PROSPECTS 5.0

PROSPECTS 5.0 Industry 5.0 Wiki August 2026 Patent Analysis

Wearable Exoskeletons for Industrial and Occupational Use

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1. EXECUTIVE SUMMARY

This report presents a patent landscape analysis of wearable exoskeletons and closely related body-worn assistive and human-augmentation technologies for industrial and occupational use. The analysis is based exclusively on a structured search of the European Patent Office (EPO) Espacenet database, which returned 38,758 patent families matching the combined technology and application criteria. All figures, trends and interpretations reported here are derived solely from that dataset.

The field has moved from a niche research topic into a mature, fast-growing area of industrial innovation. Annual publication volumes rose from roughly 130 families per year at the start of the 2000s to more than 3,000 families per year from 2018 onwards, an increase of over twenty-fold. A clear inflection appears around 2015, after which filing activity accelerated sharply and then settled onto a high, sustained plateau that has held through the most recent complete years in the dataset.

Protection is sought most heavily in the United States (19,702 families) and China (19,065 families), followed by a very large volume of international PCT filings (WO, 12,457) and European Patent Office filings (EP, 8,607). Europe occupies a central and strategically strong position in this landscape: the EPO is the fourth-largest jurisdiction of protection and the single largest CPC-assigning office in the dataset, confirming that Europe is a priority market that innovators worldwide actively seek to protect.

On the innovation-origin side, the EU-27 collectively forms one of the world's principal knowledge bases for this technology, led by Germany, France, Finland, Italy, Sweden and the Netherlands. European applicants combine strong industrial engineering, robotics and rehabilitation-technology traditions, positioning the Union to convert its research strengths into occupational and manufacturing applications aligned with the human-centric ambitions of Industry 5.0.

The technology mix is dominated by wearable human-machine interaction and sensing (head-mounted and body-worn computing, gesture, gaze and hand tracking) together with a substantial robotics and assistive-mechanics cluster (manipulators mimicking human limbs, walking and mobility aids, and on-body rehabilitation devices). This dual character reflects the convergence of digital interaction technologies with physical assistance systems that defines modern occupational exoskeletons and exosuits.

Publication activity remained essentially flat across 2020 and 2021, 3,039 and 3,038 families respectively, interrupting the steep pre-pandemic climb. This plateau is consistent with the operational disruption of the COVID-19 period. Activity resumed its upward path from 2022, indicating that the pandemic tempered the pace of growth temporarily without altering the long-term trajectory of the field.

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2. INTRODUCTION

2.1. Scope and Objectives

Wearable exoskeletons, exosuits and related body-worn assistive systems are increasingly deployed to support workers in manufacturing and other physically demanding occupational settings. By augmenting human strength, reducing musculoskeletal load and improving ergonomics, these technologies are central to the human-centric, resilient and sustainable vision of Industry 5.0. This report maps the intellectual-property landscape surrounding these technologies to help the PROSPECTS 5.0 consortium understand where innovation is concentrated, who the principal actors are, how the field is evolving over time, and where Europe stands.

2.2. Data Source and Search Strategy

The analysis draws on a single, authoritative source: the EPO Espacenet worldwide patent collection. The search combined a technology dimension with an application dimension. The technology dimension captured wearable-computing and human-machine-interaction classifications (CPC G06F1/163, G06F3/012, G06F3/014), manipulators mimicking human limbs (B25J9/0006) and free-text concepts covering exoskeletons, exosuits and musculoskeletal systems. The application dimension restricted results to industrial and occupational contexts through free-text terms such as production, manufacturing, worker, factory, shop floor, operator, occupational, plant, blue-collar and wearable.

The combined query returned 38,758 patent families. Counting is performed at the patent-family level, so each distinct invention is counted once regardless of how many national filings it generates, which avoids double-counting and gives a robust basis for cross-country comparison. Every statistic in this report is taken directly from the Espacenet result set and its associated filter breakdowns; no external data has been introduced.

2.3. Methodological Notes

Two dating conventions are used. The earliest priority date approximates when an invention was first filed and is the best proxy for the timing of inventive activity. The earliest publication date records when a family first became public. Because patent applications are typically published around 18 months after filing, and because recent priority years are still being published, the most recent one to two years are necessarily incomplete and should be read as provisional rather than as evidence of decline. Jurisdiction counts describe where protection is sought; applicant- and inventor-country counts describe where the innovation originates. Throughout this report, references to Europe and the EU-27 denote the twenty-seven member states of the European Union.

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3. TEMPORAL EVOLUTION OF THE FIELD

The dataset spans more than a century, with isolated early records reaching back to the late nineteenth century, but meaningful volume is a twenty-first-century phenomenon. Annual publications grew steadily through the 2000s and then entered a phase of rapid expansion in the mid-2010s (Figure 1).

