PROSPECTS 5.0

PROSPECTS 5.0 Industry 5.0 Wiki November 2026 Patent Analysis

Quality Control and Inspection in Manufacturing

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LIST OF ACRONYMS

AI	Artificial Intelligence
AM	Additive Manufacturing
AR	Augmented Reality
CAGR	Compound Annual Growth Rate
CPC	Cooperative Patent Classification
EPO	European Patent Office
EU-27	The 27 Member States of the European Union
IPC	International Patent Classification
PCT	Patent Cooperation Treaty
WIPO	World Intellectual Property Organization

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1. EXECUTIVE SUMMARY

This report analyses the worldwide patent landscape of quality control and inspection in manufacturing, as a contribution of PROSPECTS 5.0 to the understanding of technology trends behind the transition towards Industry 5.0. It is based exclusively on two exports from the Espacenet database of the European Patent Office, retrieved on 11 November 2026: a main dataset of **83,813 patent families** on quality control and inspection in manufacturing, and a subset of **1,454 families** in which the claims, title or abstract also refer to human-centric concepts such as workers, human operators, augmented reality, wearables, collaborative robots or explainability.

The key findings are as follows.

- **The field is growing very fast.** Families first published per year rose from 1,151 in 2015 to 12,486 in 2025, a compound annual growth rate of about 27%. Around 76% of all families were first published in 2020 or later.
- **The COVID-19 period did not interrupt this growth.** Priority filings kept increasing in every year from 2020 to 2024. The growth rate eased from about 32% in 2020 to 17% to 18% in 2021 and 2022 and recovered to 21% in 2024.
- **Quality control has become an image analysis and AI discipline.** Industrial image inspection (CPC G06T7/0004) covers 59% of the families and neural network classes (G06N3) about 21%.
- **Human-centric quality control is a small but distinct segment.** It represents 1.7% of the field and grew from 28 families in 2015 to 181 in 2025. Its technology profile is different: factory-level quality surveillance, quality management, mixed reality and user interaction are clearly over-represented.
- **Europe holds a strong position.** Summed over the Member States, EU-27 applicants appear in 16,555 families and EU-27 inventors in 17,256 families, which places the EU-27 third worldwide in the available country data, close to Japan. Germany alone ranks fourth as applicant country and third as inventor country. European patent protection is sought more often for human-centric families (16.4%) than for the field as a whole (9.8%).

The data point to a clear opportunity: the human-centric segment is still open, no applicant holds more than 20 families in it, and it matches the industrial strengths that European applicants already show in equipment, automotive, aerospace and process industries. These results can support PROSPECTS 5.0 partners and European manufacturers in positioning their innovation and intellectual property strategies.

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2. INTRODUCTION

2.1. Scope and Objectives

Quality control is one of the manufacturing functions most deeply changed by digital technologies. Camera-based inspection, machine learning and factory-level data systems are replacing manual sampling, and the role of the worker is changing with them. This makes quality control a relevant observation point for Industry 5.0, which the European Commission describes as a sustainable, human-centric and resilient industry [5].

The objectives of this report are:

- to quantify the evolution of patenting activity in quality control and inspection in manufacturing, with a focus on recent years;
- to assess whether the COVID-19 period left a visible mark on this activity;
- to describe the geographic distribution, the technology classes and the main applicants;
- to isolate and characterise the human-centric part of the field as a patent-based view on Industry 5.0;
- to describe the position of the EU-27 and the opportunities that follow from it.

2.2. Data Source and Search Strategy

All figures in this report come from the Espacenet patent search service of the European Patent Office [1]. Two searches were run on 11 November 2026 and the statistical filter results were exported [2] [3]. Results are counted in patent families, so that one invention filed in several countries is counted once.

The main query (Query 1) combines classification codes that are specific to inspection with keyword conditions in the title, abstract or claims. It covers industrial image inspection, quality surveillance in factory control, optical detection of flaws and defects in a manufacturing context, process control and monitoring in additive manufacturing, and image analysis or recognition applied to defects and quality control in production. The second query (Query 2) keeps all conditions of Query 1 and adds a human-centric keyword condition. Query 2 is therefore a strict subset of Query 1. Both queries are given in Table 1.

Table 1 Datasets used in this report

Dataset	Search logic	Families
Query 1: quality control and inspection in manufacturing	cpc = "G06T7/0004/low" OR cpc = "G05B19/41875" OR (cpc = "G01N21/88/low" AND (ctxt = "manufactur*" OR ctxt = "production")) OR ((cpc = "B22F10/30/low" OR cpc = "B29C64/393/low" OR cpc = "B22F12/90" OR cpc = "B22F10/85") AND (ctxt = "inspect*" OR ctxt = "defect*" OR ctxt = "quality control" OR ctxt = "quality assurance" OR ctxt = "quality monitoring")) OR ((cpc =/low "G06T" OR cpc =/low "G06V") AND (ctxt = "defect*" OR ctxt = "quality control" OR ctxt = "quality inspection") AND (ctxt = "manufactur*" OR ctxt = "production line" OR ctxt = "workpiece"))	83,813
Query 2: human-centric subset (Industry 5.0 perspective)	(Query 1) AND (ctxt = "industry 5.0" OR ctxt = "human-centric" OR ctxt = "human in the loop" OR ctxt = "human operator" OR ctxt = "worker" OR ctxt = "human-robot" OR ctxt = "collaborative robot" OR ctxt = "augmented reality" OR ctxt = "wearable" OR ctxt = "explainable")	1,454

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2.3. Methodological Notes

- **Counting unit.** All counts are patent families. In the country, language, classification, applicant and inventor statistics one family can be counted under several entries, so these counts cannot be added up to the total and shares do not sum to 100%.
- **Recent years are incomplete.** The export date is 11 November 2026, so 2026 is a partial year. Patent applications are normally published about 18 months after the priority date, which means that priority years 2025 and 2026 are still filling up.
- **Applicant and inventor country.** Espacenet records this field for only part of the documents. Chinese applicants are strongly under-recorded: China appears in 64,546 families as publication country but in only 4,629 families as applicant country. The applicant and inventor country data are therefore used to compare the United States, Japan, South Korea and Europe, and not to rank China.
- **Applicant names.** Names are shown as recorded by Espacenet and are not harmonised. Some organisations appear under several names (for example KLA Tencor Corp and KLA Corp).
- **EU-27 scope.** European analysis covers the 27 Member States of the European Union. EU-27 values are sums of the Member State counts and may include a limited amount of double counting for families with applicants or inventors from several Member States.
- **Human-centric subset.** Query 2 is a keyword-based proxy. The literal term Industry 5.0 is rare in patent texts, so the subset relies on the human-centric vocabulary. The sustainability and resilience dimensions of Industry 5.0 cannot be isolated reliably with keywords and are not covered by the subset.
- **No external data.** No statistics from other sources are used. Classification descriptions follow the CPC scheme [4].

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3. OVERALL PATENT LANDSCAPE

3.1. Temporal Evolution

3.1.1. Long-term Development

The oldest families in the dataset date back to the nineteenth century, but activity remained marginal for decades. Only 1,550 families were first published before 2000. Between 2000 and 2014 the field grew slowly, from about 200 to about 800 families per year. The take-off starts in 2015 and has not stopped since. Table 2 summarises the distribution by period and Figure 1 shows the yearly values.

Table 2 Families by period of earliest publication

Period	All quality control families	Share	Human-centric subset	Share
Before 2000	1,550	1.8%	16	1.1%
2000 to 2009	3,941	4.7%	40	2.8%
2010 to 2014	2,939	3.5%	43	3.0%
2015 to 2019	11,508	13.7%	298	20.5%
2020 to 2026 (11 November)	63,875	76.2%	1,057	72.7%
Total	83,813	100%	1,454	100%

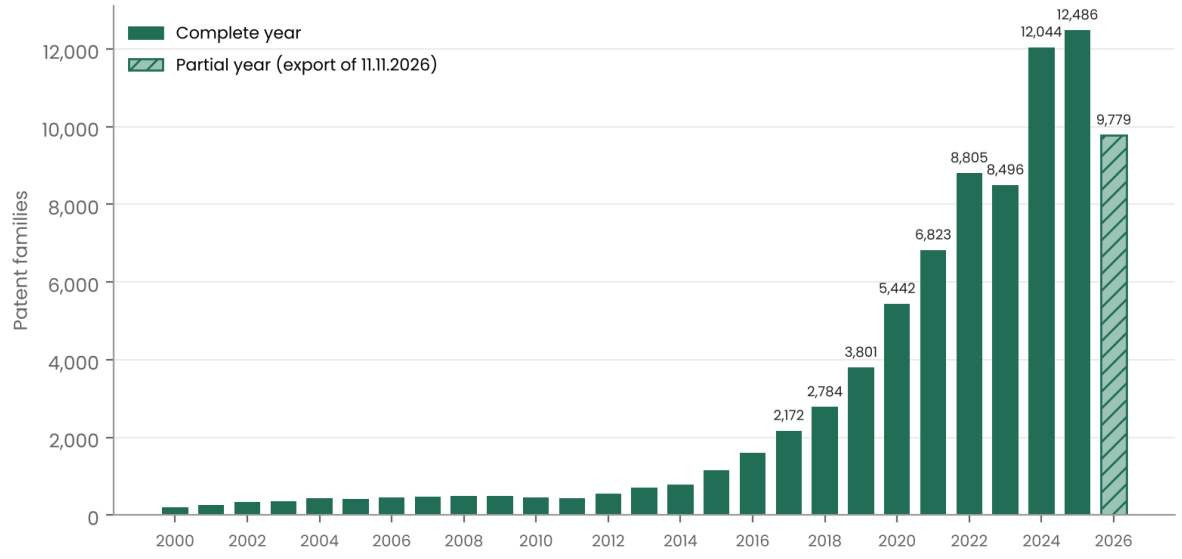


Figure 1 Patent families by earliest publication year, 2000 to 2026 (all quality control families)

Three out of four families were first published in 2020 or later, and the five complete years from 2021 to 2025 alone account for 48,654 families (58% of the total). Quality control and inspection is therefore a young patent field in practice, even if its roots are old.

