable the interoperability of solutions based on the ETSI NFV Architectural Framework. It also outlines the functional requirements in relation to a wide set of functional areas, such as the management of virtualised resources, the lifecycle management of network services and virtualised network functions, network service fault/performance management and virtualised resource capacity management.

By the end of 2016, we had also defined the content of Release 3, the main objectives of which are to provide consistent operational integration with connectivity services, to consolidate security mechanisms and to enable the support of multi-domain scenarios suitable for potential new business models. We extended the remit of ISG NFV for an additional two years to enable it to continue its work.

In January, we convened a major industry information modelling workshop in Louisville, USA, which, for the first time, brought standards bodies and Open Source communities together to accelerate the alignment of their NFV activities. This workshop was the starting point for close collaboration with external groups to ensure that information models are aligned. A second workshop, held in Bonn, Germany, in December 2016, demonstrated the level of co-operation achieved so far.

The use of Proofs of Concept (PoC) demonstrations to validate key concepts continued throughout 2016.

## Shaping the Cloud Environment

In 2016 we completed our work on the Cloud Standards Co-ordination (CSC), presenting the final results of Phase 2 at an open discussion meeting in January. The overall objective of the CSC was to draw up a detailed map of the standards needed to support a series of policy objectives defined by the European Commission, in particular in critical areas such as security, interoperability, data portability and reversibility. In February we published Special Reports on four aspects of Cloud standardisation: users' priorities, the maturity of Cloud standards, security conformance and interoperability, and the relationship between standards and Open Source development.

## Network Access

In the area of fixed radio systems, our Access, Terminals, Transmission and Multiplexing committee (TC ATTM) completed its revision of the Harmonised Standard for point-to-point equipment in line with the Radio Equipment Directive (RED). This work also took into account new system capabilities and the availability of new frequency bands. Work continued on the less urgent Harmonised Standard for point-to-multipoint systems.

We made good progress with a Technical Report (TR) on small cells microwave backhauling.

At the request of the Telecommunications Standardisation sector of the International Telecommunication Union (ITU-T) and the Broadband Forum, ETSI is leading work on the standardisation of Reverse Power Feeding. Version 2 of this Technical Specification (TS) was published in September and we began work on a further revision to refine the specification and take into account feedback from early implementers.

Work on Very-high-bit-rate Digital Subscriber Line 2 (VDSL2) continues on an ongoing basis. In 2016, we began to update our TS on European technical requirements.

Work continued on a new version of the TS on single mode optical fibre systems for home cabling in response to feedback following implementation. New work began to align the content and the terminology of the existing TS on the optical external network testing interface with standards recently published by the European Committee for Electrotechnical Standardisation (CENELEC).

## Cable

In 2016 our Integrated Broadband Cable Telecommunication Networks committee (TC CABLE) completed a TR describing the evolving electromagnetic environment following the introduction of new mobile radio communication services in the UHF 790 - 862 MHz band.

Work continued on measurement methods for the network performance of broadband data services.

We published a TS which provides guidance on the technical requirements for cable equipment with radio interfaces in support of Harmonised Standards being developed in response to the introduction of the RED.

We began work on the performance characteristics of coaxial cables used for RF signal transmission in hybrid fibre-coaxial telecommunication networks.

Work continued on a new ETSI Standard (ES) for home routers which will define a core set of features to enable multiple subscriber devices to gain access to high-speed data services using the Data Over Cable Service Interface Specification (DOCSIS).

## Numbering, Naming, Addressing and Routing

Our Network Technologies committee (TC NTECH) initiated a study into the impact of alphanumeric user identifiers on interconnection scenarios.

## The Transition to IPv6

Upgrading the Internet with the provision of additional public IP addresses is essential to ensure it can keep growing and allow new entrants to join. Internet Protocol version 6 (IPv6) was developed as a replacement for IPv4. It solves the problem of IPv4 address exhaustion, provides enhanced features and enables new Internet services in need of end-to-end connectivity and security.

Our ISG on IPv6 Integration is addressing the transition from IPv4 to IPv6, bringing together stakeholders from all over the world to work on pre-standardisation in a neutral environment, defining requirements and use cases, outlining best practices, gathering support and creating awareness of the impact of IPv6.

In 2016, we made good progress with 15 GSs, liaising with other standards-making bodies around the world to help achieve a global solution. Our output will include specifications outlining the motivation and best practices for the deployment of IPv6 in different areas – enterprise, public safety and the emergency sector. A key GS will describe IPv6, the challenges arising from transition from IPv4 to IPv6 and their co-existence, and then identify best current practices and develop guidelines for mitigating any issues identified.

Other specifications address the use of IPv6 in new technologies, in particular, the Internet of Things (IoT) and Machine-to-Machine communications, Software Defined Networking and NFV, 5G mobile Internet, Cloud computing and smart grids, as well as IPv6 over Time-Slotted Channel Hopping (6TiSCH) technology, privacy and security.

TC CABLE completed a set of Test Descriptions for each of the five IPv6 transition technologies, which provide interoperability and test cases that go beyond compliance and protocol conformance testing to enable the deployment of IPv6 transition technology in operational networks. The specifications address the engineering and end-to-end operational aspects across the whole cable network domain, including home networks, access networks, core networks (edge-to-core), data centres, service centres, transit and peering, network management and monitoring and network security. They thus provide comprehensive support to the cable industry as it makes the transition to IPv6.

## Future Networks

In October, TC NTECH completed a TR on the application of the Generic Autonomic Network Architecture (GANA) reference model to mobile backhaul and core networks. We also initiated a similar activity on the application of the GANA model to fixed broadband access and aggregation networks and completed a TR on the application of the GANA model to ad hoc and mesh networks.

An ETSI White Paper on the GANA reference model for autonomic networking, cognitive networking and self-management of networks and services was published in October.

## Next Generation Protocols

The TCP/IP protocol suite can no longer provide the scale, security, mobility and ease of deployment required for the connected society of the 21st century. Developments in the technology of local access networks (such as LTE™-A, G.Fast, DOCSIS 3.1 and 5G) will not deliver their full potential unless, in parallel, the communications and networking protocols evolve holistically. In 2016, our ISG on Next Generation Protocols (NGP) therefore began work on the future requirements for Internet Protocols. We are developing a series of GSs which will include a summary of relevant technologies, architectures and protocols under research, together with an assessment of their maturity and practicality for implementation to begin by 2020.

