Patent insight report

Quantum technologies and space

Supplementary material: methodology and technology

European Patent Office

ESPI European Space Policy Institute

IN COLLABORATION WITH

esa

Table of contents

1. General methodology

As explained in section 1 of the Quantum technologies and space report, “Using patent information”, patent filing statistics can be exploited to gain multifaceted insights into a technical or commercial field of interest. The aim of this study is to examine quantum technologies (QT) applicable for space and compile a comprehensive overview of the domain.

Previous studies on QT,[1,2] have noted significant growth in related patent applications in recent years, yet the overall numbers are still low. Our focus on space-related inventions might have led to a similarly low number of applicable patent families in this study, which would have had a significant impact on the selection and the balance between precision and recall.

While the study was being set up, it became evident that the searches had to be formulated broadly and comprehensively to avoid losing too many relevant documents. At the same time, further intellectual checking of documents would be necessary to avoid high levels of irrelevant hits (“noise”). Consequently, this patent insight report was developed as a multi-step approach, as illustrated in the figure below.

Landscaping Study

Preparation → **Collect** → **Space filter** → **Insight**

Preparation
- Collect possible QT fields with application in space
- Expert consulting to confirm relevant space applications for QT
- Create shortlist of topics of interest

Collect
- Split search queries for the each topic
- Develop individual search queries with balance between precision and recall
- Identify and collect all QT patent documents in the selected domains

Space filter
- Apply a filter to the collected dataset to identify inventions which are useful for QT space applications
- The space filter uses a combination of space keywords, patent classifications and further high-level criteria to check suitability for space

Insight
- Visualise dataset and trends
- Identify connections, correlations and networks
- Formulate insights, intelligence and conclusions

[1] Travagnin, M., Patent analysis of selected quantum technologies, EUR 29614 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-79-98120-3, doi:10.2760/938284, JRC115251, https://publications.jrc.ec.europa.eu/repository/handle/JRC115251

[2] Landscape study on patent filings – Quantum metrology and sensing, European Patent Office, 2019, http://documents.epo.org/projects/babylon/eponet.nsf/0/354147741B-1D314AC1258470004DB6F9/$File/patent_insight_report-quantum_metrology_and_sensing_en.pdf

1.1 Patent databases and tools

The search queries were devised by examiners at the EPO using EPOQUE and ANSERA, two sophisticated professional search tools used by EPO examiners. To retrieve the patents and generate the dataset, the patent database Orbit Intelligence from Questel was used. For the patent analysis, Global Patent Index (GPI) and PATSTAT from the European Patent Office were also used. The dataset was imported into a custom-built analysis dashboard tool created with Microsoft Excel for dynamic on-the-fly data analysis and chart generation. Most of the charts in this study were generated with this tool.

1.2 Data collection

To collect relevant patent documents, the search queries were split into several domains and subdomains on various levels to enable dedicated and optimised queries addressing each subdomain. The queries were devised with EPO experts from each domain, and in turn the subdomains were defined according to technology and purpose. Further detailed descriptions of the selected subdomains and technologies are available in the relevant chapter below.

Domain	Subdomains
Quantum key distribution (QKD)	QKD-1: Quantum key distribution protocol and key management
	QKD-2: Optical quantum communication
	QKD-3: Photonic quantum memories
Cold atom clocks (CAC)	CAC-1: General cold atom clocks
	CAC-2: Optical cold atom clocks
Cold atom interferometers (CAI)	CAI-1: Gyroscopes
	CAI-2: Accelerometers
	CAI-3: Gravimeters and gradiometers

The search queries used for collecting the data and documents are listed below.