3.1.2. Recent Trends

Between 2015 and 2025 the number of families first published per year multiplied by almost eleven, from 1,151 to 12,486. This corresponds to a compound annual growth rate of about 27% over ten years. The yearly values are listed in Table 3.

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Table 3 Annual patent families and year-on-year change, 2015 to 2026

Year	Earliest priority	Change	Earliest publication	Change
2015	1,393	+43.8%	1,151	+45.5%
2016	2,219	+59.3%	1,600	+39.0%
2017	2,745	+23.7%	2,172	+35.7%
2018	3,549	+29.3%	2,784	+28.2%
2019	4,563	+28.6%	3,801	+36.5%
2020	6,016	+31.8%	5,442	+43.2%
2021	7,023	+16.7%	6,823	+25.4%
2022	8,302	+18.2%	8,805	+29.0%
2023	9,873	+18.9%	8,496	-3.5%
2024	11,966	+21.2%	12,044	+41.8%
2025	10,831 (incomplete)	n/a	12,486	+3.7%
2026	5,446 (incomplete)	n/a	9,779 (partial year)	n/a

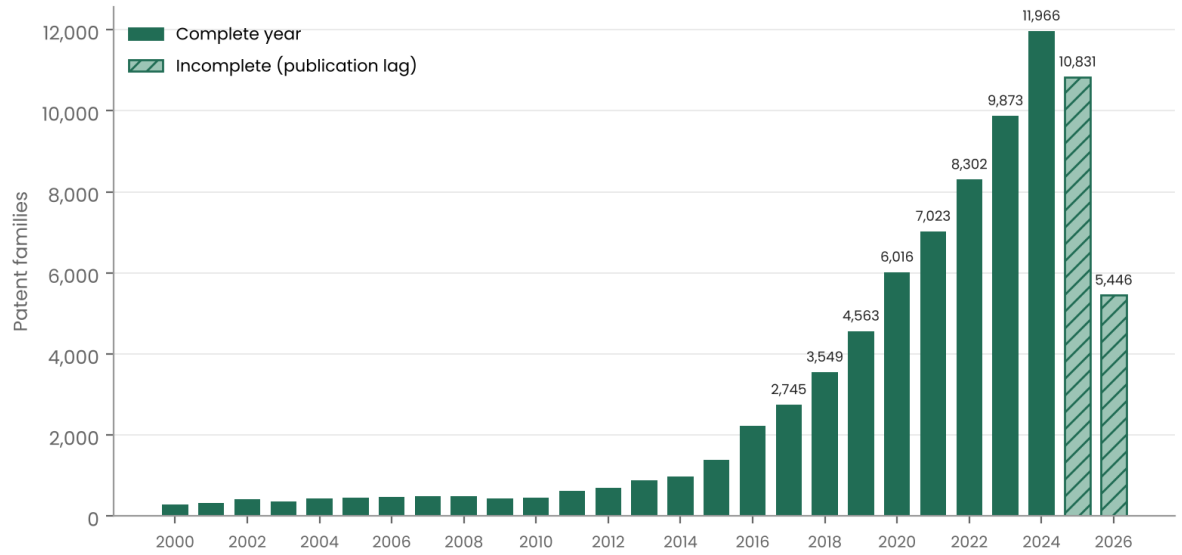


Figure 2 Patent families by earliest priority year, 2000 to 2026 (all quality control families)

The priority year is the best indicator of when the inventive work took place (Figure 2). On this basis the field has grown without interruption: every year from 2011 to 2024 exceeds the previous one, and 2024 is the highest complete year with 11,966 families. The lower values for 2025 and 2026 reflect the publication delay and should not be read as a decline.

The publication series shows the same direction with more irregularity. A slight dip in 2023 (8,496 families, 3.5% below 2022) was followed by a jump of 42% in 2024 and a new record of 12,486 families in 2025. Since priority filings continued to grow in 2021 and 2022, the 2023 dip appears to be an effect of publication timing and not a slowdown of inventive activity. By 11 November 2026, publications already reached 9,779 families, 78% of the full 2025 value.

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3.1.3. Impact of COVID-19

The data allow a direct check of the COVID-19 period. Figure 3 compares the yearly growth rates before, during and after the pandemic years.

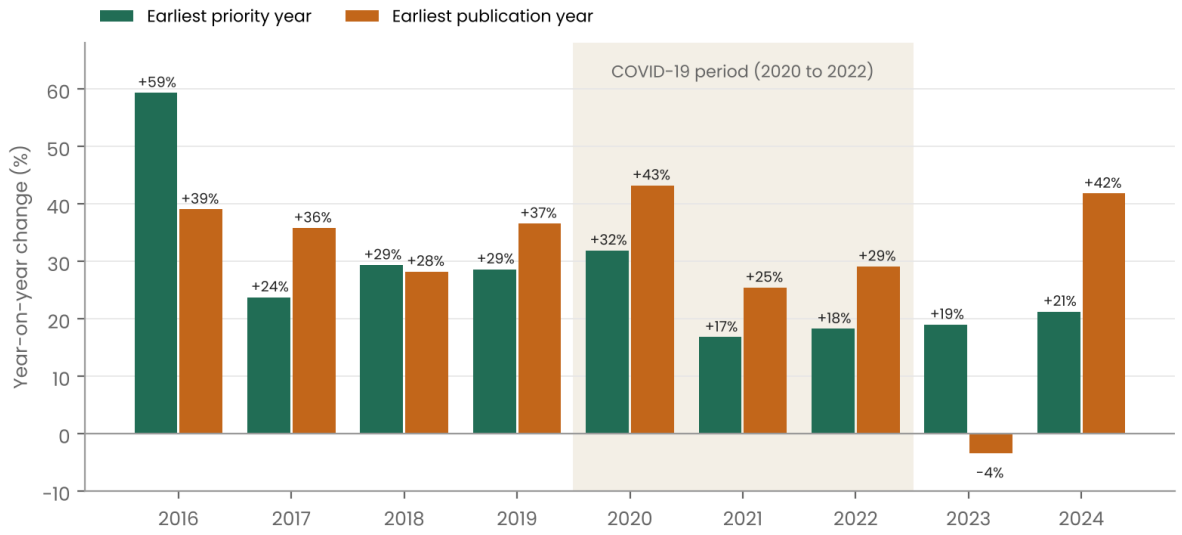


Figure 3 Year-on-year change in patent families, 2016 to 2024, with the COVID-19 period highlighted

- **No contraction.** Priority filings increased in every pandemic year: 6,016 in 2020, 7,023 in 2021 and 8,302 in 2022. The field did not shrink at any point.
- **A moderate slowdown of the growth rate.** Growth in priority filings was 29% in both 2018 and 2019 and 32% in 2020, then eased to 17% in 2021 and 18% in 2022. Inventive activity kept expanding, but at a slower pace during the two years most affected by restrictions.
- **Recovery afterwards.** Growth returned to 19% in 2023 and 21% in 2024.
- **Publication effects.** The strong publication growth in 2020 (+43%) reflects filings made before the pandemic. The only negative year in the publication series is 2023, which is consistent with a delayed and limited echo of the slower filing growth in 2021 and 2022.

Overall, the dataset shows a resilient field. A plausible reading, which the patent data alone cannot prove, is that the pandemic reinforced the interest in automated and remote inspection, because it exposed the dependence of production lines on on-site manual checks. What the data do show is that quality control innovation went through the crisis with a temporary deceleration and no loss of volume.

3.2. Geographic Distribution

3.2.1. Publication Jurisdictions

The country statistics show where protection is sought. China is by far the most frequent jurisdiction, present in 64,546 families (77%). The United States follows with 20,433 families (24%). International applications under the PCT appear in 11,270 families (13%), South Korea in 9,720, Japan in 9,390 and the European Patent Office in 8,254 (9.8%). Germany is the first national office in Europe with 3,224 families. The ranking is shown in Figure 4.