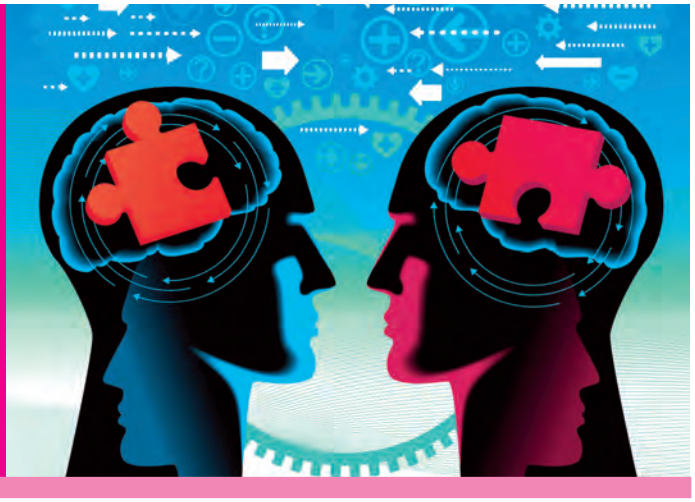
In October, we published our first GS on NGP, defining key scenarios needed to support existing defined next generation use cases. We started work on a new version with additional scenarios immediately.

At the same time, building on this specification, we began defining a GS outlining the requirements for NGP, and a Group Report (GR) identifying and evaluating routing technologies likely to be suitable for NGP. We also began work on self-organising control and management planes, and the evolved architecture for mobility using Identity Oriented Networks.

# Interoperability

## Interconnecting in a Multi-polar World

Interoperability is driven by market demand. It is crucial in a multi-vendor, multi-network and multi-service environment and is one of the reasons why we develop standards. It gives users much greater choice of products, and allows manufacturers to benefit from the economies of scale of a wider market. Interoperability is therefore a crucial factor in the success of modern technologies – especially in the introduction of new technologies.



## An Innovative Approach to Technical Quality and Interoperability

Many years of experience has taught us that integrating validation and testing activities into the standards development process can contribute significantly to the production of interoperable standards and, ultimately, to the release of interoperable products based on those standards. Mutual feedback between the standardisation and the validation and testing processes helps to maximise the quality of both the implementations and the standards. With correct timing, especially in the early stages, validation and testing can also reduce the overall development time of a standard, leading to the earlier placement of interoperable products on the market.

Our technical committees apply best working practices to ensure that our standards are well-specified and testable and thus provide a solid basis for the implementation of robust and interoperable products. We also apply comprehensive validation through Proofs of Concept (PoCs) and interoperability events and we develop conformance test specifications to accompany a significant proportion of our standards.

Our Centre for Testing and Interoperability (CTI) is a centre of excellence, providing hands-on expertise. This includes supporting PoC programmes and organising Plugtests™ interoperability events, the development of test specifications and the application of 'best practice' specification approaches.

In 2016 we continued to apply Open Source-like software development approaches to the production of test specifications and platforms, encouraging feedback from a broad base of users.

## Implementation-Driven Standardisation

We are working with Open Source communities to encourage dialogue and the sharing of practices, with the goal of ensuring that the mutual benefits of well-respected procedures and dynamic innovation can be combined in tomorrow's technologies.

In 2016, we established a new project to develop an Open Source Network Functions Virtualisation (NFV) Management and Orchestration (MANO) software stack. In its first year of operation, the ETSI Open Source MANO (OSM) project provided a regularly updated reference implementation of NFV MANO and feedback to the standards work of our Industry Specification Group (ISG) on NFV.

## Plugtests Events

In our Plugtests events companies can interconnect prototype or production implementations of standards to test for interoperability and, where needed, conformance to requirements. These events provide a highly cost effective and practical way of identifying inconsistencies in either an implementation or the standard itself. Our Plugtests events are often supported by the European Commission (EC).

In 2016 we organised 12 Plugtests events, with varying formats to meet the specific needs of our members and the industries we serve.

### Emergency Communications

In March 2016 we ran a Plugtests event on Next Generation 112 (NG112) Emergency Communications, which has been identified as a potential answer to the increasing requirements and demands of content-rich emergency calling. The event involved a testing campaign based on use cases developed by ETSI and the European Emergency Number Association (EENA) and provided a unique opportunity for vendors of emergency communication equipment to test their products against different implementations and scenarios. The tests were based on the Next Generation 112 Long Term Definition document and standards developed by ETSI, the Third Generation Partnership Project (3GPP™) and the Internet Engineering Task Force (IETF).

In the run-up to the formal roll-out in 2018 of eCall, the in-vehicle emergency call service, we held the 5th eCall interoperability event in November/December. The event was open to vendors of eCall in-vehicle systems, Public Safety Answering Points systems and eCall test solutions.

Interoperability events are becoming increasingly popular for emergency and critical communications; we began planning our first mission-critical Push-to-Talk Plugtests events, with two events foreseen in 2017.

### Intelligent Transport Systems

In our continuous effort to support the rapid deployment of Intelligent Transport Systems (ITS), in partnership with ERTICO, we organised the fifth Co-operative ITS Plugtests event, in Livorno, Italy. We were given access to the port of Livorno and the Florence-Livorno highway so ITS infrastructure vendors could deploy Roadside Units (RSUs) in the port as well as along the highway and connect RSUs to the highway control centre.

### Other Highlights

Our programme also included events on oneM2M, Small Cell LTE™, eSignatures, Time-Slotted Channel Hopping (6TiSCH) mode and the Associated Signature Container as well as a Mobile-Edge Computing (MEC) PoC Zone.

## Test Specifications and Frameworks

In 2016 we completed work on test specifications for Smart Machine-to-Machine communications and created a Specialist Task Force to work on oneM2M conformance testing.