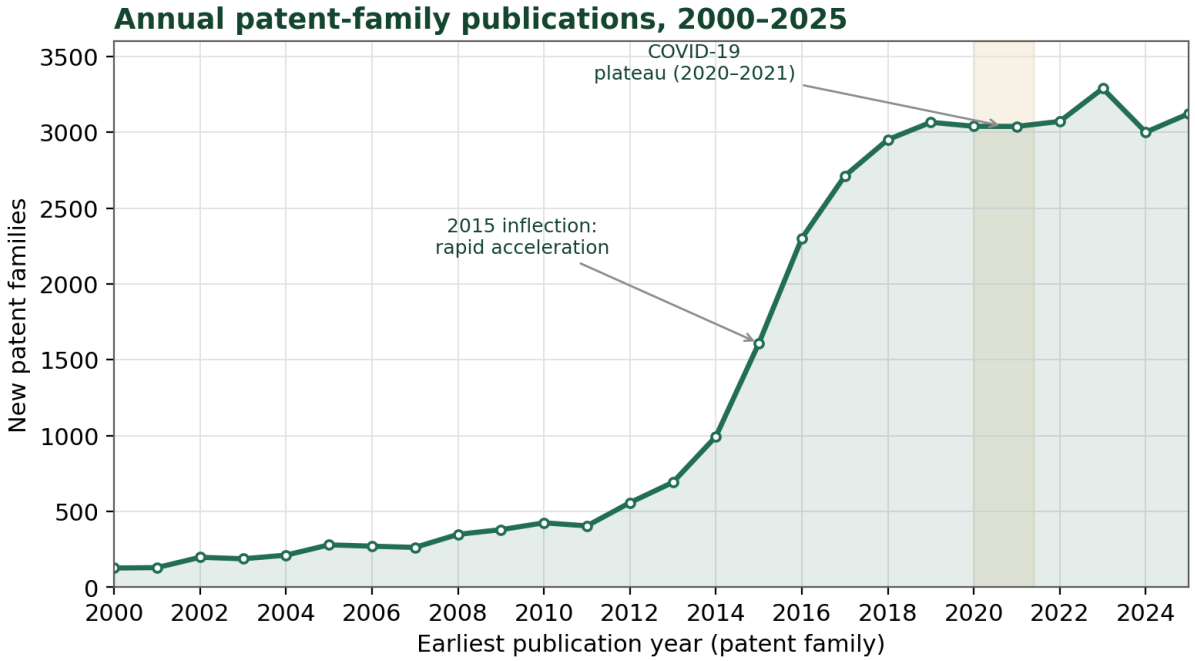

Figure 1 Annual patent-family publications by earliest publication year (2000–2025).

Three phases are visible. A slow-growth phase through to about 2011 saw annual volumes rise from around 130 to roughly 400 families. A rapid-acceleration phase then took hold: publications climbed from 558 in 2012 to 1,609 in 2015 and 2,712 in 2017, effectively quadrupling in five years. From 2018 the field reached a high-plateau phase, holding consistently above 3,000 families per year — 2,951 in 2018, 3,065 in 2019 and 3,288 in 2023, the strongest complete year on record. This trajectory signals a technology that has passed from early research into sustained, industrial-scale development.

The 2015 inflection is notable. It coincides with the broad commercial emergence of wearable computing and advanced human-machine interfaces and with growing industrial interest in occupational exoskeletons, both of which are strongly represented in the technology breakdown discussed later in this report.

3.1. Priority Activity and the Leading Edge of Invention

Examining earliest priority dates, the timing of first filings, confirms the same underlying momentum and locates the leading edge of inventive activity. Priority filings rose from 505 in 2010 to a peak of 3,242 in 2022, the highest single-year figure in the dataset (Figure 2).