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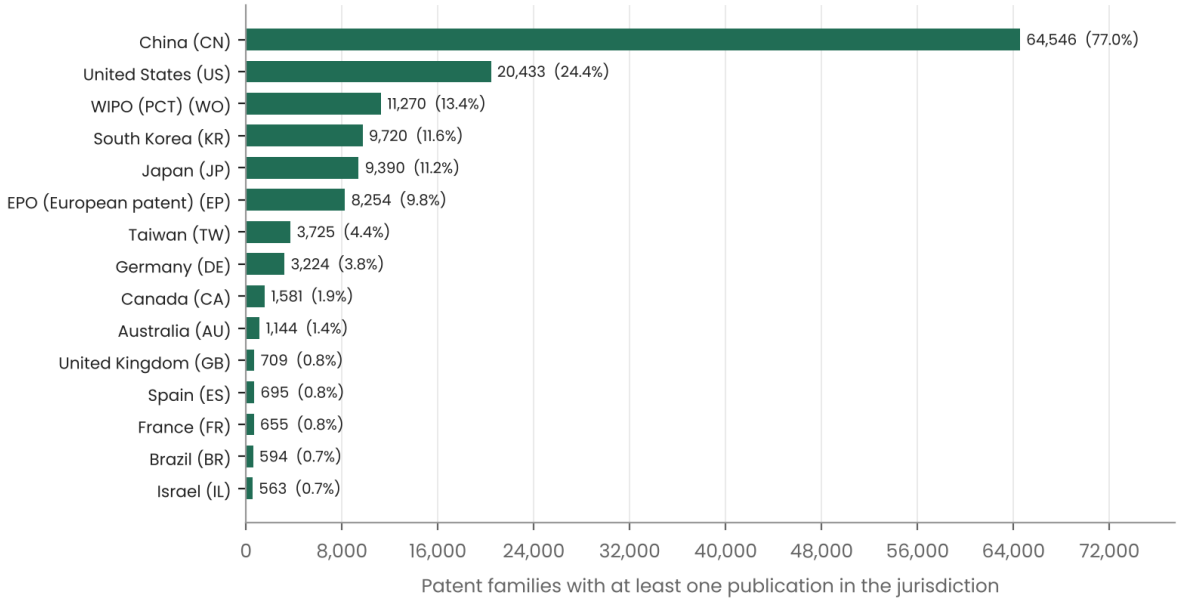


Figure 4 Top 15 publication jurisdictions (all quality control families)

The high Chinese share reflects a very large volume of domestic filings. The language statistics confirm it: 65,172 families have a Chinese-language publication, compared with 9,359 in Korean, 9,181 in Japanese, 6,640 in German and 4,354 in French. The families published through the PCT, the EPO and the United States form the internationally oriented part of the field.

3.2.2. Applicant and Inventor Countries

Where the country of the applicant is recorded, the United States leads with 27,861 families, followed by Japan (20,011), South Korea (11,157) and Germany (7,587). France (2,541), the Netherlands (2,172) and Italy (1,302) are also among the top 15. The inventor country statistics give a similar picture, with Germany in third place (7,991) ahead of South Korea (7,168). Both rankings are shown in Figure 5.

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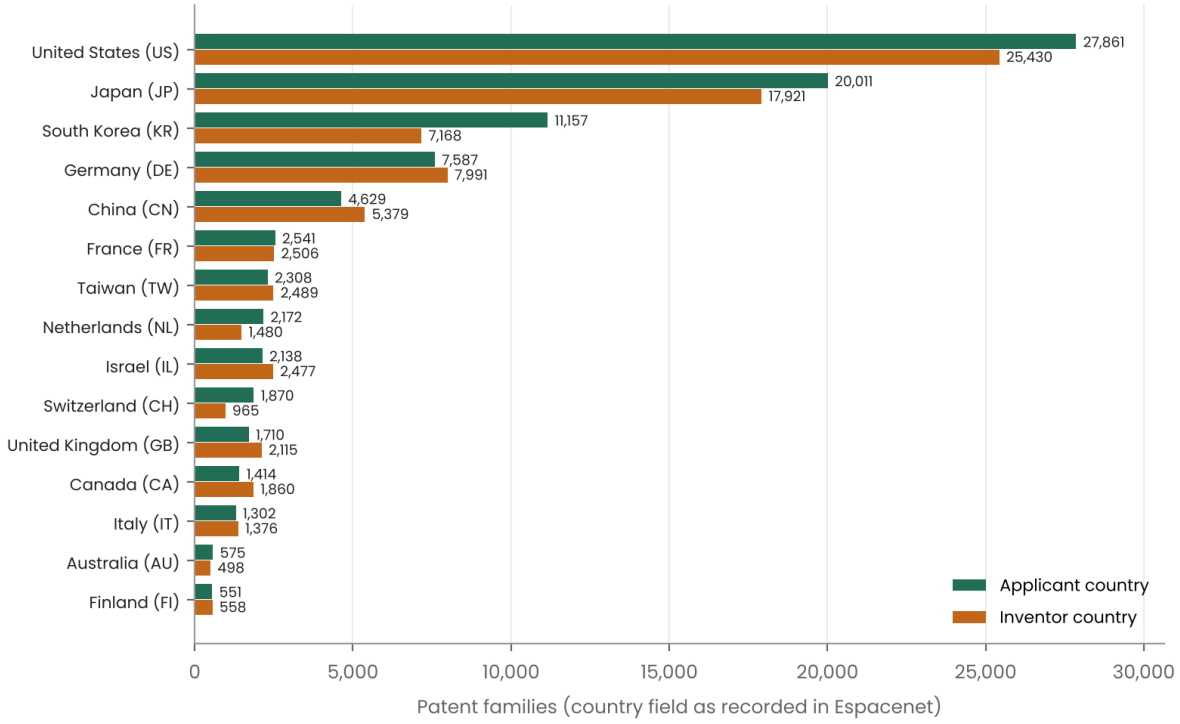


Figure 5 Top 15 applicant countries and the corresponding inventor counts (all quality control families)

As explained in the methodological notes, China is under-recorded in this field and its position in Figure 5 does not reflect its real weight. For the other countries the comparison between applicant and inventor counts is informative. South Korea, the Netherlands and Switzerland have more families as applicant country than as inventor country, which is typical for countries hosting large corporate applicants. Germany, the United Kingdom, Canada, Israel and India show the opposite pattern: their inventors contribute to more families than their domestic applicants own.

3.2.3. Classification Offices

The CPC assigning office statistics indicate which office classified the families. The Chinese office assigned CPC symbols to 58,722 families, the EPO to 41,498 (about half of the field), the United States office to 21,072 and the Korean office to 9,272. The EPO therefore plays a central role in the classification of this technology, well beyond the 8,254 families that include a European publication.

3.3. Technology Classification

3.3.1. Main Technology Groups

The CPC main groups show what the inventions are about (Figure 6). Image analysis (G06T7) is present in 76% of the families, and the specific code for industrial image inspection (G06T7/0004) in 49,200 families (59%). Image and video recognition (G06V10) follows with 30%, optical investigation of materials (G01N21) with 25% and neural networks (G06N3) with 21%. The IPC statistics give the same ranking (G06T7, G06V10, G01N21, G06N3).

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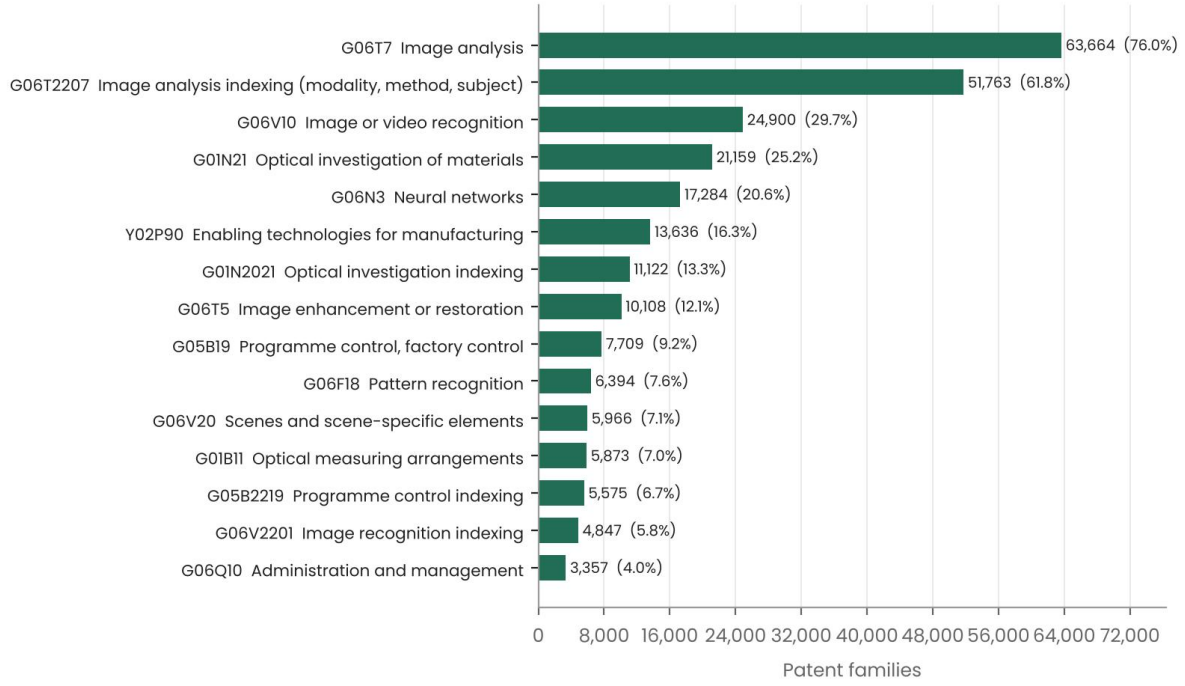