In support of 3GPP, we focused on conformance test specifications for LTE-Advanced features in 3GPP Release 12. This included Frequency Division Duplex - Time Division Duplex carrier aggregation, small cell enhancements (e.g. dual connectivity), power saving optimisations, Wireless Local Area Network/3GPP radio interworking, device-to-device proximity services, and the Internet Protocol Multimedia Subsystem (IMS), especially use of the codec for enhanced voice services. We also addressed the LTE-Advanced-Pro features in 3GPP Release 13, which are required for the Internet of Things (IoT), especially Narrowband IoT, enhanced machine-type communication and extended discontinuous reception.

Interoperability is particularly important to the provision of good Quality of Service and Quality of Experience in complex end-to-end systems such as the IMS running over LTE. Our Core Network and Interoperability Testing committee (TC INT) produces specifications to facilitate the implementation of IP-based networks that can carry both fixed and mobile services simultaneously.

In 2016 we published an ETSI Guide (EG) on testing networks that exhibit some form of autonomic adaptive behaviour, such as NFV, MEC and Self-Organising Networks. We defined, validated and produced various test specifications to support Voice over LTE (VoLTE) and we made good progress with a framework for Internet-related performance measurements.

## Methods for Testing and Specification

Our Methods for Testing and Specification committee (TC MTS) creates standards for testing and specification languages and provides frameworks and methodologies to enable our other committees to produce documents that are easy to understand and easy to use. This work is critical to the market success of numerous technologies.

In 2016 we continued the evolution and maintenance of our enormously successful testing language, Testing and Test Control Notation Version 3 (TTCN-3), along with its tool conformance test suites.

### Test Description Language

However the main focus of our work was the promotion and evolution of Test Description Language (TDL), the new language we launched in 2015 to fill the gap between the simple expression of what needs to be tested, i.e. the test purposes described in prose or the Test Purpose Language (TPLan), and the concrete coding of executable tests with existing test specification languages such as TTCN-3. TDL exploits the benefits of model-based software engineering and offers higher quality tests through better design and by making them easier to review by non-testing experts. It is thus improving and accelerating test development without sacrificing quality. TDL will be used primarily for functional testing, but could also be used for other types of testing.


### The Annual ETSI International User Conference on Advanced Automated Testing (UCAAT)

Organised by ETSI, with the support of TC MTS and the CTI, the fourth UCAAT was held in October 2016 in Budapest, Hungary, and was our most successful ever. The conference is dedicated to application aspects of automated testing including model-based, Cloud, mobile, test methodologies and management and standardised test specifications, focusing on the practical challenges that are often faced by industry.

The programme this year included topics such as 'Internet of Things', 'Cloud and Big Data', 'Mindset for Automation', 'Continuous Integration', 'Advanced Automation', Model Based Testing' and 'Behaviour and Context Driven Development'. The conference demonstrated the popularity of TTCN-3, and recognised the important contribution of TC MTS to its development and use. We also included a tutorial on TDL which was very well attended.

## Mission-critical Communications to Rely on

Communication is a key factor in an emergency situation, whether small incidents such as a man overboard or major natural disasters.


## TETRA

Terrestrial Trunked Radio (TETRA) is the leading technology choice for critical communications users, with 3,8 million terminals in use in 2016 and a projected 5 million by 2020. At the same time, use of the technology in business critical markets such as the transport sector, the commercial sector and utilities increased significantly again in 2016.

To maintain its success, TETRA is evolving towards a fully integrated and seamless Information and Communications Technologies solution, providing narrowband/wideband/broadband wireless communications for mission-critical and business-critical Professional Mobile Radio (PMR) applications. Broadband will be a crucial factor in this, as it can supply the high data speeds required for various key applications including, for example, streaming video from the scene of an incident.

In 2016, our TETRA and Critical Communications Evolution committee (TC TCCE) therefore focused on standardising a broadband extension to the TETRA standard. However, in the medium term most users see a hybrid of critical communications TETRA and broadband networks as the way forward, so we are also looking at methods of integrating TETRA into broadband solutions, and enabling migration from (future) TETRA to broadband.

To minimise the work required and to optimise the standardisation process, the plan is to enhance existing standards for technologies, such as LTE™ and 5G, by the development of interfaces and applications, to make them suitable for mission-critical applications. We are therefore developing an architecture encompassing a range of application layer interfaces to LTE, defined in a set of Technical Specifications (TSs). In 2016 we began to revise the TS which covers the mobile to network interface architecture of a critical communications application operating over a broadband Internet Protocol interface. We also began to look at extending our work to interfaces to 5G. In addition, work is ongoing on the detailed specification for the mobile to infrastructure interface.

We revised our Technical Report (TR) on the user requirements specification on interworking between the Critical Communications Application and TETRA and on migration of services from TETRA to broadband (LTE).

In September we published a new TR on the addition of voice services to the TETRA Enhanced Data Service (TEDS) channels to improve spectral efficiency. We continued to improve the functionality of TETRA Release 1 and TEDS, particularly data functionality.

We made good progress updating numerous existing standards and specifications in response to feedback from manufacturers and users, including 14 documents relating to interworking at the inter-system interface between two TETRA systems. Most of these revisions were completed by the end of 2016. When all the various standards and specifications have been published, we will develop corresponding TSs. This work will simplify the future integration of TETRA into LTE.

Security will continue to be a key issue for critical communications in the future. In 2016 we updated the management rules for TETRA encryption and authentication algorithms. Work continued on a study into security mechanisms for mission-critical broadband systems and we began work on a new TR on the security of interworking between TETRA and broadband critical applications.

## Emergency Calling and Alerting

Our Emergency Telecommunications committee (SC EMTEL) completed its work on Advanced Mobile Location (AML) and a TR was published in March. AML is a system transmitting a caller's location to the Public Safety Answering Point (PSAP) during an emergency call, allowing emergency workers to locate the caller with accuracy as close as 5 metres. This is a significant improvement on the current cell ID localisation, and several handset manufacturers deployed AML in 2016.

The work initiated early in 2015 on Total Conversation – a three-way emergency video call between a caller, a PSAP and a sign language interpreter – was completed with the publication of a TR which provides guidelines for implementation and use.

We published a TR which describes the rules and procedures to implement public warnings, making use of pre-defined libraries that enable the simple and systematic multi-language and multi-mode presentation of warning messages in any European country. We then initiated new work aimed at developing a TS for alerting libraries and a TR outlining implementation guidelines.