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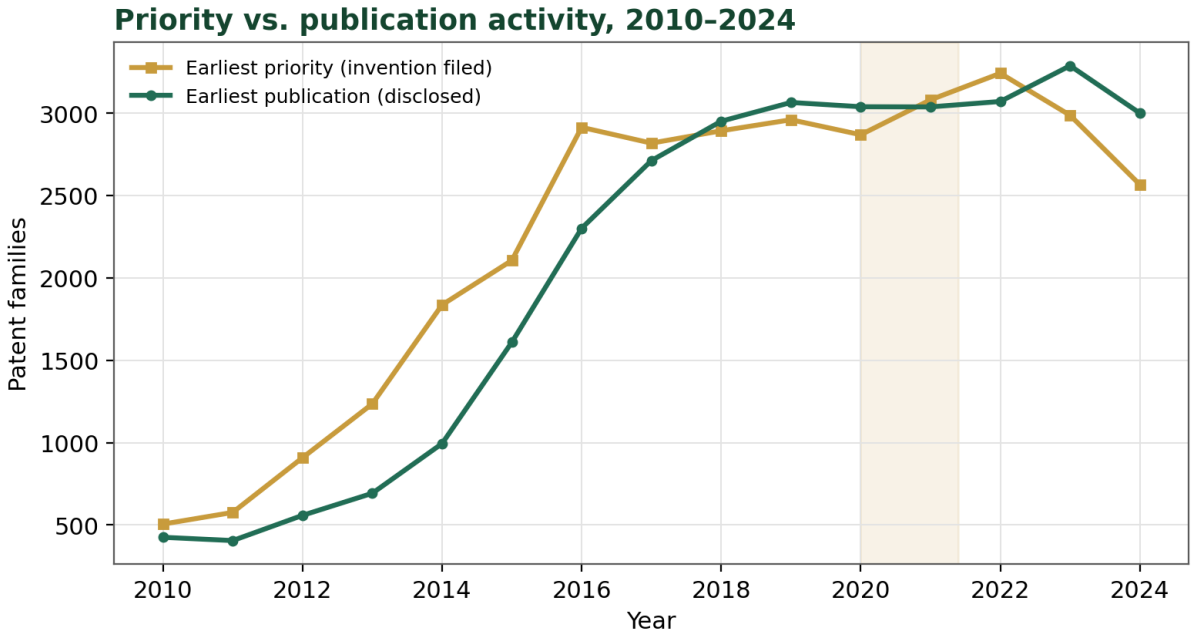

Figure 2 Earliest-priority versus earliest-publication activity (2010–2024).

The priority curve runs ahead of the publication curve, as expected given the publication delay inherent in the patent system. The apparent fall in the final years of the priority series reflects that many recently filed families have not yet been published and entered the counts, rather than any genuine slowdown. Read together, the two series describe a field whose inventive output is being sustained at its highest-ever levels.

3.2. The COVID-19 Period

The pandemic left a visible but contained imprint. After several years of steep growth, annual publications were essentially flat across 2020 and 2021, at 3,039 and 3,038 families respectively, a pause in what had been a rapidly rising curve. The priority series shows a similar softening, dipping from 3,081 in 2021 to levels consistent with disrupted filing conditions before recovering.

This pattern is consistent with the operational reality of 2020–2021: restricted access to laboratories, factories and testing facilities, disrupted R&D schedules and constrained processing at patent offices. Importantly, the interruption was temporary. Publications climbed again to 3,071 in 2022 and 3,288 in 2023, showing that the pandemic slowed the pace of growth for roughly two years without changing the field's long-term direction. For occupational exoskeleton technologies specifically, the heightened attention to worker health, safety and resilience during this period plausibly reinforced the underlying demand that drives continued filing.

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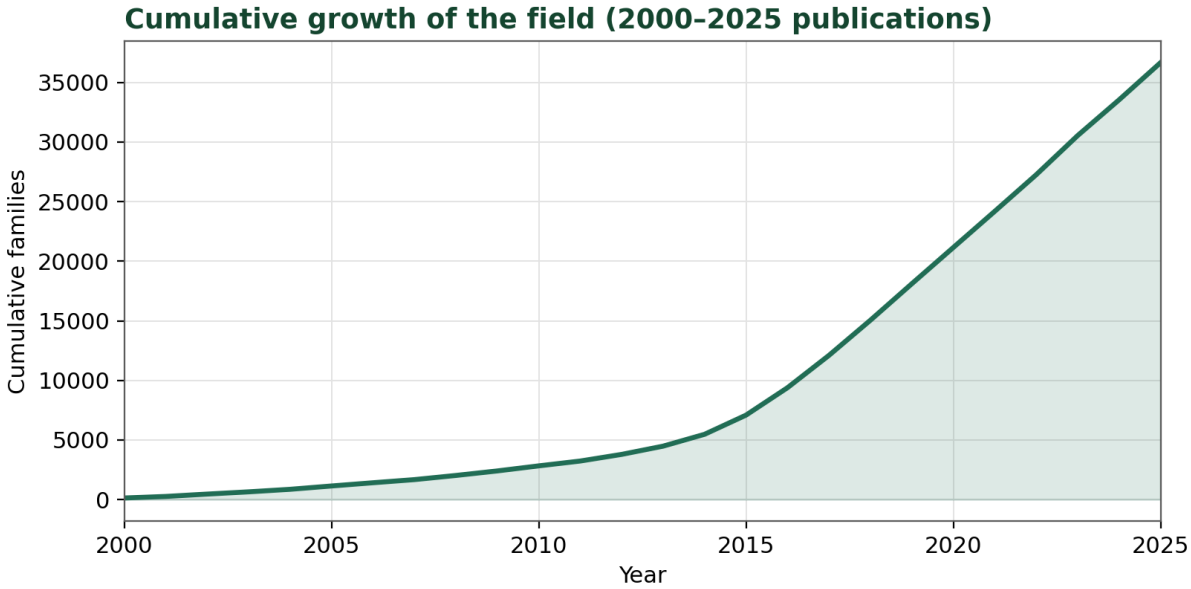

Figure 3 Cumulative growth of published patent families (2000–2025).