Figure 6 Top 15 CPC main groups (all quality control families)

Beyond the inspection step itself, a second layer of codes relates to the factory level. Enabling technologies for manufacturing (Y02P90) appear in 16% of the families and programme and factory control (G05B19) in 9%. The code for quality surveillance within total factory control (G05B19/41875) covers 6,843 families. Administration and management (G06Q10, 4.0%) and ICT for specific sectors such as manufacturing (G06Q50, 3.5%) show that quality data are increasingly linked to management systems.

3.3.2. Artificial Intelligence

The data confirm that quality control has become one of the main industrial application areas of AI. Besides the neural network group G06N3 (17,284 families), the image analysis indexing codes for learning-based methods (G06T2207/20081, 16,946 families) and artificial neural networks (G06T2207/20084, 15,881 families) each cover about one fifth of the field. Recognition using neural networks (G06V10/82) is present in 12,076 families and convolutional networks (G06N3/0464) in 9,220.

The exported statistics do not cross classification with year, so the timing of the AI uptake cannot be measured directly. However, the scale of these codes, in a field where three quarters of the families are from 2020 or later, indicates that the recent growth and the adoption of deep learning go together. In technology terms the sequence is clear: affordable industrial cameras and computing first made image-based inspection practical, deep learning then made it accurate enough for complex defects, and factory-level data integration is the next step that these codes already make visible.

3.3.3. Application Domains

The CPC indexing scheme identifies the inspected object for part of the families. Workpieces and machine components come first (7,409 families), followed closely by semiconductors and wafers (6,124). Metal surfaces, printed circuit boards, textiles and paper, concrete

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structures, solder joints, printing, display panels and food products follow, as shown in Figure 7.

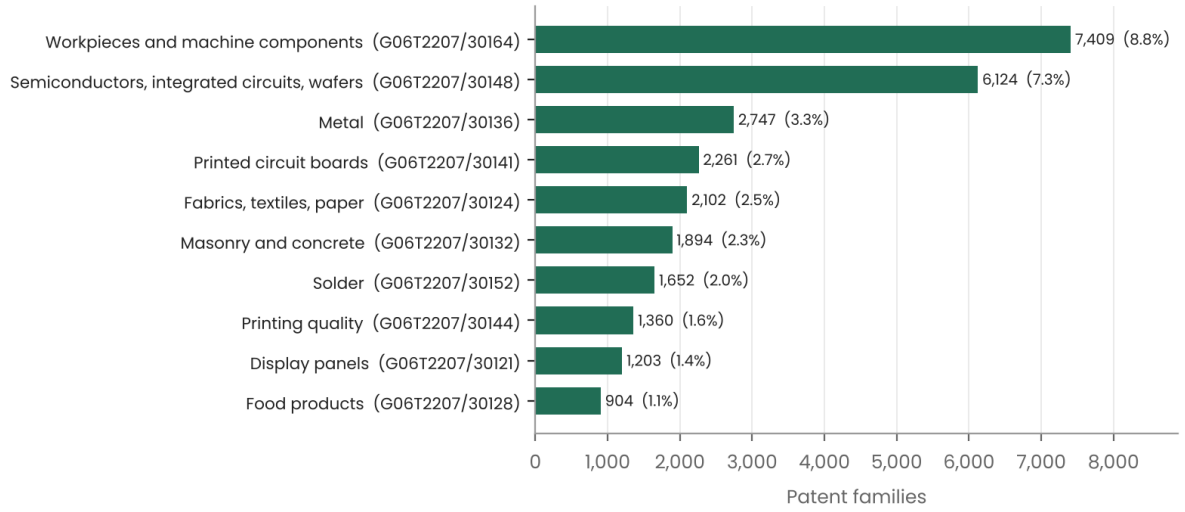


Figure 7 Inspected objects identified by CPC indexing codes (all quality control families)

Electronics-related inspection is particularly strong when semiconductors, printed circuit boards, solder and displays are considered together, and it is supported by further codes for testing during semiconductor manufacture (IPC H01L21/66, 2,987 families). At the same time, the presence of textiles, concrete, metal and food shows that image-based quality control has spread to almost every manufacturing sector.

3.3.4. Additive Manufacturing

Additive manufacturing is covered by Query 1 through its process control and monitoring codes. It represents a specialised niche of about 2% of the field. The relevant codes are listed in Table 4.

Table 4 Additive manufacturing codes in the main dataset

CPC code	Description	Families	Share
B33Y50	Data acquisition or processing for additive manufacturing	2,004	2.4%
B33Y10	Processes of additive manufacturing	1,825	2.2%
B22F10	Additive manufacturing from metallic powder	1,818	2.2%
B29C64	Additive manufacturing of plastics	1,362	1.6%
B33Y30	Apparatus for additive manufacturing	1,267	1.5%
B22F12	Apparatus for metal additive manufacturing	1,163	1.4%
B22F12/90	Means for process control, such as cameras or sensors	885	1.1%
B22F10/85	Data processing for controlling metal additive manufacturing	799	1.0%

In additive manufacturing, quality is controlled inside the process, layer by layer, with cameras and sensors integrated in the machine. These families therefore illustrate a wider trend from end-of-line inspection to in-process monitoring.

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3.4. Applicants and Inventors

The applicant ranking in Figure 8 combines three groups: electronics and imaging companies, semiconductor inspection and equipment specialists, and Chinese universities.

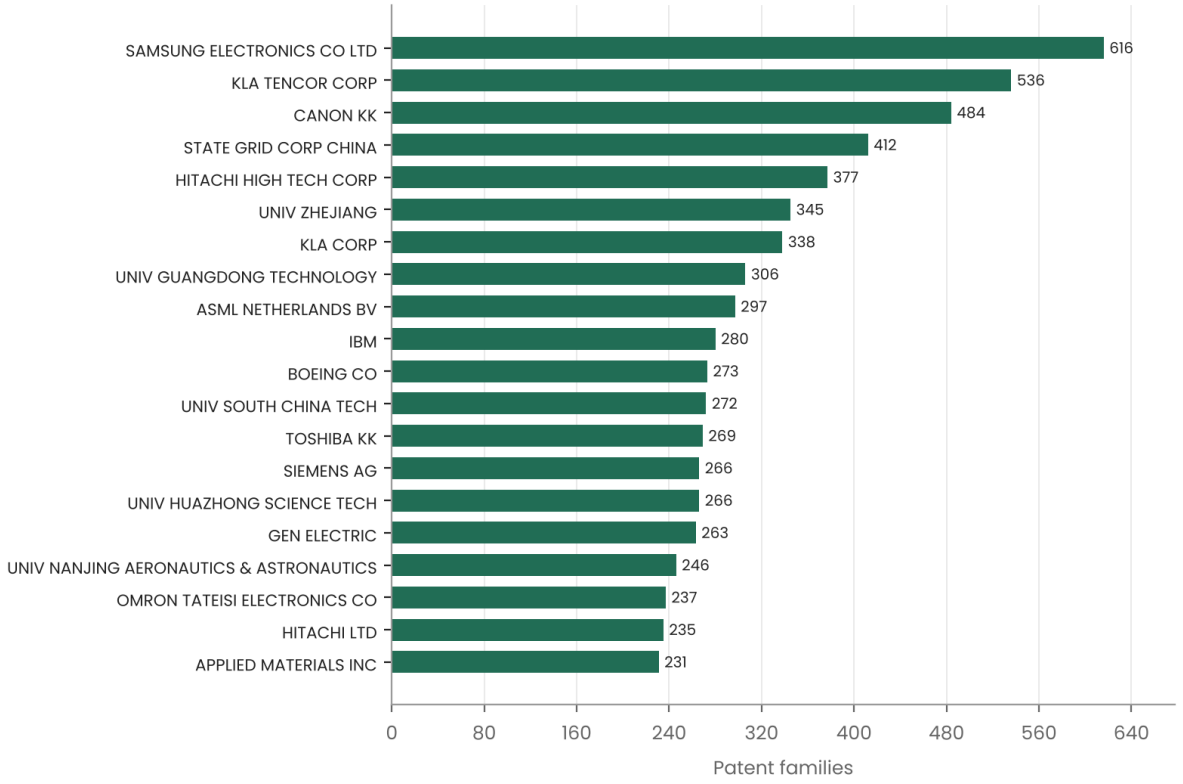


Figure 8 Top 20 applicants as recorded in Espacenet (all quality control families)