In co-operation with the European Emergency Number Association (EENA), we organised the first Next Generation 112 (NG112) Emergency Communications Plugtests™ event in Europe, which was held in March in Sophia Antipolis, France. NG112 offers a potential solution to the increasing requirements and demands of content-rich emergency calling.

Following this event, we began new work on networks dedicated to emergency services. We began preparing a TS which will provide the requirements, the functional architecture, the protocol and the procedures for implementing the Pan-European Mobile Emergency Application (PEMEA). There are presently hundreds of emergency calling applications in use across Europe but their use is constrained to the boundaries of the PSAP with which they are integrated. This TS will make it possible for data to arrive at the most appropriate PSAP, wherever the call is made. A second TS will describe the core elements and corresponding technical interfaces for network independent access to emergency services, and our work will be completed with a TR describing the test cases and scenarios for interoperability testing of the core elements for independent access networks.

Work in response to European Commission Mandate M/493 on the location enhanced emergency call service progressed well in 2016 with the development of protocol specifications applicable to the interfaces of the functional architecture for emergency caller location. This service is intended to cover a situation where different service providers and network operators need to co-operate to determine the location of an emergency caller.

We completed a TS on conformance and interoperability testing for eCall, the in-vehicle emergency call service which automatically relays data about an accident from the vehicle involved to the emergency services.

## Other Public Safety Activities

Our Satellite Earth Stations and Systems committee (TC SES) develops standards for satellite communications in emergency situations.

In the Third Generation Partnership Project (3GPP™) we are helping to develop the use of LTE for mission-critical communications. In 2016 the first set of 3GPP mission-critical specifications was completed, covering voice communication (Push-to-Talk – PTT). New work was started on mission-critical video and data communications.

We are also creating standards for maritime safety equipment, avalanche beacons, and various mechanisms for road safety through the use of Intelligent Transport Systems.

In September, in co-operation with the European Conference of Postal and Telecommunications Administrations Electronic Communications Committee (CEPT ECC), we organised a workshop entitled 'Public Protection and Disaster Relief: Regulatory changes and new opportunities for broadband PPDR'.

The event provided a platform for interested parties to discuss recent developments and identify future activities in relation to standardisation, national implementation and regulation.

# Working in Partnership

## Working with Europe

We value our partnership with the European Commission (EC) and the European Free Trade Association (EFTA) highly. As a European Standardisation Organisation (ESO), we provide world class standards and specifications to support European Union (EU) legislation and public policies.

In 2016 we worked on a number of existing EC mandates and accepted a further three standardisation requests: M/543 (material efficiency aspects for energy-related products in support of the implementation of Directive 2009/125/EC), M/544 (Ecodesign requirements for networked standby) and M/546 (Urban Intelligent Transport Systems (ITS)). We also commented on draft standardisation requests that were under preparation, including for web accessibility, and on the draft Annual Union Work Programme for European Standardisation which will be used as a planning tool to prepare for possible future standardisation requests and actions.

The major mandated activity in 2016 covered the development and production of candidate Harmonised Standards under M/536 in support of the Radio Equipment Directive for which we have developed a large work programme with ambitious target time schedules.

We completed phase 2 of mandate M/460 for electronic signatures, and continued to work on the issue of enhanced emergency calls (M/493). We began significant new work in response to M/530 (privacy and personal data protection management). We co-operated with the European Committee for Standardisation (CEN) and the European Committee for Electrotechnical Standardisation (CENELEC) in relevant areas.

We participated in all of the meetings of the EC's Committee on Standards that took place in 2016 and all four meetings of the Information and Communications Technologies (ICT) Multi-Stakeholder Platform. We regularly took part in meetings of the Task Force on the Rolling Plan for ICT Standardisation and contributed to the drafts and final outcome for the anticipated ICT Rolling Plan 2017. We continued to attend as an observer at various Member State committees and their working groups.

## Collaboration between the ESOs

Co-operation and collaboration with CEN and CENELEC continued in 2016. We participate in the CEN and CENELEC Technical Boards and attend their General Assemblies. The Joint Presidents' Group ensures management level co-ordination, in addition to direct links between our technical committees. By working together on appropriate topics, especially those which are the subject of EC standardisation requests, we ensure that industry benefits from a more integrated European standardisation system.

In 2016 we continued to work closely together in areas such as ITS, smart energy, smart metering and electronic signatures, to ensure the development of a coherent set of standards and to avoid the duplication of effort and overlapping work. Other significant areas of activity in 2016 included electromagnetic compatibility, combined equipment, energy efficiency and accessibility, cyber security and the Internet of Things (IoT).

## Working with NSOs

We partner in our role and responsibility as an ESO with our network of National Standards Organisations (NSOs). About half of the NSOs are also members of ETSI, but all perform the important task of organising national approval procedures for our European Standards (ENs). In addition, NSOs are in close contact with local industry in their countries, especially with small businesses. NSOs distribute our standards, they act as information points on the status of our work, and may even accompany local Small and Medium-sized Enterprises in their first steps in standardisation. Most of our NSOs are also members of CEN or CENELEC, and therefore play a part in ensuring alignment between our work and that of these other ESOs, especially in fields where ICT is an enabling technology for other industries.

In 2016 we continued to meet with the NSOs prior to each meeting of our General Assembly to exchange information. These meetings also cover more detailed discussions on specific technical subjects of interest to NSOs, and on the processes related to ENs and Harmonised Standards. We began a consultation on the EN Approval Process, with the goal of improving the balance between the timely production of standards and allowing sufficient time for the NSOs to review and comment, and then for us to process those comments.

## Partnership Agreements

Co-operation and collaboration is the best way to achieve alignment between our standards and those produced elsewhere, to avoid the duplication of effort and to ensure that our work is widely accepted and implemented. Working in partnership also helps reduce fragmentation in standardisation, particularly in a world of converging technologies, and is an important means by which we ensure our activities keep up to date with market needs. Establishing partnership agreements with fora, consortia and international and regional Standards Developing Organisations around the world is one of the key mechanisms we have adopted in working with others.