Viewed cumulatively, the field has compounded steadily, with the great majority of all families in the dataset published since 2015. The steepening slope of the cumulative curve underlines that this is a young, expanding domain rather than a mature or saturated one (Figure 3).

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4. GEOGRAPHIC DISTRIBUTION

4.1. Jurisdictions of Protection

The countries in which protection is sought reveal which markets applicants consider commercially important. The United States and China stand out, each associated with roughly 19,000 families, followed by a very high volume of PCT international filings and European Patent Office filings (Figure 4).

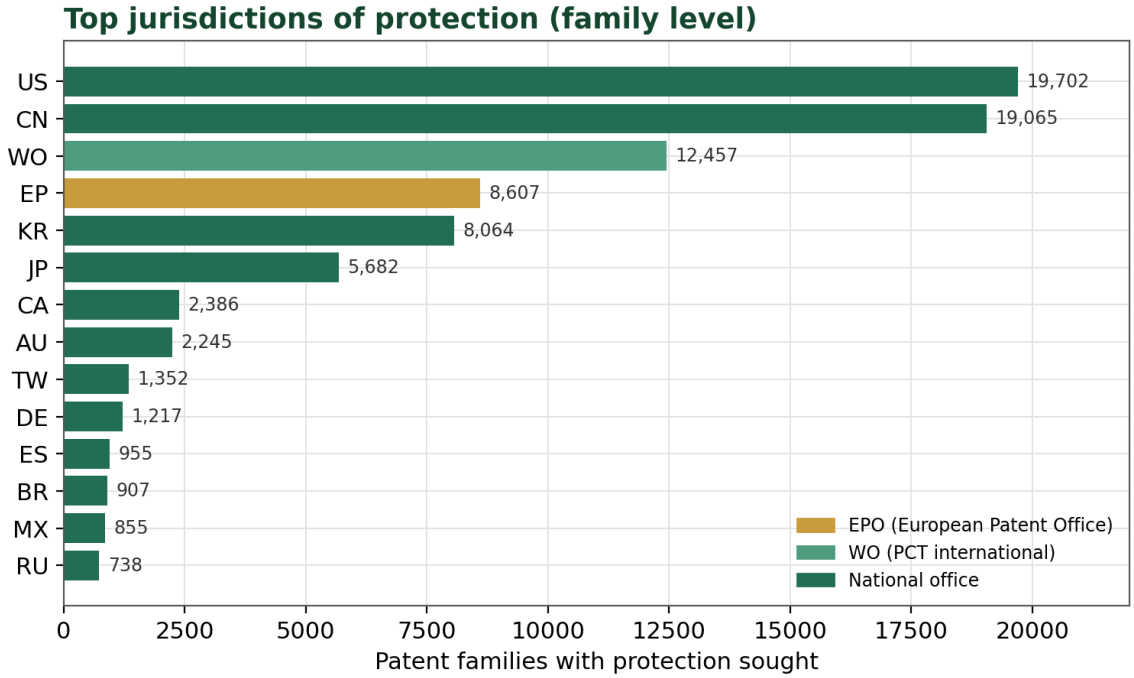

Figure 4 Top jurisdictions of protection at family level.

Europe's position here is a strength. The 8,607 EP filings represent applicants choosing to secure protection across multiple European states through a single, centralised route, which is a strong signal of the commercial value placed on European markets (Table 1). The large volume of PCT (WO) filings further indicates that many applicants keep European entry open through the international phase. Together these confirm Europe as a core destination market that global innovators actively prioritise.

Table 1 Leading jurisdictions where protection is sought (family level).

Jurisdiction	Families	Interpretation
US - United States	19,702	Largest single market for protection
CN - China	19,065	Very large and fast-growing market
WO - PCT (international)	12,457	High reliance on the international route
EP - European Patent Office	8,607	Europe a priority multi-country market
KR - Republic of Korea	8,064	Major electronics/robotics hub
JP - Japan	5,682	Established robotics and HMI base
CA - Canada	2,386	Significant secondary market
AU - Australia	2,245	Significant secondary market

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4.2. Origin of Innovation: Applicant Countries

Applicant-country data show where the innovation is generated. The United States leads (38,871 families), followed by the Republic of Korea (14,154) and Japan (7,505), reflecting the strength of their electronics, robotics and human-machine-interface industries (Figure 5).