Subdomains	Queries
QKD-1: Quantum key distribution protocol and key management	(((QUANTUM_KEY_DISTRIBUTION OR QKD OR CV_QKD OR QUBIT? OR Q_BIT? OR QUANTUM_BIT? OR ENTANGLE+ OR BB84 OR E91 OR SAGA OR DARPA OR SECOQC)/TX AND H04L-009/08/IPC/CPC) OR H04L-009/0852/IPC/CPC)
QKD-2: Optical quantum communication	(((QUANTUM_KEY_DISTRIBUTION OR QKD OR QUBIT? OR Q_BIT? OR QUANTUM_BIT? OR ENTANGLE+ OR (PAIR+ 2D (PHOTON+ OR LIGHT? OR RADIATION? OR PULSE? OR QUANTUM?)))/TI/AB/TX AND ((H04B-010/60 OR H04B-010/61 OR H04B-010/63 OR H04B-010/64 OR H04B-010/65 OR H04B-010/66 OR H04B-010/67 OR H04B-010/69 OR G01J-2001/442 OR H04B-010/50 OR H04B-010/51 OR H04B-010/52 OR H04B-010/53 OR H04B-010/54 OR H04B-010/55 OR H04B-010/56 OR H04B-010/57 OR H04B-010/58)/IPC/CPC OR (SNSPD OR ((SUPERCONDUCTING_NANOWIRE) 3D (SINGLE_PHOTON_DETECTOR)))/TI/AB/TX)) OR H04B-010/70/IPC/CPC)
QKD-3: Photonic quantum memories*	(((QUANTUM 3D (STOR+ OR MEMOR+)) OR QUBIT? OR QBIT? OR QUANTUM_BIT?) AND ((PHOTON+ OR (QUANT+ 2D OPTI+)) 9D (STOR+ OR MEMOR+ OR SAVE+ OR (INFOMAT+ 4D PROCESS+) OR INTERFACE+)))/TX AND ((B82Y-010 OR H01L-039 OR H01L-027/18 OR G11C-013/04 OR G11C-013/06 OR H01P-007/06 OR G21K-001/006)/IPC/CPC)
CAC-1: General cold atom clocks	((((COLD OR COOL+ OR TRAP+) S (ATOM+ OR ION+ OR PARTICLE?)) OR (MAGNETO W OPTIC+) OR MOT OR (OPTIC+ 2D PUMP+) OR (LASER 2D (COOL+ OR TRAP+)))/TX AND (G04F-005/14 OR G04F-005/145 OR H03L-007/26)/IPC/CPC)
CAC-2: Optical cold atom clocks	((((COLD OR COOL+ OR TRAP+) S (ATOM+ OR ION+ OR PARTICLE?)) OR (MAGNETO W OPTIC+) OR MOT OR (OPTIC+ 2D PUMP+) OR (LASER 2D (COOL+ OR TRAP+)))/TX AND (G04F-005/14 OR G04F-005/145 OR H03L-007/26)/IPC/CPC) AND ((OPTIC+ 2D (CLOCK? OR LATTICE? OR ION?)) OR (FEMTO+ 2D COMB?) OR (OPTIC+ 2D (REFERENC+ OR FREQUENC+))/TX)
CAI-1.1: Gyroscopes	(((COLD OR COOL+ OR TRAP+) 2D (ATOM+ OR ION+ OR PARTICLE?)) OR (MAGNETO W OPTIC+) OR MOT OR (BOSE W EINSTEIN) OR BEC OR ((MATTER OR PARTICLE?) 2D WAVE?) OR ((ATOM+ OR PARTICLE?) 2D INTERFEROM+) OR (OPTIC+ 2D PUMP+))/TX AND (G01C-019/58 OR G01C-019/60 OR G01C-019/62)/IPC/CPC
CAI-2.1: Accelerometers	(((COLD OR COOL+ OR TRAP+) 2D (ATOM+ OR ION+ OR PARTICLE?)) OR (MAGNETO W OPTIC+) OR MOT OR (BOSE W EINSTEIN) OR BEC OR ((MATTER OR PARTICLE?) 2D WAVE?) OR ((ATOM+ OR PARTICLE?) 2D INTERFEROM+) OR (OPTIC+ 2D PUMP+))/TX AND (G01P-015/08)/IPC/CPC
CAI-3.1: Gravimeters and gradiometers	(((COLD OR COOL+ OR TRAP+) 2D (ATOM+ OR ION+ OR PARTICLE?)) OR (MAGNETO W OPTIC+) OR MOT OR (BOSE W EINSTEIN) OR BEC OR (FERMI 2D GAS) OR DFG OR ((MATTER? OR PARTICLE?) 2D WAVE?) OR ((ATOM+ OR PARTICLE?) 2D INTERFEROMET+) OR (OPTIC+ 2D PUMP+))/TX AND (G01V-007/00 OR G01V-007/04 OR G01V-007/14)/IPC/CPC

* For photonic quantum memories, the additional selection for suitable technologies was based on the condition of coherence time (>4 ms) for use in space applications, which describes the time it takes for light to travel to and from a suitable satellite orbit. Further details are provided in the technology descriptions below.