By the end of 2016, our partnership agreements portfolio numbered over 100 active partnerships. During the year, we entered into a new Co-operation Agreement with the Taiwan Association of Information and Communication Standards. We also established Memoranda of Understanding with the QuEST Forum, the European co-operation for Accreditation, the European Telecommunications Network Operators' Association, Eurosmart, the OpenFog Consortium and the European Conference of Postal and Telecommunications Administrations (CEPT) Committee for International Telecommunication Union (ITU) Policy.

Letters of Intent were signed with the Open Edge Computing Initiative and the Smart Grid and Cyber-Physical Systems Program Office of the U.S. National Institute of Standards and Technology (NIST).

We renewed our partnerships with the ITU, the GSM Association, the Telecommunications Technology Association, CEPT's Electronic Communications Committee, GlobalPlatform, the Near Field Communication Forum and the Wireless World Research Forum. We updated our partnership agreements with the Home Gateway Initiative and the Car Connectivity Consortium to allow for our adoption of their specifications as part of the Publicly Available Specification (PAS) process.

## Seconded Experts in Emerging Markets

As globalisation makes our world increasingly interconnected, we continue to place special emphasis on bridging the gap with new players in emerging markets and regions. In partnership with CEN and CENELEC, the EC and EFTA, we have therefore appointed 'Seconded Experts' to raise the profile of European standardisation and to intensify co-operation on standardisation issues in key emerging regions.

### India

Following the completion in March of the second phase of the Seconded European Standardisation Expert in India (SESEI) project, the project partners agreed to continue for a third term and the expert was reappointed. He continued to participate in workshops and other events to promote European standardisation activities, particularly in strategic areas such as smart cities, cyber security, device certification and Network Functions Virtualisation. The SESEI was involved in two major policy initiatives, Digital India and Make in India, which will shape our co-operation with Indian organisations.

Our Director-General undertook a mission to India in February 2016, during which meetings were held with several government bodies.

ETSI is the project manager for SESEI.

### China

Now in her second year of the third phase of this project, our Seconded European Standardisation Expert for China (SESEC) continued to attend events to promote the European standardisation and regulatory model and to explain European standardisation developments in specific sectors. Key topics include the IoT and M2M, communication networks, cyber security and digital identity, smart cities, and electrical and electronic products. Overall, the aim of the SESEC project is the enhancement of the EU-China dialogue and co-operation in the field of standardisation with a view to assisting EU industry to do business in China.

The SESEC continued to monitor the effect of China's Standardisation Reform, which was expected to impact on the substance of the EU-China co-operation on standardisation issues, and the new 'One Belt One Road' initiative for standard connectivity. The SESEC also supported us in strengthening our links with Chinese partners, especially the China Communications Standards Association and the China Electronics Standardisation Institute. New links were established with the Standardisation Administration of China and with the China ITS Industry Alliance, with a view to organising interoperability testing for ITS standards.

In addition, we attended the 7th EU-China dialogue on ICT policy in July. We participated in the first meeting of the EU-China Expert Working Group on the Economic Impact of Cybersecurity Challenges and the Digital Economy, an initiative co-organised by EC DG Connect and the Cyber Administration of China (CAC). We also took part in the first meeting of the joint EU-China Working Group on the Digital Economy which provided an opportunity to liaise with CAC and introduce our work, particularly in relation to the production of global standards.

## Forapolis™ Support Services

Drawing on over two decades of ETSI experience, in 2016 Forapolis provided customised support services to three third party organisations in which ETSI members are involved. One of these organisations completed its work and terminated its contract with us at the end of June. Forapolis services are provided without any cross-subsidy from the Members' contributions.

# Specialist Task Forces and other Funded Projects

Specialist Task Forces (STFs) are expert teams established under the direction of an ETSI committee to work together for limited periods on specific technical work. In this way, STFs are able to accelerate the development of urgently needed standards or support strategic activities required by our members or by the European Commission (EC) and the European Free Trade Association (EFTA). A similar mechanism has been adopted to support 'Funded Projects' for the Third Generation Partnership Project (3GPP™) partners.

Altogether, 43 STFs and other funded projects were active in 2016, involving 115 service providers for a total of about 2,26 M€ spent. Voluntary contributions equivalent to 176 k€ were provided by 3GPP members and partners.

In 2016, we allocated an additional 250 k€ of the ETSI contribution to the STF budget to support conformance testing for oneM2M, testing for Intelligent Transport Systems and Core Network and Interoperability Testing.

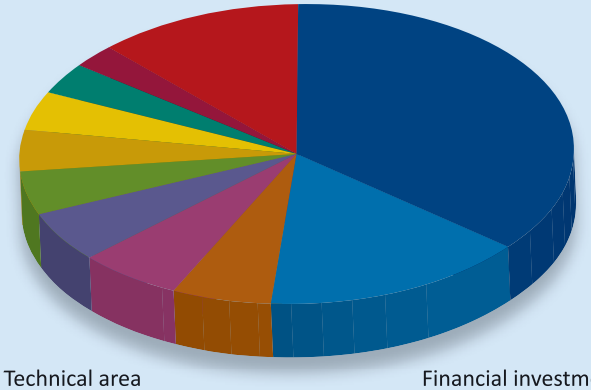
## EC/EFTA Funding

2016 saw the full implementation of lump sum financing for standardisation actions financed by the EC/EFTA, on which action grants for STFs will be based in the future. It should be noted that the lump sum unit is updated on an annual basis by the EC, so the amount changes every year. The number of action grants agreed in 2016 continued to be fewer than in previous years but again proposals were submitted in the latter part of the year to be considered for grants in 2017. However, we were once more able to submit and progress our Operating Grant for 2017.

The EC budget for standardisation for 2016 remained stable in comparison with 2015. The amount available for the Operating Grants of the European Standardisation Organisations did not therefore see a further reduction. Our Operating Grant remained at around 2,45 M€ in 2016. We were also able to successfully report and achieve the finalisation and full payment of the 2015 Operating Grant. Following discussions with the EC, the 2017 Operating Grant was expected to be agreed for 2,55 M€, i.e. an increase on the 2016 amount.