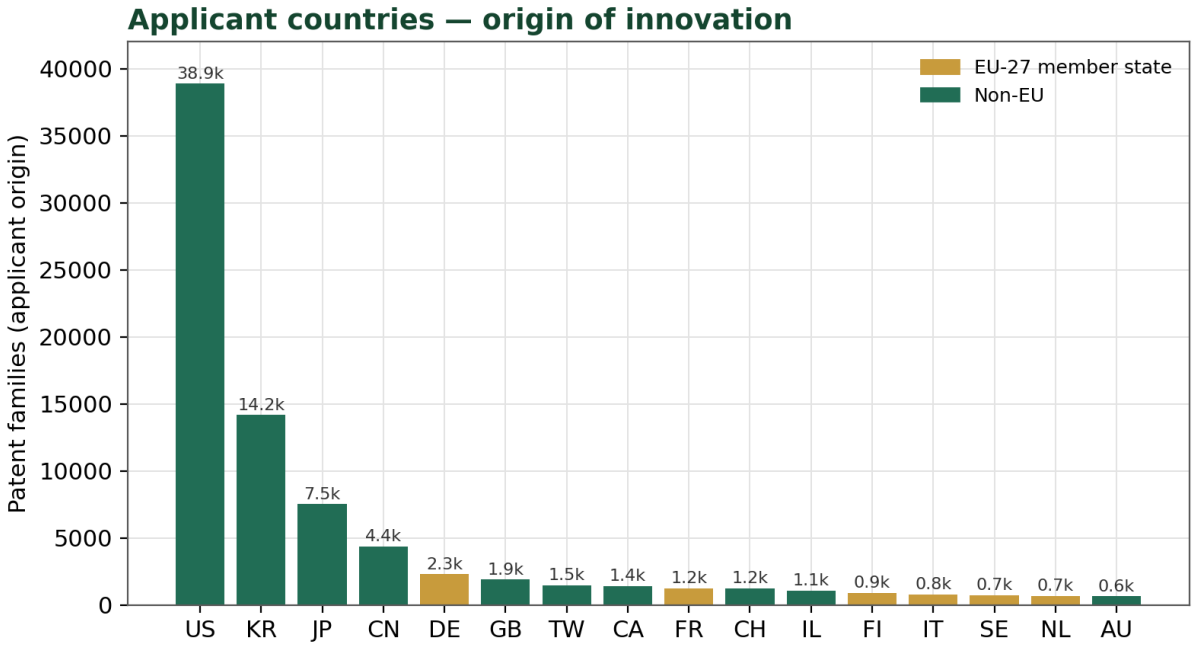

Figure 5 Applicant countries by origin of innovation, with EU-27 members highlighted.

Several EU-27 member states appear prominently among the leading origins of innovation, including Germany (2,276), France (1,244), Finland (907), Italy (786), Sweden (714) and the Netherlands (670). Rather than reading these individually, it is more informative to view the EU-27 as a single innovation bloc, which is the subject of the next section.

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5. EUROPE IN FOCUS: THE EU-27 INNOVATION BASE

Consistent with a European-strategic reading of the landscape, this section aggregates the EU-27 member states into a single view. Taken together, the EU-27 constitutes one of the world's principal centres of invention for wearable and assistive occupational technologies, combining deep engineering traditions with world-class rehabilitation and robotics research (Figure 6).

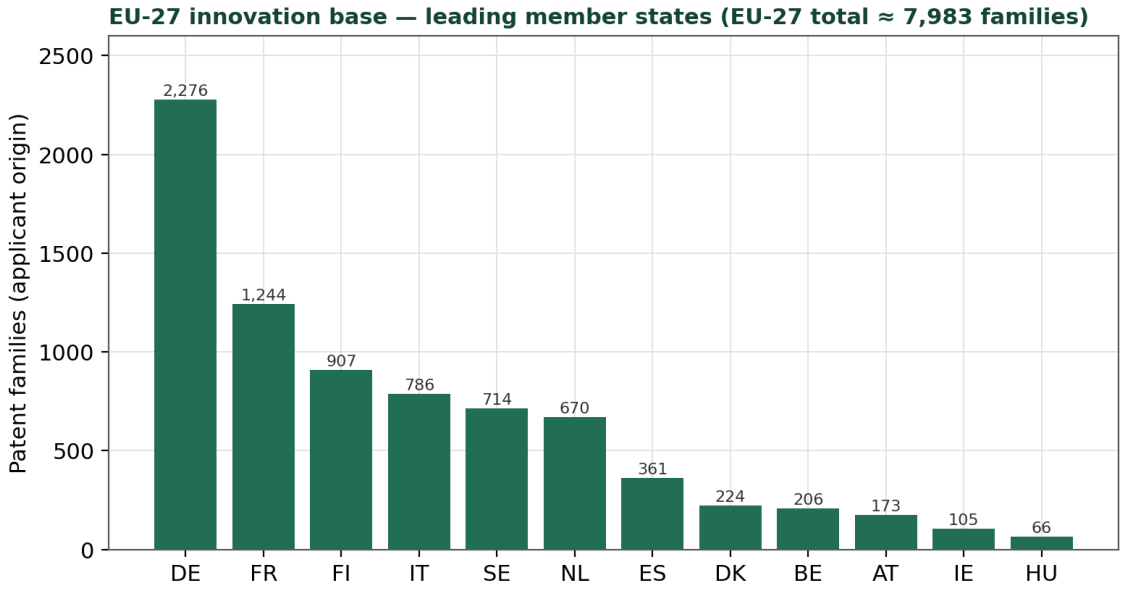

Figure 6 Leading EU-27 member states by origin of innovation (applicant country).