1.3 Space filter

While the preparation, collection and filtering steps are common in these analyses, the challenge of identifying QT patents applicable to space was that the legal documents had to be used to determine whether an invention is suitable or, capable for or enables the use of related building blocks or components in space in a dedicated application. As described in chapter 1.6 of the report, “Methodology”, this particular challenge was addressed by creating a space filter that uses keywords, patent classifications and additional criteria. The detailed selection is provided below.

Space filter set-up

Space filter – keywords/query	((AEROSPAC? OR AIRCRAFT?)/TI/AB/CLMS OR (COSMIC+ OR DEEP_SPACE OR OUTER_SPACE OR EARTH_STATION? OR GROUND_STATION? OR INTER_PLANETAR+ OR MICRO_GRAVIT+ OR SATELLITE? OR MICRO_SATELLITE? OR NANO_SATELLITE? OR SPACE_CRAFT? OR SPACE_VEHICLE? OR SPACE_SHIP? OR SPACE_STATION? OR SPACE_BORNE OR SPACE_PROBE? OR ZERO_GRAVIT+)/TI/AB/TX OR
Space filter – classifications	(B64G OR H01Q1/288 OR H04B10/118 OR H04B7/185)/IPC/CPC)
Space filter – additional concepts used for manual filtering	Miniaturisation and compactness Chip-scale, embedded systems and waveguides Transportable (used for navigation) Low power consumption High sensitivity (case-dependent) Suitable for use in vacuum (or related space environment)

The keywords and classification are used in a combined filter query. The keywords are used to flag the patent families that mention selected keywords in the title, abstract or claims or in the general text of the patent application. The classification codes (CPC/IPC)[3] are used to flag patent documents, which are sorted by category, among other things.

This filtering system was used to remove obvious noise from the dataset. However, spot checks revealed that additional criteria needed to be used to either reject or add patent families in specific cases to the space-related dataset. The datasets for space-related cold atom clocks and cold atom interferometers underwent multiple iterations of these additional criteria checks.

However, the initial dataset for quantum key distribution patent documents contained a much higher count, so only random samples were checked for space relevance and suitability, as defined by the additional criteria. Furthermore, using these criteria to perform a check on all the datasets would have required an in-depth analysis of every document. The objectivity of any such assessment would have been a challenge, especially if these criteria had not been explicitly mentioned in the patent document and could therefore not be unambiguously identified as being space-related. Therefore, this study relies on a compromise between a clear filter query and additional manual sampling.

[3] CPC: Cooperative Patent Classification, IPC: International Patent Classification.

1.4 Patent counting

Patent counting was done at family level (unless stated otherwise) using the simple patent families (GPI and PATSTAT) and Fampat families (Orbit). In these databases, all the publications for patents of a single invention are grouped together, and all members of the family must share the same priority numbers. This generates less noise, resulting in more precise and comprehensive results and duplicate-free invention-based family records that are quicker to scan and understand.

1.5 Timeframe

The dataset for the study was limited to the publication years 2001-2020 in order to focus on second-generation QT. Since the counting was family-based, the earliest publication year across patent family members was used for the statistical graphs and tables.

1.6 Geographic and document coverage

All the databases used (Orbit, GPI and PATSTAT) have worldwide patent coverage based on patent data from the EPO master documentation database (DOCDB) and patent data provided by patent offices worldwide. No restriction to specific countries/patent jurisdictions was applied when creating the dataset – this was done at a later stage for analysis if needed (e.g. EP or EPC filings only). Regarding the document coverage, the patents were retrieved and the dataset generated on the basis of a full-text search using Orbit. The data also includes utility models in countries that have this type of intellectual property right (e.g. China, Russia, Germany and Spain).

1.7 Data harmonisation

As the analysed patent data originated from multiple patent authorities worldwide, it was common to see misspellings and translation errors in the bibliographic data. These could have hampered the statistical analysis, especially as regards the analysis by applicant or inventor since different name variations were counted as separate entities. It was thus necessary to manually correct and group the inventor and applicant names. Furthermore, applicant and company names were standardised according to known mergers, acquisitions and changes of ownership. Known subsidiaries of big corporations were aggregated to the main company name using the "data rules" tool from Orbit.