We continued to manage and invoice the action grants received from the EC/EFTA efficiently, and we finalised and closed actions started in 2013 onwards. The actions signed in 2016 covered activities related to electronic signatures, Intelligent Transport, broadband energy efficiency, air traffic interoperability, the new phase of the Seconded European Standardisation Expert in India (SESEI), training materials for Information and Communications Technologies standardisation plus the organisation of Plugtests™ interoperability events.

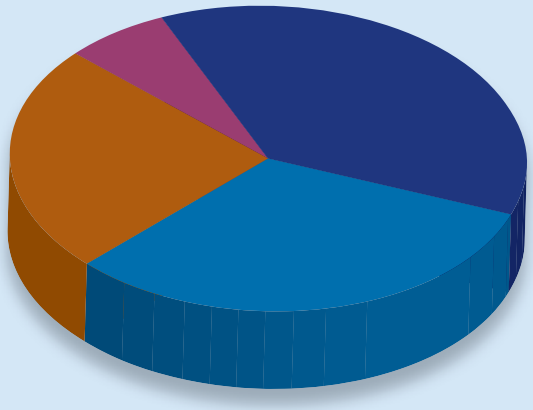
**Technical areas in which funded resources were invested in 2016**



| Technical area | Financial investment (k€) | % |
|---|---|---|
| 3GPP | 817 | 36% |
| Smart Machine-to-Machine (SmartM2M) | 343 | 15% |
| Core Network and Interoperability Testing (INT) | 137 | 6% |
| Digital Enhanced Cordless Telecommunications (DECT™) | 134 | 6% |
| Electronic Signatures and Infrastructures (ESI) | 127 | 6% |
| Intelligent Transport Systems (ITS) | 104 | 5% |
| Reconfigurable Radio Systems (RRS) | 99 | 4% |
| Methods for Testing & Specification (MTS) | 98 | 4% |
| Human Factors (HF) | 72 | 3% |
| Access, Terminals, Transmission and Multiplexing (ATTM) | 61 | 3% |
| Others | 264 | 12% |
| **TOTAL** | **2 255** | |

*Figures are rounded to the nearest k€.*

**Funding sources in 2016**



| | |
|---|---|
| ETSI Funding | 42% |
| 3GPP Partners | 29% |
| EC/EFTA Mandates ICT | 22% |
| 3GPP Members | 7% |

# Standards Production

In 2016 we published over 2 700 standards, specifications, reports and guides, bringing the total published since our establishment in 1988 to over 41 000.

The number of documents published in 2016 is significantly higher than in 2015. This was due mainly to two factors: the numerous new and revised Harmonised Standards which we produced to support the introduction of the Radio Equipment Directive, and the freeze-point of the Third Generation Partnership Project (3GPP™) Release 13, in December 2015, as a result of which more than 900 drafts were received by our Secretariat at the end of 2015 for processing at the beginning of 2016.

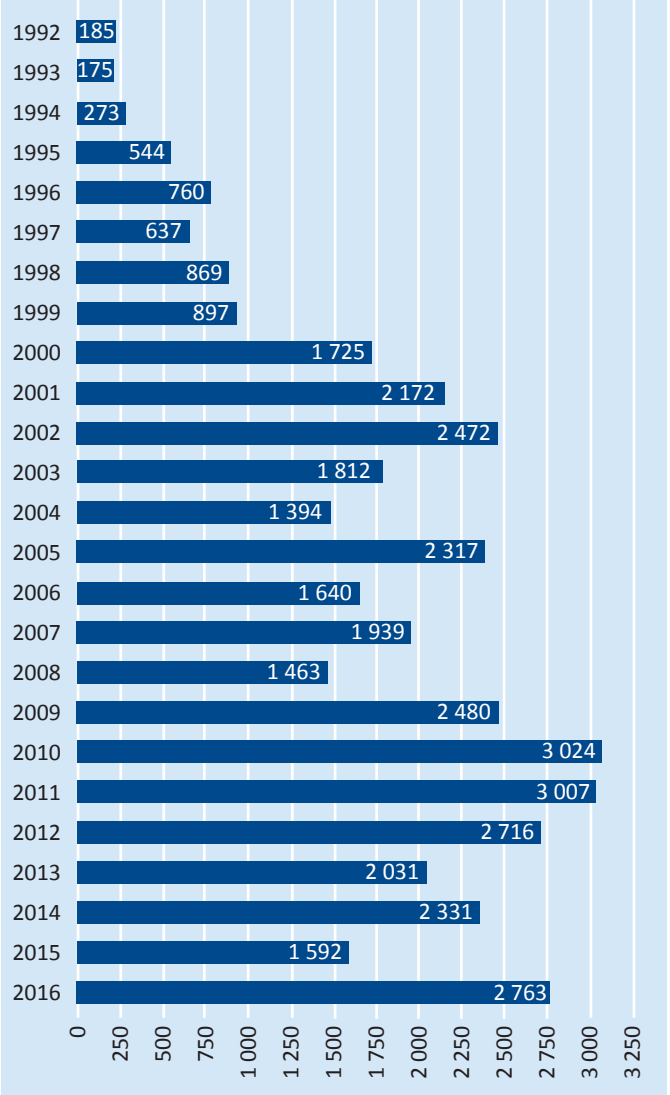
## Intellectual Property Rights

Our Intellectual Property Rights (IPR) Policy is highly regarded around the world. We work constantly to improve it, consulting widely with our members, the European Patent Office (EPO), the EC, the United States Government and relevant partner organisations, to meet the needs of our members, public authorities and the ICT industry in general.

In 2016 our IPR Special Committee continued to focus on ways to increase the transparency of patent declarations and the information we provide to members and the public, particularly the transparency of the declaration process and the information available in the ETSI IPR online database. Our legal department undertook a review of the database and made modifications to improve its accuracy. We began identifying and mapping the standardisation process to patents activities.

Throughout the year, we contributed the views and represented the interests of the standardisation community on patents, standards and the interplay between them at conferences and workshops worldwide.