- **Semiconductor inspection specialists.** KLA appears twice (KLA Tencor Corp with 536 families and KLA Corp with 338), together with Hitachi High-Tech (377), ASML Netherlands (297), Applied Materials (231 and 213 for its Israeli entity) and Tokyo Electron (208).
- **Diversified industrial and electronics groups.** Samsung Electronics (616) leads the list, followed by Canon (484), IBM (280), Boeing (273), Toshiba (269 and 231 under two names), Siemens (266), General Electric (263), Omron (237) and Hitachi (235).
- **Chinese universities and utilities.** State Grid Corporation of China (412) and several universities, such as Zhejiang University (345), Guangdong University of Technology (306) and South China University of Technology (272), show the weight of public research in the Chinese filings.
- **Battery manufacturers.** Contemporary Amperex Technology (229 and 139 under two names) and LG Energy Solution (191) indicate that battery production has become a major user of inspection technology.

The field is not concentrated. The largest single entry represents 0.7% of the families, and the 20 entries of Figure 8 together add up to 6,549 families, less than 8% of the total. Thousands of companies and research organisations contribute, which leaves room for new entrants and specialised players.

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The inventor ranking is dominated by very common Chinese names (for example Wang Wei with 305 families and Zhang Wei with 289). These entries group different persons with the same name and cannot be interpreted individually. They are consistent with the high share of Chinese filings.

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4. INDUSTRY 5.0 PERSPECTIVE: HUMAN-CENTRIC QUALITY CONTROL

4.1. Size and Evolution of the Segment

Query 2 identifies 1,454 families in which the quality control invention is described together with the worker, the human operator, human-robot collaboration, augmented reality, wearables, human-in-the-loop approaches or explainability. This is 1.7% of the field. The segment is recent: 73% of its families were first published in 2020 or later. Figure 9 shows the yearly values.

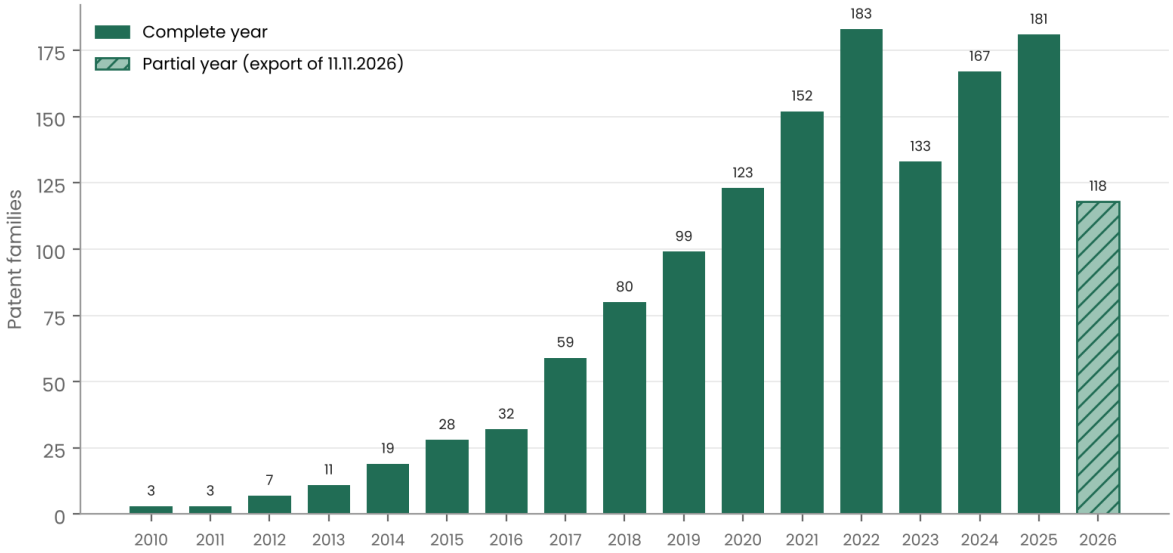


Figure 9 Human-centric subset: patent families by earliest publication year, 2010 to 2026

The segment grew from 28 families in 2015 to 99 in 2019 and 183 in 2022. After a lower year in 2023 (133 families) it recovered to 167 in 2024 and 181 in 2025, with 118 families already published in 2026. The priority year series shows a similar pause: 156 families in 2021, 150 in 2022 and 138 in 2023, followed by a new high of 173 in 2024.

This pause is more visible than in the field as a whole. It suggests that human-centric developments, which depend on work with operators on the shop floor, were more exposed to the conditions of the COVID-19 period than fully automated inspection. The recovery in 2024 and 2025 shows that the interest has returned.

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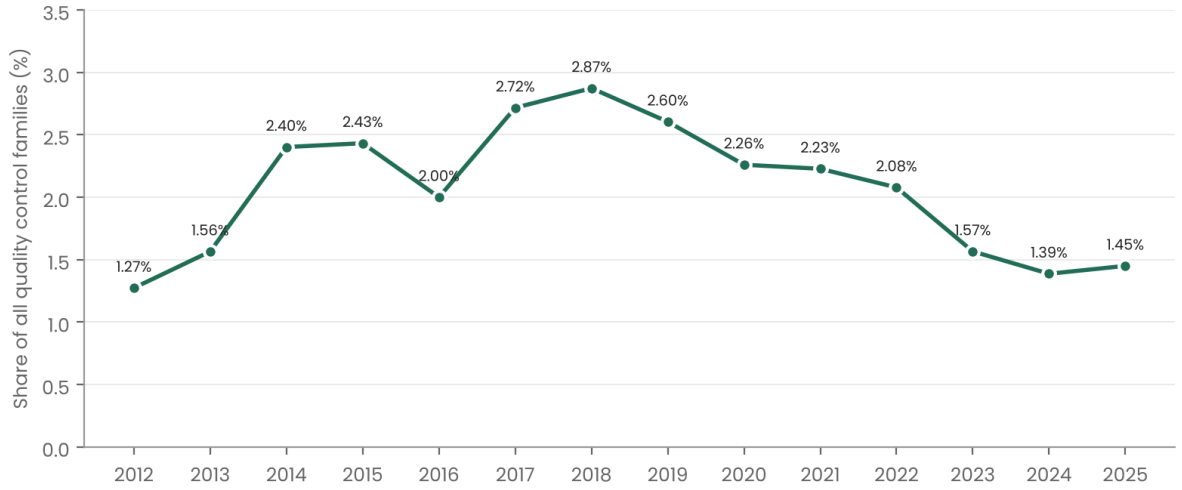


Figure 10 Share of the human-centric subset in all quality control families, by earliest publication year

In relative terms (Figure 10), the human-centric share rose from 1.3% in 2012 to a peak of 2.9% in 2018 and then moved down to about 1.4% in 2024 and 2025. The segment keeps growing in absolute numbers, but automated AI-based inspection has grown even faster. From an Industry 5.0 point of view this is an important observation: the technology push of recent years has been directed mainly at automation, and the integration of the human role into quality control is still at an early stage. The segment is open for organisations that want to take a leading position.

4.2. Geographic Distribution

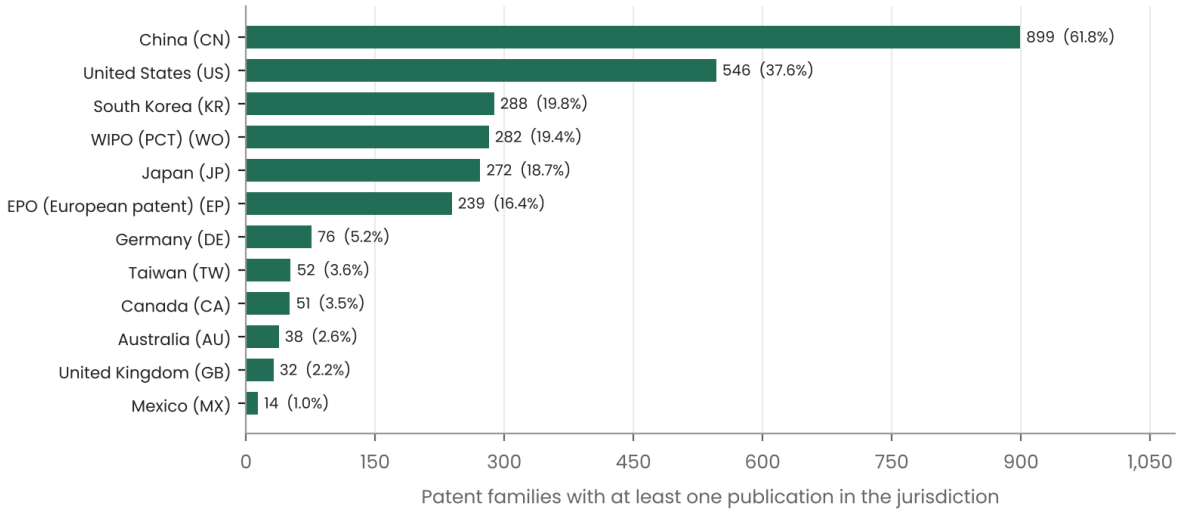


Figure 11 Human-centric subset: top 12 publication jurisdictions

The human-centric families are more international than the field as a whole, as Figure 11 shows. China is present in 62% of them (77% in the main dataset), while the United States reaches 38% (24%), PCT applications 19% (13%), South Korea 20% (12%), Japan 19% (11%) and the European Patent Office 16.4% (9.8%). Applicants in this segment more often seek protection in several markets, including Europe.