Within the Union, Germany provides the largest contribution, anchored by its automotive, industrial automation and robotics base, sectors where occupational exoskeletons deliver clear ergonomic value on the shop floor (Table 2). France follows with strong representation across robotics and assistive systems. Finland's presence is striking relative to its size and reflects a concentrated, high-quality technology sector, while Italy, Sweden and the Netherlands contribute established engineering and human-machine-interface expertise. Denmark, Belgium, Austria and other member states add further depth.

Table 2. Principal EU-27 member states contributing to the field (applicant origin).

EU-27 Member State	Families (applicant)	European Strength
Germany	2,276	Industrial automation, robotics, automotive ergonomics
France	1,244	Robotics and assistive systems
Finland	907	Concentrated high-tech and HMI sector
Italy	786	Mechanical engineering and rehabilitation tech
Sweden	714	Industrial engineering and design
Netherlands	670	Human-machine interaction and health tech
Denmark	224	Health and assistive technology
Belgium	206	Research-intensive engineering
Austria	173	Industrial and mechatronics expertise

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This distributed strength is a European asset. No single member state dominates; instead, complementary national specialisms - German industrial robotics, French and Italian assistive-systems research, Nordic high-tech and human-centred design, and Dutch health-technology innovation - combine into a broad and resilient innovation base. This diversity is well matched to Industry 5.0's emphasis on human-centric, sustainable manufacturing, and it gives Europe multiple pathways to translate research into deployable occupational exoskeleton and exosuit solutions.

The complementary picture from the protection side reinforces the point: with the EPO the fourth-largest jurisdiction of protection and the largest CPC-assigning office in the dataset, Europe is simultaneously a significant source of invention and one of the most sought-after markets in which to secure it. Europe is therefore positioned not to catch up but to lead in the human-centric segment of this technology, where its strengths in ergonomics, worker wellbeing and industrial engineering are most directly relevant.

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6. TECHNOLOGY CLASSIFICATION

Classifying the dataset by Cooperative Patent Classification (CPC) subgroup reveals the technical composition of the field (Figure 7). Two broad clusters stand out: wearable human-machine interaction and sensing, and physical assistance and robotics.

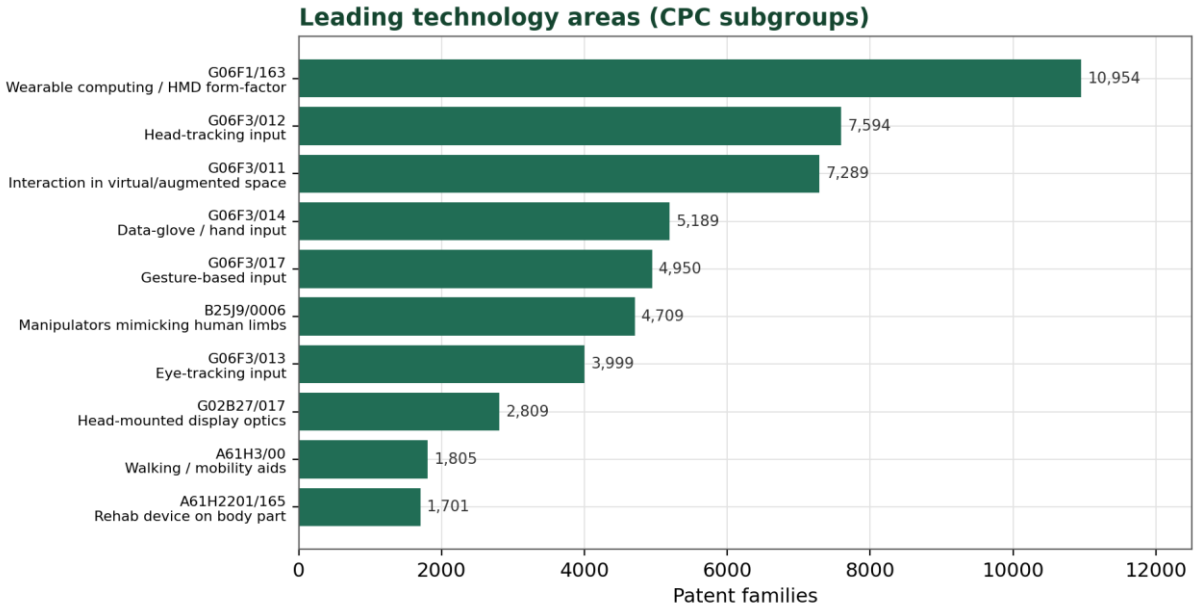

Figure 7 Leading technology areas by CPC subgroup.