2. Technology descriptions

2.1 Quantum key distribution protocol and key management

Secure quantum communication relies on generating and distributing quantum cryptographic keys that are used only by the sender and recipient to encrypt and decrypt data or messages. For quantum key distribution protocols and management, quantum cryptographic keys or passwords are generated, shared or updated, usually through the use of photons. While there are several different quantum key distribution protocols (e.g. BB84, SARG04, E91) and link configurations, the fundamental security of those keys and their management is based on the physical quantum-mechanics principle known as the "no-cloning theorem". Under this theorem, identical copies of an arbitrary unknown quantum state are forbidden, so it is impossible to create an identical copy of a quantum key. The communicating parties can thus be certain (in practice, to a known confidence threshold) that a third party has not tampered with their set of keys. However, unconditional security in encryption is only ensured when the key and message are of the same length, the key is only used once and – most importantly – the key is truly random. Therefore, quantum random-number-generators are being studied, leveraging the physically random nature of quantum states. Nevertheless, other implementations with pseudo-random number generators and beam splitters are possible. One crucial future challenge for quantum key distribution protocols remains preventing attacks of any kind as these could jeopardise security.

Lastly, long-distance quantum key distribution via optical free-space links to satellites or aeroplanes looks to be the most promising aspect, due to the exponential degradation of optical signals in terrestrial fibre networks.[4,5]

While quantum protocols and key management do not necessarily depend on the type of transmission, it was decided to exclude optical-fibre inventions since they are potentially less relevant for "free-space" transmission to satellites. Quantum key distribution applications in aerospace, which have to withstand vibrations and need ground-based tracking systems, were included as they are also moving towards application in space.

2.2 Optical quantum communication

Analysing optical aspects of quantum communication involves receipt, transmission, coding and modulation, synchronisation, measurement, filtering and quantum repeaters. The applicable technologies and designs in this subdomain may cover, for example, transmitter and receiver components as well as mechanical and optical pointing mechanisms.[5]

Key areas for optimisation are highly accurate optical links, (high-brightness) photon sources compatible with launch and space environments, moving receiver platforms, free-space daylight quantum key distribution and greater feasibility of uplink transmissions. The major limitations of increasing secure key rates involve the timing resolution of the detectors. Adaptive optics systems and detectors enhanced in terms of both timing resolution and number-resolving can therefore increase the secure bit stream. Superconductor nanowire single-photon detectors (SNSPD) for improved detection of single-pair entangled photons are a major emerging trend.[6,7]

2.3 Quantum memories

While quantum memories are highly relevant in fibre-based networks to overcome the range limitation by implementing "quantum repeater" protocols, they can also be similarly deployed in space. Depending on the link configuration for secure quantum communication, quantum memories could be used to enable and expand inter-satellite networks as well as ground-to-space communication. The key benefit of a quantum memory is that it enables true end-to-end encryption.

Using a quantum memory to extend the range of quantum communication links via a quantum repeater protocol inherently involves exchanging photons between two distant memories.

4 ScyLight — ESA's secure and laser communication technology framework for SatCom, https://ieeexplore.ieee.org/document/8357400

5 Olivia Lee, Tom Vergoossen, An updated analysis of satellite quantum-key distribution missions, https://arxiv.org/ftp/arxiv/papers/1909/1909.13061.pdf

6 Espacenet query

7 Olivia Lee, Tom Vergoossen, An updated analysis of satellite quantum-key distribution missions, https://arxiv.org/ftp/arxiv/papers/1909/1909.13061.pdf

When transmitting signals between a ground station and a satellite or from satellite to satellite, the significant time lags while the photon travels the relevant distances have to be borne in mind; the quantum information has to be preserved during this time. Considering typical distances of satellite orbits from the ground, a one-way travel time of about 2 ms is a realistic estimate. Consequently, a lower limit for a complete upward and downward travel cycle is 4 ms. At least for this period of time, the quantum information must not be lost. Providing a quantum memory that coherently stores photon quantum information for at least 4 ms is thus a technological challenge that must be addressed in those systems.

As a result, to be used in the aforementioned space applications, the quantum memory must satisfy fundamental criteria, including efficiency of storage and recall and the memory coherence time. Firstly the memory must be able to store the quantum state of a photon efficiently and without corruption, and secondly, the coherence time must be at least 4 ms. Furthermore, satellite missions and their link performance will also be impacted by the fidelity and capacity of the storage.