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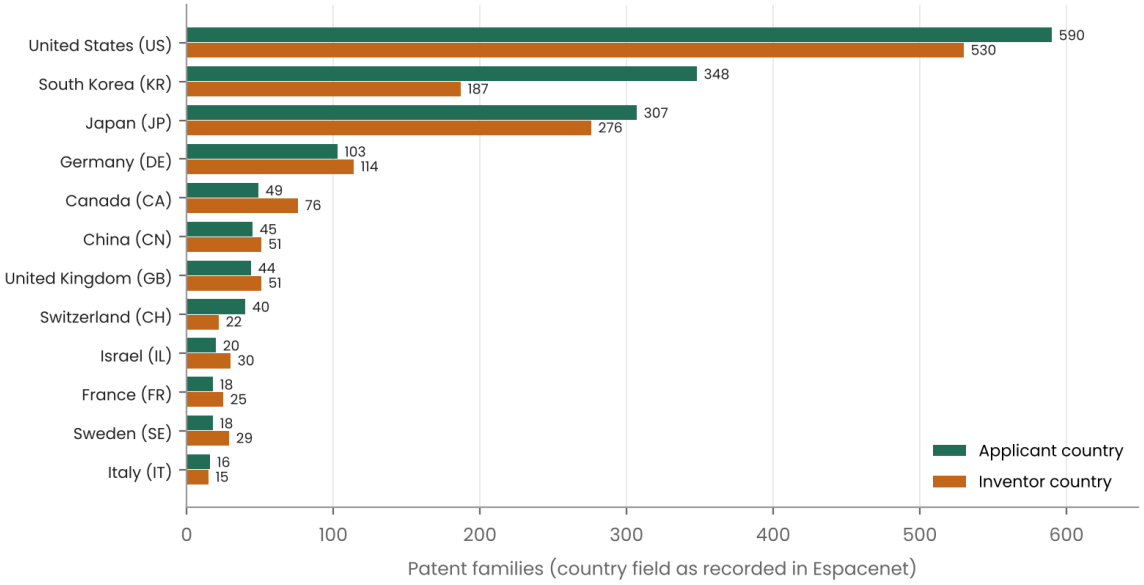


Figure 12 Human-centric subset: top 12 applicant countries and the corresponding inventor counts

Where the applicant country is recorded (Figure 12), the United States leads (590 families), followed by South Korea (348), Japan (307) and Germany (103). Among the European Union countries, France and Sweden (18 each), Italy (16), Finland (13), Spain and Ireland (12 each) also contribute. Türkiye appears with 10 families, at a level comparable to several Member States.

4.3. Technology Profile

The comparison of classification shares between the subset and the main dataset shows that human-centric quality control is not simply a smaller copy of the field. It has its own technology profile. Figure 13 compares the main groups and Table 5 gives the detailed codes.

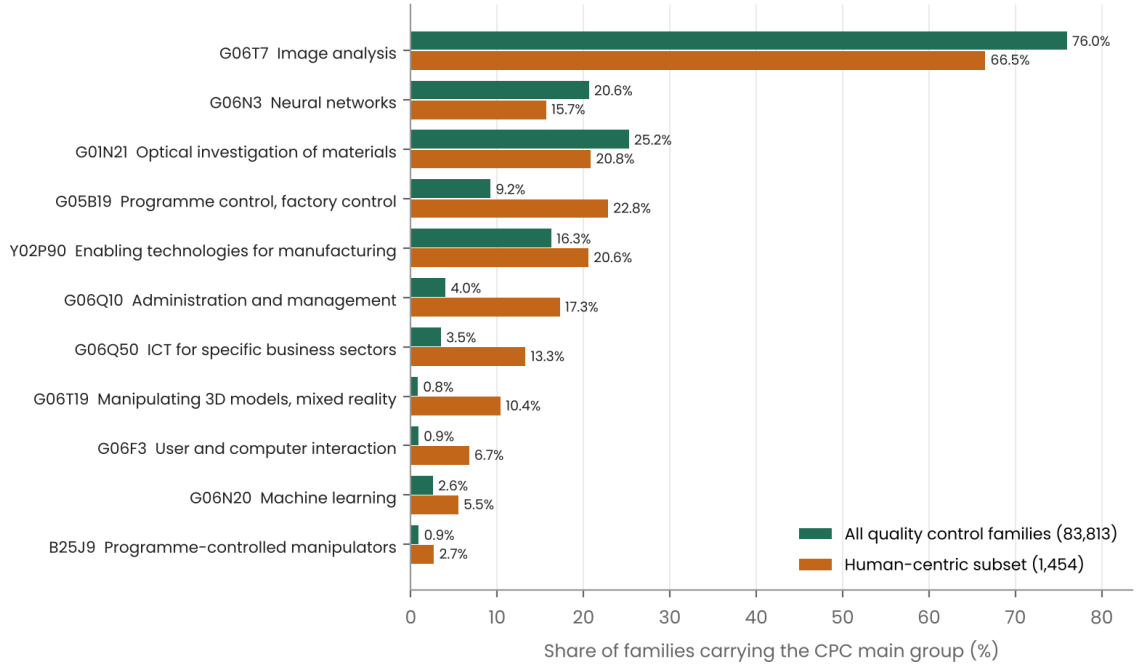


Figure 13 Share of families carrying selected CPC main groups: all quality control families and human-centric subset

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Table 5 Selected CPC codes in the main dataset and in the human-centric subset

CPC code	Description	All families	Share	Subset	Share
G06T7/0004	Industrial image inspection	49,200	58.7%	678	46.6%
G05B19/41875	Factory control with quality surveillance of production	6,843	8.2%	288	19.8%
Y02P90/02	Total factory control, smart factories	4,093	4.9%	194	13.3%
G06Q50/04	ICT for the manufacturing sector	1,555	1.9%	104	7.2%
G06Q10/06395	Quality analysis or management	1,101	1.3%	62	4.3%
G05B2219/32368	Quality control (control systems indexing)	1,865	2.2%	64	4.4%
G06T2207/20081	Training and learning methods	16,946	20.2%	212	14.6%
G06T2207/20084	Artificial neural networks	15,881	18.9%	177	12.2%
G06T2207/30148	Semiconductors, integrated circuits, wafers	6,124	7.3%	28	1.9%
G06T2207/30164	Workpieces and machine components	7,409	8.8%	141	9.7%

- **From the inspection station to the factory system.** Factory control with quality surveillance is present in 20% of the human-centric families against 8% overall, and quality management and manufacturing ICT codes are three to four times more frequent.
- **Mixed reality and interaction.** The main group for 3D models and mixed reality (G06T19) is carried by 10.4% of the subset against 0.8% of the field, and user and computer interaction (G06F3) by 6.7% against 0.9%. The mixed reality code G06T19/006 alone covers 124 human-centric families. Inspection results are brought to the operator through augmented reality and wearable displays.
- **Collaboration with robots.** Programme-controlled manipulators (B25J9) are three times more frequent in the subset (2.7% against 0.9%).
- **Less pure automation.** AI codes remain important but are less dominant (learning methods in 15% of the subset against 20% overall), and semiconductor inspection, the most automated domain, almost disappears (1.9% against 7.3%). Workpieces and machine components keep the same weight, which points to discrete manufacturing and assembly as the natural ground for human-centric quality control.

The technology chain behind this profile can be described in steps. Automated image inspection generates reliable defect information. Factory-level integration makes this information available in real time. Augmented reality, wearables and collaborative robots then bring it to the person at the workstation, who decides and acts. Explainable AI is the element that allows the operator to trust and correct the system. Each step depends on the previous one, which explains why the human-centric segment develops later than automated inspection.