Table 3 Leading CPC subgroups and their technology areas.

CPC subgroup	Technology area	Families
G06F1/163	Wearable computing / head-mounted form factor	10,954
G06F3/012	Head-tracking input	7,594
G06F3/011	Interaction in virtual/augmented space	7,289
G06F3/014	Data-glove / hand input	5,189
G06F3/017	Gesture-based input	4,950
B25J9/0006	Manipulators mimicking human limbs	4,709
G06F3/013	Eye-tracking input	3,999
G02B27/017	Head-mounted display optics	2,809
A61H3/00	Walking and mobility aids	1,805
A61H2201/165	On-body rehabilitation devices	1,701

The largest single area, wearable computing and head-mounted form factors (G06F1/163, 10,954 families), together with the cluster of interaction technologies - head tracking, hand and gesture input, gaze tracking and display optics - shows that a substantial part of the field concerns how workers perceive information and interact with systems while wearing devices. This is the sensing-and-interface backbone of human-augmentation systems (Table 3).

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The second cluster is more mechanical. Manipulators that mimic human limbs (B25J9/0006, 4,709 families), walking and mobility aids (A61H3/00, 1,805) and on-body rehabilitation devices (A61H2201/165, 1,701) correspond directly to the load bearing, strength-augmenting function of exoskeletons and exosuits. The presence of strong medical and rehabilitation classifications (A61H, A61B, A61P families elsewhere in the dataset) reflects the shared engineering lineage between clinical assistive devices and occupational exoskeletons, an area where European rehabilitation-technology expertise is particularly deep.

The co-occurrence of these two clusters is the defining feature of the landscape: modern occupational exoskeletons integrate sensing and human-machine interaction with physical actuation and support. Innovation increasingly sits at their intersection.

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7. COMPETITIVE LANDSCAPE

7.1. Leading Applicants

The applicant ranking is led by large electronics and technology companies, reflecting the prominence of the wearable-computing and interaction cluster identified above. Samsung Electronics is the single most active applicant with 1,876 families, ahead of Apple (876) and a group of major platform and electronics firms (Figure 8).

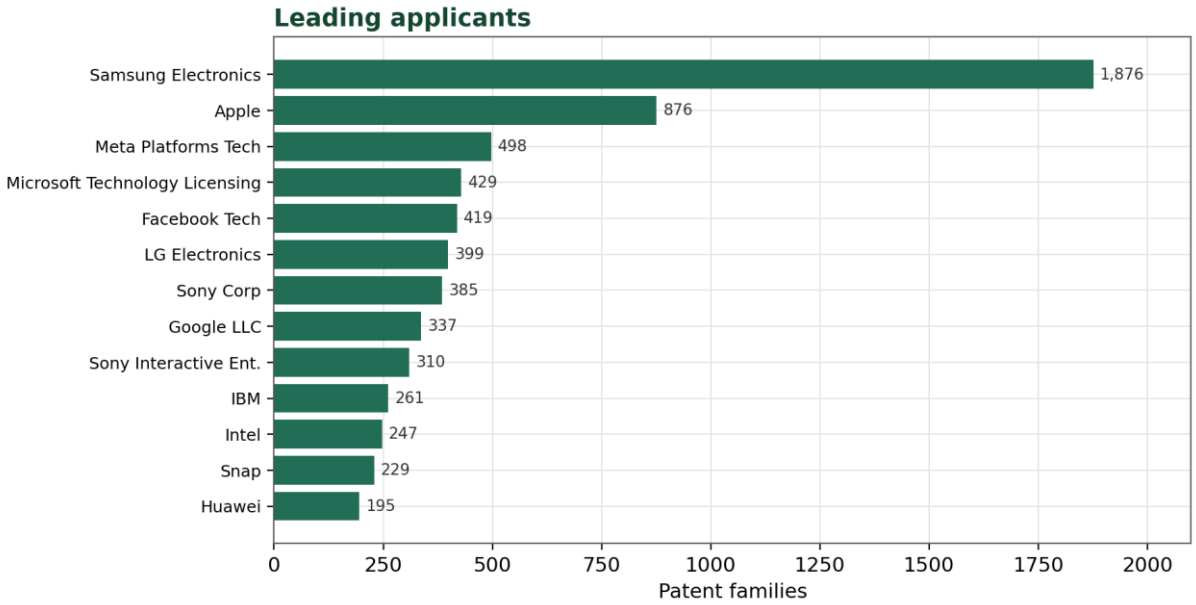

Figure 8 Leading applicants by number of patent families.