**The number of deliverables published, for each of the years 1992 – 2016**




**Distribution by type of published document**

| | in 2016 | Total since 1988 |
|---|---|---|
| Technical Specification (TS)[1] | 2 312 | 31 820 |
| Technical Report (TR)[2] | 243 | 3 391 |
| ETSI Standard (ES) | 13 | 769 |
| European Standard (telecommunications series) (EN)[3] | 148 | 4 826 |
| ETSI Guide (EG) | 5 | 251 |
| Special Report (SR) | 9 | 96 |
| Group Specification (GS) | 31 | 132 |
| Group Report (GR) | 2 | 2 |
| TOTAL | 2 763 | 41 287 |

1 Includes GSM™ Technical Specification (GTS)
2 Includes old deliverable types: Technical Committee Reference Technical Report (TCR-TR), Technical Committee Technical Report (TC-TR) and ETSI Technical Report (ETR)
3 Includes amendments and old deliverable types: European Telecommunication Standard (ETS), Interim ETS (I-ETS) and Technical Basis for Regulation (TBR)

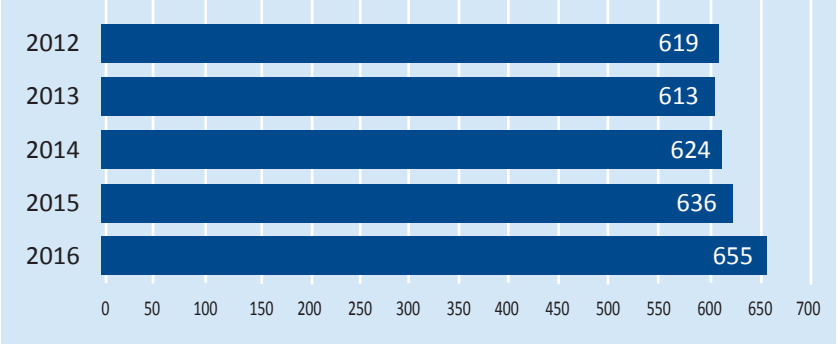
# Membership

Overall ETSI membership (all categories) increased again in 2016. At the end of the year, we had a total of 804 members, drawn from 67 different countries and provinces across five continents. This was made up of 655 full members drawn from 44 European countries, 131 associate members drawn from 23 non-European countries and 18 observers. 123 of our members are Small and Medium-sized Enterprises (SMEs) and 85 are micro-enterprises. Small organisation members now represent 27% of the overall membership, an increase of 2% on 2015.

The European Commission and the European Free Trade Association Secretariat, which hold special roles as Counsellors, attend the General Assembly and the ETSI Board and continue to play an active part in our work.

Our membership team continued to build, enhance and maintain close relationships with our members in 2016 to ensure we meet their needs and that all members benefit fully from their membership of ETSI. In 2016 we began preparing an induction programme for new members, particularly SMEs and micro-enterprises, to help guide them through the initial stages of membership.

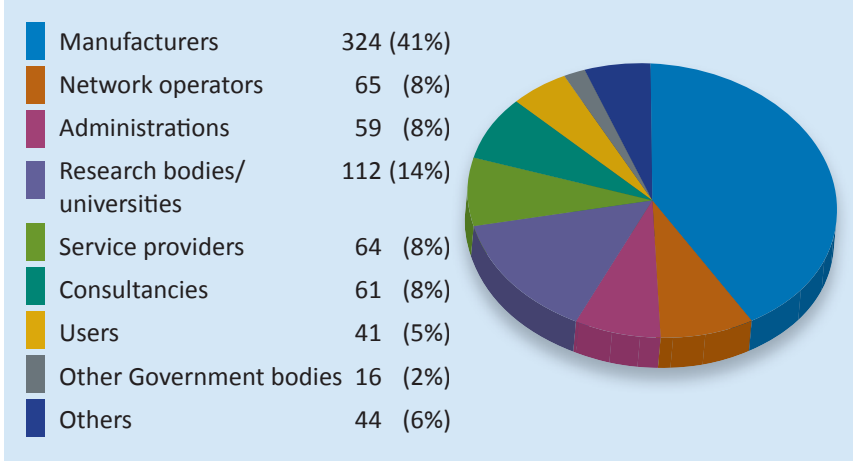
### Evolution of ETSI Full Membership




### Membership by type

| | 1-1-2016 | 31-12-2016 |
|---|---|---|
| Full Members | 636 | 655 |
| Associate Members | 129 | 131 |
| Observers | 19 | 18 |
| Total | 784 | 804 |

### Full and Associate Membership by category




### Overall membership by country/province

| | |
|---|---|
| Albania | 2 |
| Andorra | 1 |
| Australia | 6 |
| Austria | 17 |
| Azerbaijan | 1 |
| Belgium | 34 |
| Bosnia Herzegovina | 2 |
| Botswana | 1 |
| Bulgaria | 2 |
| Brazil | 1 |
| Canada | 11 |
| China | 9 |
| – Taiwan (Province of China) | 13 |
| Croatia | 2 |
| Cyprus | 1 |
| Czech Republic | 5 |
| Denmark | 16 |
| Estonia | 3 |
| Finland | 14 |
| Former Yugoslav Republic of Macedonia (FYROM) | 1 |
| France | 110 |
| Georgia | 1 |
| Germany | 127 |
| Greece | 5 |
| Hungary | 4 |
| Iceland | 1 |
| India | 3 |
| Indonesia | 1 |
| Ireland | 16 |
| Israel | 9 |
| Italy | 26 |
| Japan | 8 |
| Jordan | 1 |
| Korea | 6 |
| Kosovo | 1 |
| Latvia | 1 |
| Lebanon | 1 |
| Lesotho | 1 |
| Lichtenstein | 1 |
| Lithuania | 1 |
| Luxembourg | 9 |
| Malaysia | 1 |
| Malta | 2 |
| Moldova | 1 |
| Montenegro | 1 |
| Netherlands | 28 |
| Norway | 15 |
| Poland | 10 |
| Portugal | 3 |
| Qatar | 2 |
| Romania | 2 |
| Russian Federation | 8 |
| Serbia | 1 |
| Singapore | 1 |
| Slovakia | 2 |
| Slovenia | 3 |
| South Africa | 3 |
| Spain | 24 |
| Sweden | 26 |
| Switzerland | 19 |
| Tunisia | 1 |
| Turkey | 7 |
| Ukraine | 1 |
| United Arab Emirates | 5 |
| United Kingdom | 111 |
| United States of America | 51 |
| Uzbekistan | 1 |
| 67 COUNTRIES OR PROVINCES IN TOTAL | 804 |

# The Financial Situation

The management of the finances of ETSI is described by
- the budget report
- the financial statements (balance sheet and income and expenditure statement) which are established according to French laws and regulations.