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4.4. Applicants

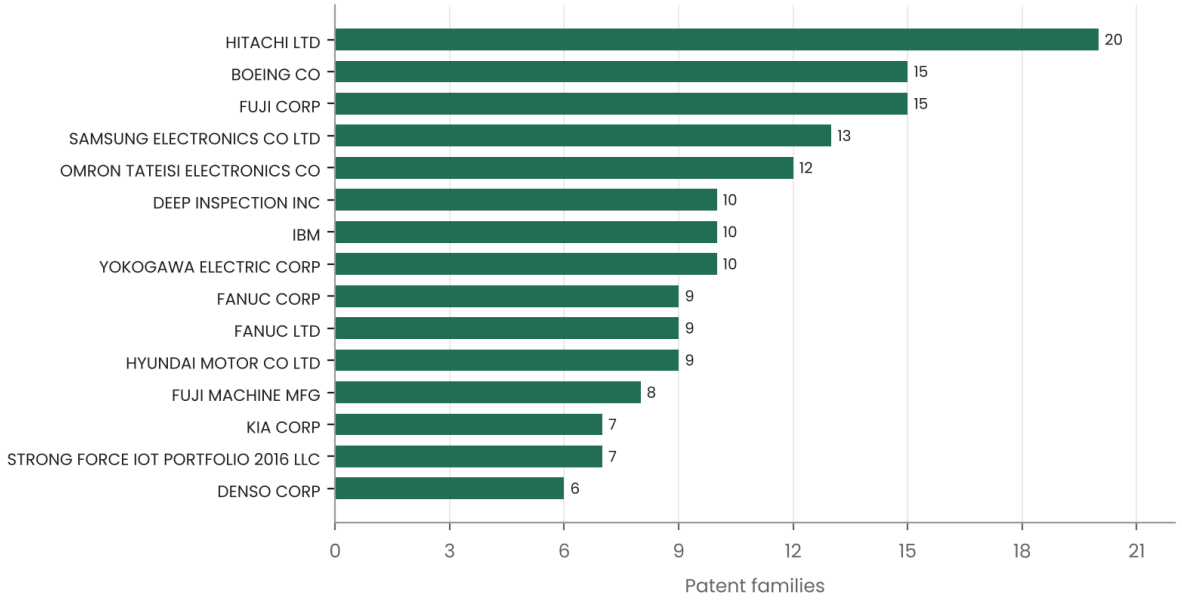


Figure 14 Human-centric subset: top 15 applicants as recorded in Espacenet

As Figure 14 shows, the segment is led by Japanese, Korean and United States companies from automation, automotive and aerospace: Hitachi (20 families), Boeing (15), Fuji Corp (15, plus 8 as Fuji Machine Mfg), Samsung Electronics (13), Omron (12), IBM (10), Yokogawa Electric (10), Fanuc (9 under each of two names), Hyundai Motor (9) and Kia (7). Siemens AG (6) is the first European applicant, and Henkel also appears among the applicants with 3 families.

No applicant holds more than 20 families, or 1.4% of the segment. The list of applicants is long and most of them have only one or two families. Compared with the main dataset, the portfolios are small and the positions are not yet established.

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5. EUROPE IN FOCUS

5.1. Europe as a Base of Applicants and Inventors

The EU-27 is one of the three main origins of quality control inventions in the available country data. Summing the Member States, EU-27 applicants appear in 16,555 families and EU-27 inventors in 17,256 families. Figure 16 gives the breakdown by Member State.

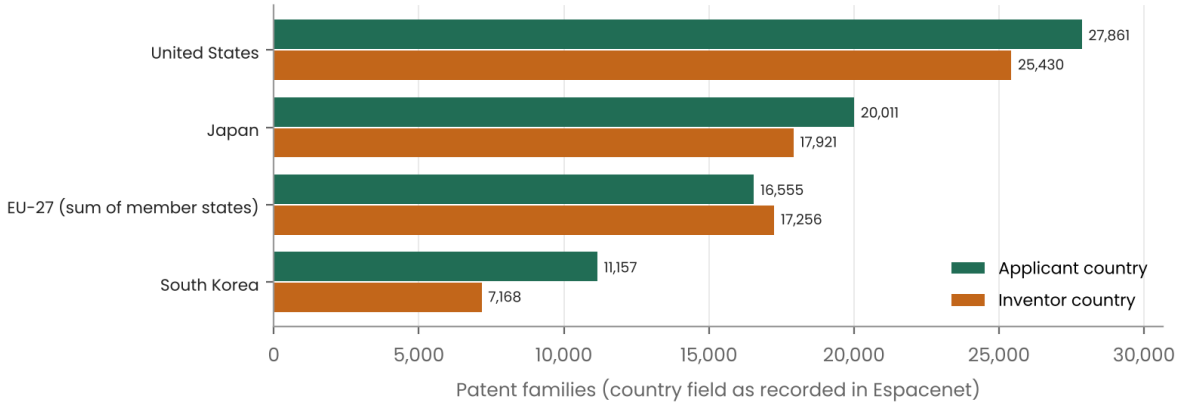


Figure 15 Applicant and inventor counts: EU-27 compared with the United States, Japan and South Korea (all quality control families)

With these values (Figure 15) the EU-27 is third behind the United States and Japan and clearly ahead of South Korea. On the inventor side the EU-27 (17,256) is almost level with Japan (17,921). China is not included in this comparison because its applicant country data are incomplete, as explained in the methodological notes.

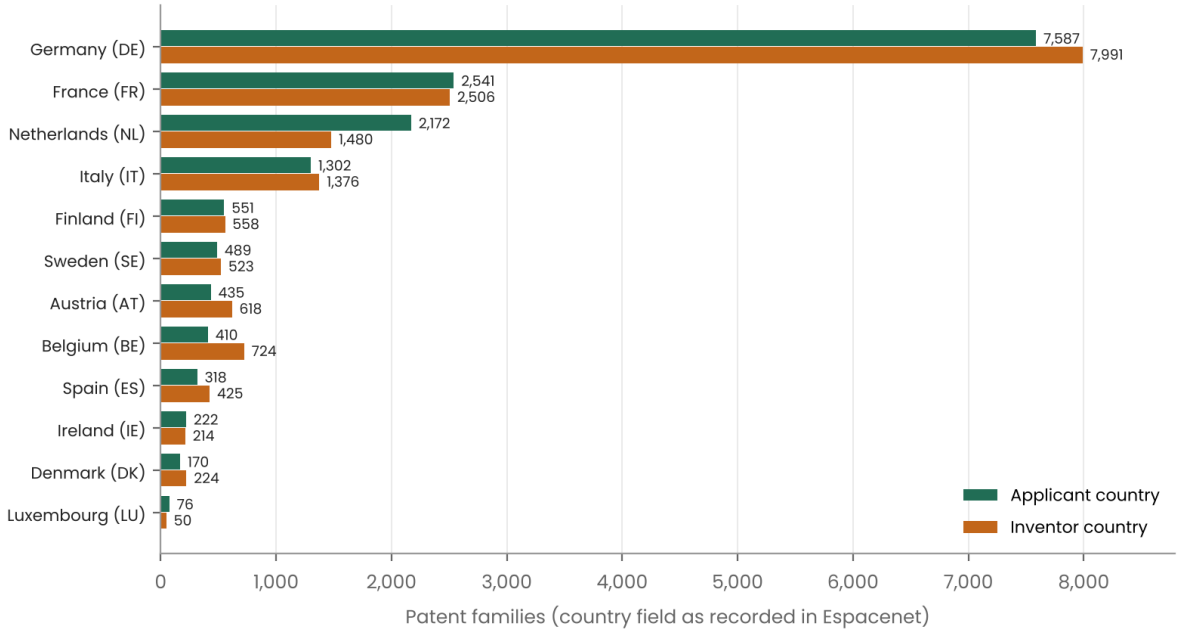


Figure 16 EU-27 Member States: applicant and inventor counts, top 12 (all quality control families)

- **Germany** is the European centre of gravity, with 7,587 families as applicant country and 7,991 as inventor country. It ranks fourth worldwide among applicant countries and third among inventor countries.

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- **France** (2,541 and 2,506) and **the Netherlands** (2,172 and 1,480) follow. The Dutch applicant count exceeds its inventor count, which reflects the role of large Dutch-based applicants in semiconductor equipment.
- **Italy** (1,302 and 1,376), **Finland**, **Sweden**, **Austria**, **Belgium** and **Spain** form a broad second group.
- **European inventors are in demand.** In Belgium (724 inventor families against 410 applicant families), Austria (618 against 435), Spain (425 against 318) and Germany, inventors contribute to more families than domestic applicants own. European engineering talent is therefore present in more inventions than the applicant statistics alone show.

5.2. Leading European Applicants

European applicants are present across the whole range of sectors that use inspection technology. Figure 17 lists the largest applicants headquartered in the EU-27 that can be identified in the Espacenet applicant ranking.