Table 4 Leading applicants and their principal technology focus.

Applicant	Families	Type
Samsung Electronics	1,876	Electronics / wearables
Apple	876	Consumer technology
Meta Platforms Technologies	498	AR/VR and interaction
Microsoft Technology Licensing	429	Software / mixed reality
Facebook Technologies	419	AR/VR and interaction
LG Electronics	399	Electronics
Sony Corporation	385	Electronics / robotics
Google LLC	337	Software / wearables
IBM	261	Enterprise technology
Intel	247	Semiconductors / computing

Beyond these corporate leaders, the dataset shows a broad and internationally distributed base of applicants, including a notable number of universities and research institutes, among them Chinese technical universities, the Korea Advanced Institute of Science and

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Technology, and the University of California. This academic presence is characteristic of a field still generating substantial fundamental invention, and it signals opportunities for the kind of research–industry collaboration that European consortia are well placed to lead. European industrial actors, including automotive and mobility companies, also appear within the broader applicant base, consistent with the EU-27's strong showing on the origin-of-innovation side.

The fragmentation below the top handful of applicants is significant: the leaders account for only a modest share of the 38,758 families, meaning the field is not dominated by a small oligopoly. This relatively open competitive structure leaves room for specialised European entrants, particularly in the occupational and ergonomic segment, where the largest consumer-electronics applicants are less concentrated (Table 4).

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8. METHODOLOGY AND LIMITATIONS

This landscape is built entirely from the Espacenet search result set and its filter breakdowns. The following considerations should be kept in mind when interpreting the findings.

- Family-level counting. All counts are at the patent-family level, so each invention is counted once. This is the appropriate basis for comparing jurisdictions and applicants without double-counting national filings.
- Recent-year incompleteness. Because publication typically follows filing by around 18 months, and because the most recent priority years are still being published, the last one to two years understate true activity and should be read as provisional.
- Search-definition sensitivity. Results depend on the chosen CPC classes and free-text terms. The query deliberately combines a technology dimension with an occupational/industrial application dimension; a different term set would shift the totals, though the broad structure of the landscape is robust.
- Classification overlap. A single family can carry multiple CPC subgroups, so technology-area counts describe prevalence rather than mutually exclusive categories.
- Jurisdiction versus origin. Jurisdiction counts show where protection is sought; applicant- and inventor-country counts show where innovation originates. The two answer different questions and are reported separately.

Within these bounds, the dataset of 38,758 families provides a large and reliable basis for characterising the scale, timing, geography, technology mix and competitive structure of the field.

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9. CONCLUSIONS

Wearable exoskeletons and related body-worn assistive technologies for industrial and occupational use have matured into a substantial, fast-growing and internationally active field of innovation. The Espacenet dataset of 38,758 patent families shows twenty-fold growth in annual activity since the early 2000s, a decisive inflection around 2015, and a sustained plateau above 3,000 families per year from 2018 onwards, with 2022–2023 among the strongest years on record.

The COVID-19 period produced a visible but temporary pause across 2020–2021, after which activity resumed its long-term climb, a resilience that speaks to the strategic durability of the field, reinforced by the pandemic's heightened focus on worker health and safety.

Europe is strongly positioned. The EPO is the fourth-largest jurisdiction of protection and the largest CPC-assigning office in the dataset, confirming Europe as a priority market that global innovators actively protect. On the origin side, the EU-27 forms one of the world's principal innovation bases, led by Germany, France, Finland, Italy, Sweden and the Netherlands, with complementary national specialisms that together create a broad and resilient European capability. The technology mix, combining wearable human-machine interaction with physical assistance and rehabilitation engineering, plays directly to European strengths in ergonomics, worker wellbeing and industrial robotics, and aligns closely with the human-centric ambitions of Industry 5.0.

The relatively open competitive structure, the significant academic presence, and Europe's dual strength as both a source and a destination for this technology together suggest that Europe is well placed to lead the occupational and human-centric segment of the exoskeleton field. For PROSPECTS 5.0, the landscape points to clear opportunities to build on Europe's engineering and rehabilitation-technology base, to foster research–industry collaboration, and to translate a strong innovation position into deployable, worker-centred manufacturing solutions.

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10. REFERENCES

[1] European Patent Office, Espacenet patent search, result set of 38,758 patent families (search reference Espacenet_search_result_20260713), retrieved 13 July 2026. This report relies exclusively on this Espacenet result set and its associated filter breakdowns (jurisdictions, priority and publication years, CPC/IPC classifications, applicants and applicant/inventor countries).

[2] European Patent Office, Cooperative Patent Classification (CPC) scheme — definitions of subgroups referenced in this report (e.g. G06F1/163, G06F3/011–017, B25J9/0006, G02B27/017, A61H3/00, A61H2201/165).

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