Within the existing technologies for quantum memories, the following have been identified as being of particular interest in view of the above criteria:

— Rare earth ions in crystal lattices
Rare earth ions are doped into a crystal matrix. Absorption of a photon excites a nuclear transition state within the rare earth ion, and this is preserved until the excitation relaxes and releases a photon of the same quantum state. The high energetic stability of the rare earth ions as well as their relative protection from external influences within the regular crystal matrix coherently preserves the quantum state for a sufficiently long coherence time. Crystal matrices are typically metal oxide systems. Coherence times of 82 ms[8] and even longer[9] have been reported.

— Colour centres in diamonds
This concept is based on a similar idea to the previous one, i.e. providing absorbent nuclear transitions within a largely undisturbed crystal lattice. However, in this case the crystal matrix is diamond and the absorptions are provided by colour centres. For the purposes of photonic quantum memory, these colour centres can be created by nitrogen doping. By applying particular techniques to certain colour centres, coherence times of up to 13 ms[10] have been reported.

— Cold atoms
The photonic quantum information is saved as an excited state in a cloud of cold atoms. The low temperature prevents interaction with the environment and fosters a long coherence time. Unlike the two previous systems, this is not a solid-state concept and requires an appropriate trap, such as a magneto-optical trap, in which the memory medium is kept as a low-temperature gas. While there are expectations that these may be useful for memory applications, coherence times reported in patent literature are 5.3 µs,[11] significantly below the 4 ms threshold mentioned above.

2.4 Cold atom clocks

The measurement of atom states in an atom clock can be enhanced by cooling the atoms with lasers, thus improving the performance of atom clocks. These cold atom clocks are commonly used and can be considered today's time and frequency transfer standard. Typically, the atoms are cooled, trapped and launched from an atomic fountain and then exposed to a microwave field. When the atom enters the detector stage of the clock, its state can be determined. In a continuous process, it is thus possible to correlate the microwave field frequency with the highest yield of excited atom states. In turn the oscillations can be counted to measure the duration of an event.[12],[13]

Even more accurate measurements can be obtained by optical cold atom clocks, in which a resonance frequency in the optical domain is used instead of a microwave field. These innovations were awarded a Nobel Prize in Physics in 2005.[14] The accuracy of optical cold atom clocks has been reported to be improved by one order of magnitude compared with previous clocks.[15]

In space, cold atom clocks are a critical element for global navigation satellite systems and positioning, navigation and timing applications, which rely on precise timing to

8 Method of Extending Hyperfine Coherence Times in Pr3+:Y2SiO5, E. Fraval et al., https://journals.aps.org/prl/pdf/10.1103/PhysRevLett.92.077601

9 Zhong, M., Hedges, M., Ahlefeldt, R. et al. Optically addressable nuclear spins in a solid with a six-hour coherence time. Nature 517, 177–180 (2015), https://doi.org/10.1038/nature14025

10 WO2019033009 – https://worldwide.espacenet.com/patent/search/family/065272538/publication/WO2019033009A1?q=pn%3DWO2019033009A1
EXTENDED COHERENCE AND SINGLE-SHOT READOUT OF A SILICON-VACANCY SPIN IN DIAMOND

11 US2013048846A1 – https://worldwide.espacenet.com/patent/search/family/047742261/publication/US2013048846A1?q=pn%3DUS2013048846A1
TWO-DIMENSIONAL MAGNETO-OPTICAL TRAP FOR NEUTRAL ATOMS

12 https://qt.eu/discover-quantum/underlying-principles/atomic-clocks/

13 Tests of Cold Atom Clock in Orbit, Liang Liu et al., https://arxiv.org/ftp/arxiv/papers/1709/1709.03256.pdf

14 https://www.nobelprize.org/prizes/physics/2005/summary/

15 https://www.nist.gov/news-events/news/2013/08/nist-ytterbium-atomic-clocks-set-record-stability

accurately determine the position of satellites and users on Earth. Space-borne cold atom clocks need to fulfil additional requirements, for example caused by the microgravity environment.[16] In general, precise timing is key in a number of terrestrial applications like energy, industry and telecommunications.