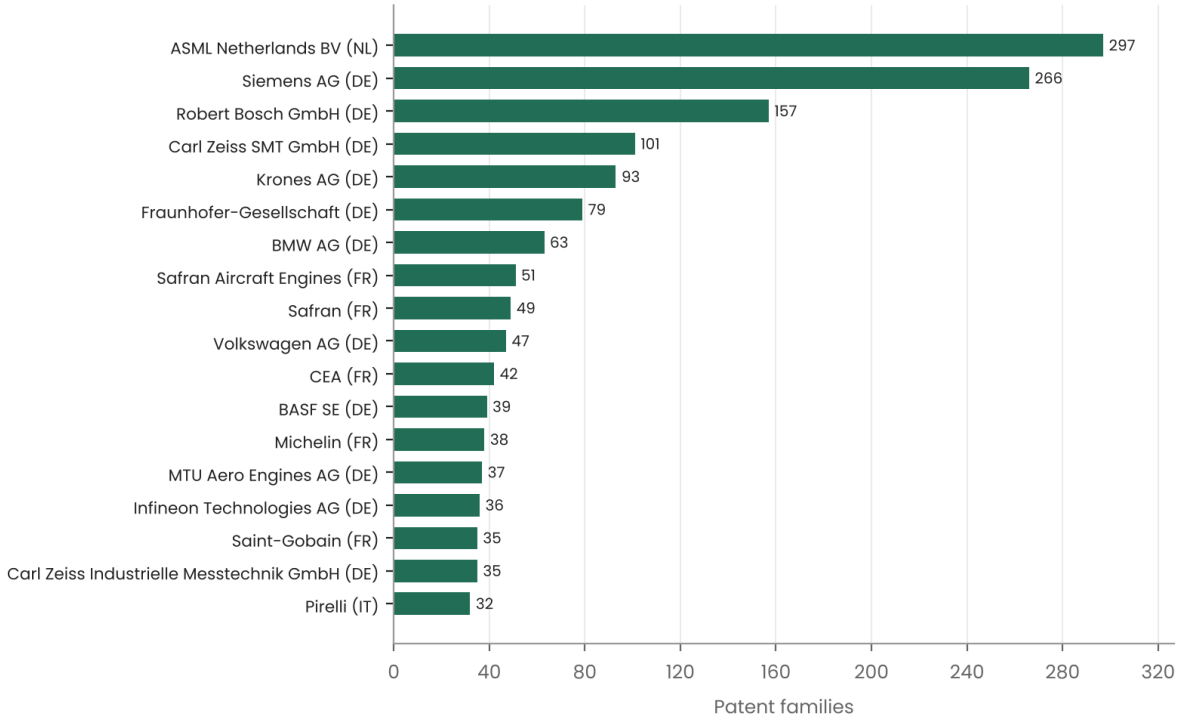


Figure 17 Leading applicants headquartered in the EU-27, as recorded in Espacenet (all quality control families)

- **Semiconductor and optical equipment:** ASML Netherlands (297 families, ninth worldwide in the ranking), Carl Zeiss SMT (101), Infineon Technologies (36) and Carl Zeiss Industrielle Messtechnik (35).
- **Industrial automation and automotive:** Siemens (266), Robert Bosch (157), BMW (63), Volkswagen (47), Michelin (38) and Pirelli (32).
- **Aerospace:** Safran Aircraft Engines (51), Safran (49) and MTU Aero Engines (37).
- **Process and packaging industries:** Krones (93), BASF (39) and Saint-Gobain (35).
- **Research organisations:** Fraunhofer-Gesellschaft (79) and CEA (42).

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This diversity is a European strength. Quality control know-how is embedded in the sectors where European industry is a world leader, from lithography and metrology to vehicles, aero engines and packaging lines, and it is supported by strong applied research organisations.

5.3. Europe as a Market for Protection

The European Patent Office is the sixth most frequent jurisdiction, with 8,254 families, and Germany adds 3,224 families with a national publication. Among the other Member States, Spain (695), France (655), Poland (314), Austria (293) and Italy (293) are the most frequent; these national counts may include national publications of European patents. In addition, the EPO assigned CPC symbols to 41,498 families, about half of the field, which reflects its central role in the international patent system.

5.4. Europe in the Human-Centric Segment

In the human-centric subset, EU-27 applicants appear in 212 families and EU-27 inventors in 236 families. On the inventor side the EU-27 is third worldwide, behind the United States (530) and Japan (276) and ahead of South Korea (187). Germany is fourth as applicant country (103) and as inventor country (114), and Sweden (29 inventor families), France (25), Italy and Spain (15 each) and Ireland (9) follow. Table 6 compares the main indicators.

Table 6 EU-27 indicators in the main dataset and in the human-centric subset

Indicator	All quality control families	Human-centric subset
Total families	83,813	1,454
Families with a European (EP) publication	8,254 (9.8%)	239 (16.4%)
Families with a German national publication	3,224 (3.8%)	76 (5.2%)
EU-27 applicant count (sum of Member States)	16,555	212
EU-27 inventor count (sum of Member States)	17,256	236
Germany, applicant count and world rank	7,587 (4th)	103 (4th)
Germany, inventor count and world rank	7,991 (3rd)	114 (4th)
Families classified by the EPO (CPC assigning office)	41,498 (49.5%)	848 (58.3%)

Two points stand out. First, Europe is a preferred market for human-centric quality control: 16.4% of these families include a European publication, against 9.8% for the field as a whole. Applicants from all regions consider Europe an important place to protect this type of invention. Second, the segment is still open. The largest portfolio worldwide has 20 families and European companies such as Siemens and Henkel are already present.

5.5. Opportunities for Europe

- **Build on existing strengths.** European applicants already hold solid positions in inspection for semiconductors, automotive, aerospace and process industries. Extending these portfolios towards operator assistance, augmented reality and explainable inspection is a natural next step.

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- **Use the open space.** The human-centric share of the field is below 2% and no dominant applicant exists. Early and focused patenting can secure strong positions at limited cost.
- **Combine industry and research.** The presence of Fraunhofer and CEA next to industrial applicants, and the high number of European inventors, are a good basis for collaborative projects, including those funded by European programmes.
- **Protect at home.** The higher share of European publications in the human-centric segment shows that Europe is seen as a lead market for these solutions. European innovators are well placed to serve it.

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6. CONCLUSIONS

This analysis of 83,813 patent families shows that quality control and inspection in manufacturing is one of the fastest growing fields of industrial innovation. Activity has multiplied by almost eleven in ten years, and three quarters of all families were first published in 2020 or later. The growth is driven by image analysis and artificial intelligence, which now define the field, and it extends from electronics to metal, textiles, construction materials and food.

The COVID-19 period did not reverse this trend. Priority filings increased every year, with a moderate slowdown of the growth rate in 2021 and 2022 and a recovery afterwards. The human-centric segment shows a more visible pause in 2022 and 2023 and a return to growth in 2024 and 2025.

From the perspective of Industry 5.0, the central result is that the human-centric part of quality control is small (1,454 families, 1.7% of the field) but has a distinct profile. It connects inspection with factory-level quality surveillance, quality management, mixed reality, user interaction and collaborative robots. Its share has not yet followed the rise of automated AI inspection, which means that the integration of the worker into digital quality control remains an open field for innovation.

Europe is well placed in this landscape. The EU-27 is the third origin of inventions in the available country data, close to Japan, with Germany, France, the Netherlands and Italy in leading positions and with world-class applicants in equipment, automotive, aerospace and process industries. European protection is sought more often for human-centric inventions than for the field in general. European manufacturers, technology providers and research organisations therefore have both the industrial base and the market to take a leading role in human-centric quality control.

Three lessons follow for PROSPECTS 5.0 and its stakeholders. Patent data are a practical way to observe the transition towards Industry 5.0, provided that the search strategy is specific enough. Technology is advancing in a clear sequence, from automated inspection to factory integration and then to the human interface, and each step opens new space for intellectual property. Finally, the limits of the data should be kept in mind: the most recent years are incomplete, applicant country information is partial, and the human-centric subset is a keyword-based proxy. A future update could add dedicated searches for the sustainability and resilience dimensions and follow the 2025 and 2026 filings once they are fully published.

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7. REFERENCES

[1] European Patent Office. Espacenet patent search [online]. Available at: https://worldwide.espacenet.com [Accessed 11 November 2026].

[2] European Patent Office. Espacenet filter statistics for Query 1, quality control and inspection in manufacturing, 83,813 results. Export file Filters_20261111_1105.xlsx, 11 November 2026.

[3] European Patent Office. Espacenet filter statistics for Query 2, human-centric subset, 1,454 results. Export file Filters_20261111_1111.xlsx, 11 November 2026.

[4] European Patent Office and United States Patent and Trademark Office. Cooperative Patent Classification (CPC) scheme [online]. Available at: https://www.cooperativepatentclassification.org [Accessed 11 November 2026].

[5] European Commission, Directorate-General for Research and Innovation. Industry 5.0: Towards a sustainable, human-centric and resilient European industry. Luxembourg: Publications Office of the European Union, 2021.

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PROSPECTS 5.0

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