Mr Anis Nassif, Concertae, whose auditor's mandate was approved by the 68th General Assembly, has audited the 2016 ETSI accounts and certified that the annual financial statements are true, sincere and give a fair view of the activities carried out during the past financial year.

## Budget Maintenance

In total, compared with 2015, income increased by 0,8% or roughly 177 k€, while expenditure was down by 3,9% or 898 k€. After having made provision of roughly 11 k€ for Income Tax to be paid and 1 100 k€ in credit notes to be issued to Members to offset the excess of income over expenditure, the net result of the year is 91 k€. This compares with a net result of 117 k€ in 2015.

The key points of the budget management are the following:

### Expenditure

Secretariat costs were 2,8% under budget and lower by 3,9% compared with 2015.

In addition to the close monitoring of the expenditure budget along with delays in implementing some planned projects that also contributed to the budget underspend, in 2016 no payment was made to the Pension Fund to cover ETSI's liabilities with regards to 'Indemnités de Fin de Carrière', the current coverage being already sufficient to cover ETSI's liability.

It was confirmed that Partners' services were delivered without any cross-subsidy from the Members' contributions.

2,9 M€ were spent on acquiring expertise for Specialist Task Forces and other standardisation-related technical expertise.

### Income

Members' contributions (15,9 M€ before credit notes) were 7,5% over budget and increased by 3,9% compared with 2015. They funded roughly 71% of the budget.

European Commission (EC)/European Free Trade Association (EFTA) payments amounted to 3,9 M€ to cover expenses related to the operation of the European standardisation platform and standardisation projects.

With the termination of some Partners' service contracts, income generated by support services supplied to fora and consortia (Forapolis™) amounted to 0,26 M€, which represents a 12,5% decrease compared with 2015. This decreasing trend will continue until the end of 2017, when these activities are planned to be terminated.

**2016 Budget Statements**

| INCOME | (k€) | EXPENDITURE | (k€) |
|---|---|---|---|
| Members' contributions and Observer fees net of credit notes | 14 797 | Secretariat staff costs | 12 397 |
| EC/EFTA contracts | 3 919 | Other Secretariat costs | 5 680 |
| 3GPP™ Partners | 1 945 | Special projects | 389 |
| Voluntary contributions | 176 | European Friends of 3GPP | 576 |
| Forapolis | 262 | Provision and losses | 396 |
| European Friends of 3GPP | 627 | Experts' costs | 2 917 |
| Sales | 135 | | |
| Plugtests™ | 0 | | |
| Financial income | 69 | | |
| Other income | 515 | | |
| TOTAL INCOME | 22 446 | TOTAL EXPENDITURE | 22 355 |

In 2016, there was a net result of 91 k€.

## Financial Statements for the Year 2016

The final accounts and the balance sheet are summarised below.

The fiscal accounting period is 1 January 2016 – 31 December 2016.

### Statement of Income and Expenditure Year 2016

| | Income (€) | Expenditure (€) |
|---|---|---|
| Income | 22 449 879 | |
| Purchases | | 8 288 998 |
| Expenses | | 14 145 781 |
| Financial income & expenses | 70 518 | 4 966 |
| Extraordinary income & expenses | 23 854 | 2 250 |
| Income Tax | | 11 322 |
| TOTAL | 22 544 251 | 22 453 317 |

There was a net result of 90 934 € in 2016.

## Summary of the Balance Sheet

### Assets

| Net amounts at: | 31 Dec 2015 (€) | 31 Dec 2016 (€) |
|---|---|---|
| Fixed assets | 6 875 318 | 6 349 933 |
| Debtors | 16 793 229 | 15 643 371 |
| Securities/cash | 6 683 684 | 9 103 427 |
| Prepaid expenses | 138 469 | 157 798 |
| TOTAL ASSETS | 30 490 700 | 31 254 529 |

### Liabilities

| Net amounts at: | 31 Dec 2015 (€) | 31 Dec 2016 (€) |
|---|---|---|
| Equity | 8 278 661 | 8 278 661 |
| Provisions | 396 771 | 435 098 |
| Balance carried forward | 292 128 | 408 732 |
| Result of the year | 116 604 | 90 934 |
| Creditors | 5 081 594 | 5 838 543 |
| Deferred revenue | 16 324 942 | 16 202 561 |
| TOTAL LIABILITIES | 30 490 700 | 31 254 529 |

*Figures are rounded to the nearest €.*


- 2G, 3G, 4G, 5G Mobile Communications
- Air Traffic Management
- Automotive Radar
- Autonomic Systems
- Body Area Networks
- Broadband Wireless Access
- Broadcasting
- Cable Networks
- Cloud Technology
- Cognitive Radio
- Content Delivery
- Cyber Security
- DECT™
- Digital Mobile Radio
- Digital Rights Management
- eHealth
- Electromagnetic Compatibility
- Electronic Signatures
- Emergency Communications
- Energy Saving
- Environmental Aspects
- Fixed-line Access
- Fixed Radio Links
- Human Factors
- IMS Network Testing
- Intelligent Transport
- Internet of Things
- Interoperability
- Lawful Interception
- Low Power Radio
- Machine-to-Machine Communications
- Maritime Communications
- Media Content Distribution
- Millimetre Wave Transmission
- Mission-Critical Communications
- Multi-access Edge Computing
- Network Functions Virtualisation
- Network Management
- Next Generation Networks
- Open Source Software
- Powerline Communications
- Protocols
- Public Safety Systems
- Quality of Service
- Quantum Key Distribution
- Quantum-Safe Cryptography
- Radio Regulations
- Radio Systems
- Rail Communications
- Safety
- Satellite Communications
- Security Algorithms
- Short Range Radio
- Smart Appliances
- Smart Cards
- Software Defined Radio
- Telemedicine
- Testing
- Terrestrial Trunked Radio (TETRA)
- Wireless Medical Devices

## To find out about our plans for the future, see our Work Programme 2017-18.



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