2.5 Cold atom interferometers

Within interferometers, the properties of waves (such as electromagnetic waves) can be studied. By superimposing waves, it is possible to observe interference effects, enabling very high-precision measurements. To do so, cold atom interferometers leverage the wave-particle dualism of atoms in quantum physics. However, to enable the interaction, manipulation and measurement, the atoms have to be cooled by lasers to a low µ°K range using a magneto-optical trap. Further cooling to low n°K range is necessary to achieve Bose-Einstein condensation. The working principles for cold atom interferometry are only accessible in these cold states as the atom beams sent through the interferometer will share the same quantum state, stay collimated and provide the required time for interacting with the beam.[17]

The development of underlying technologies for the trapping, cooling and interaction has attracted multiple Nobel Prizes in Physics in recent decades (1989, 1997, 2001, 2012).[18,19]

The high sensitivity and accuracy of cold atom interferometers allow for numerous applications in space. As well as fundamental-physics experiments in microgravity, the use of cold atom interferometers is suitable for drift-free gyroscopes, accelerometers and especially gravimeters.[20,21] One challenge is their non-continuous operation, which can be addressed by either combining them with conventional interferometers or running several in parallel, as mentioned in patents US7847924 and CN106842347B. However, pulsed operation is also possible as long as the measurement frequency is high enough to prevent the satellite orbit velocity from impairing the signal spatial resolution on the ground.

A typical cold atom interferometer consists of four main components: a cold atom source, a preparation stage, a three-pulse laser interferometer and a detection stage. To use a cold atom interferometer as a gyroscope, the interferometer instrument needs to be attached to a moving platform. Where no external forces influence the atoms passing through the interferometer, the atoms can ideally be assumed to move on inertial straight paths. As they pass through the interferometer stage, the atoms are split into two paths, reconverging at the end. Under these ideal circumstances, the detectable phase difference of the atom wave function represents the accumulated influence of the movement of the platform. As such, the working principle of the cold atom interferometer can be exploited so that it can be used as an inertial sensor, e.g. for application in guidance, navigation and control on satellites and spacecraft.

Similarly, cold atom interferometer set-ups can be implemented as accelerometers and gradiometers on satellites to conduct scientific experiments and, most significantly, measure Earth's gravitational field and its anomalies. Dedicated missions like GRACE/GRACE-FO (NASA/DLR) and GOCE (ESA) contributed to this scientific research into Earth's geoid. Furthermore, non-gravitational accelerations can also be measured through dedicated satellite tracking and the use of cold atom interferometer-based accelerometers on satellite platforms. Lastly, experimental set-ups in microgravity like the Bose-Einstein Condensate and Cold Atom Laboratory (BECCAL, NASA/DLR) will offer additional new opportunities to explore cold atom interferometry and quantum optics.[22]

[16] Wei Ren, Tang Li, Qiuzhi Qu, Bin Wang, Lin Li, Desheng Lü, Weibiao Chen, Liang Liu, Development of a space cold atom clock, National Science Review, Volume 7, Issue 12, December 2020, Pages 1828–1836, https://doi.org/10.1093/nsr/nwaa215 and US10749540B2

[17] Travagnin, M., Cold atom interferometry sensors: physics and technologies, EUR 30289 EN, Publications Office of the European Union, 2020, ISBN 978-92-76-20405-3, doi:10.2760/315209, JRC121223, https://publications.jrc.ec.europa.eu/repository/handle/JRC121223

[18] Ibid.

[19] https://www.nobelprize.org/prizes/lists/all-nobel-prizes-in-physics/

[20] Landscape study on patent filings – Quantum metrology and sensing, European Patent Office, 2019, http://documents.epo.org/projects/babylon/eponet.nsf/0/354147741B1D314AC1258470004DB6F9/$File/patent_insight_report-quantum_metrology_and_sensing_en.pdf

[21] Rainer Kaltenbaek et al., Quantum technologies in space, https://link.springer.com/article/10.1007/s10686-021-09731-x

[22] Frye, K., Abend, S., Bartosch, W. et al. The Bose-Einstein Condensate and Cold Atom Laboratory. EPJ Quantum Technol. 8, 1 (2021), https://doi.org/10.1140/epjqt/s40507-020-00090-8

Where to get additional help

Visit epo.org

- Patent search at epo.org/espacenet
- European Patent Register at epo.org/register
- Online filing services at epo.org/online-services
- Training at epo.org/academy
- Job vacancies at epo.org/jobs
- FAQs, publications, forms and tools at epo.org/service-support

Subscribe

- Our newsletter at epo.org/newsletter

Visit epo.org/contact

- Contact forms to send enquiries by mail
- Our Customer Services phone number
- Our contact details

Follow us

- facebook.com/europeanpatentoffice
- twitter.com/EPOorg
- youtube.com/EPOfilms
- linkedin.com/company/european-patent-office