

SAMPLE

# Imaging Radar for Autonomous Systems

Patent Landscape Analysis

September 2025





# THE AUTHORS



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## Dr. Nicolas Baron

Nicolas is CEO and co-founder of Knowmade. He manages the development and strategic orientations of the company and personally leads the Semiconductor department. He holds a PhD in Physics from the University of Nice Sophia-Antipolis, and a Master of Intellectual Property Strategies and Innovation from the European Institute for Enterprise and Intellectual Property (IEEPI Strasbourg), France.

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The author of the report is available to address any questions you may have.

A **one-hour online presentation** of the report is included with your purchase. This session offers the opportunity for a direct interaction with the author, including a presentation of the results and a dedicated Q&A session.

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# INTRODUCTION

## Context of the report

This report provides a detailed analysis of the global patent landscape for **imaging radar technologies applied to autonomous systems**. Based on more than **10,600 identifiable patent families (inventions)**, including selected over **2,800 core inventions**, the study captures the strong acceleration of innovation in this field over the past decade. The increase in patent activity is closely tied to the growing demand for high-resolution, real-time perception solutions across a wide range of autonomous platforms.

Imaging radar technologies analyzed in this report cover **six high-impact domains: terrestrial, aerial, marine, space, robotics, and defense**. Among these, **terrestrial applications** remain the most active and mature area in terms of both volume and technical complexity. Patent filings related to **advanced driver-assistance systems (ADAS)**, Level 2 to Level 4 autonomous driving, and robotaxi platforms account for a significant share of the dataset. This reflects the urgency of equipping vehicles with robust sensing capabilities able to operate under adverse weather, poor lighting, and dynamic road conditions. Key industrial players such as **Intel-Mobileye, Bosch, Magna, Huawei-Yinwang, Waymo, and General Motors** have built extensive and diversified patent portfolios centered on terrestrial imaging radar use cases.

A major driver of recent innovation is the shift toward **4D imaging radar**, which enables simultaneous measurement of range, velocity, azimuth, and elevation. This advancement allows radar systems to produce dense point clouds and support complex perception tasks such as object classification, free-space detection, and scene reconstruction. Since 2018, patenting activity in 4D radar has intensified, with a growing number of inventions covering antenna configurations, beamforming methods, calibration procedures, radar-SLAM, and deep learning-based radar interpretation. As a result, 4D radar is becoming a core technology in next-generation perception architectures, especially for road-based autonomous platforms.

To analyze the technological content of the patent landscape, this report segments the inventions into **five progressive technical layers**. The foundational layer includes signal generation and spatial sampling techniques such as FMCW, MIMO, and beamforming. The second layer focuses on radar system platforms, including hardware modules, SoCs, and 4D radar integration. The third layer addresses imaging and calibration processes, including synthetic aperture radar (SAR), ISAR, and radar-camera alignment. The fourth layer covers perception and mapping functions, such as radar-based SLAM, object tracking, and scene modeling. Finally, the fifth layer encompasses AI enhancement and sensor fusion, including deep learning networks, radar-vision fusion frameworks, and multi-sensor decision making. Most of the leading IP holders show activity across several of these layers, indicating a strong trend toward full-stack radar system development.

From a geographical perspective, the **United States** and **China** lead the global radar IP landscape. The U.S. remains strong due to early innovation by automotive OEMs and technology providers, while China has shown the fastest growth since 2022, fueled by both incumbent players and emerging radar startups. **Europe** maintains a steady presence, particularly through Tier-1 automotive suppliers. The competitive IP environment is shaped by a mix of large multinational corporations and smaller, highly focused technology firms. While established players such as **Bosch, Intel-Mobileye, and GM** continue to invest heavily, newer entrants like **Arbe Robotics, Uhnder, Cheng-Tech, Zadar** and **Geometrical-PAL** are building specialized patent portfolios around 4D radar chip design, signal processing, and perception software.

In conclusion, terrestrial imaging radar stands as the primary engine of innovation and IP development in the autonomous systems space. The convergence of radar hardware, signal processing, and AI-based perception is reshaping the technical landscape, with 4D imaging radar emerging as a central technology. As the field continues to evolve, patenting strategies will play a key role in defining competitive advantage, technological leadership, and barriers to entry in both automotive and broader autonomous domains.

# INTRODUCTION

## Scope of the report

We have selected and analyzed more than **22,200 patents and patent applications** published worldwide up to **May 2025**, representing more than **10,600 patent families** (inventions) relevant to the scope of this report. Among them, more than **2,800 patent families** have been identified as **core inventions**, showing a stronger relevance to the imaging radar domain.

The patent search strategy has been implemented using advanced search equations in the patent database and by a cautious patent selection performed by the analyst to get the most out of the corpus.

More details are available in METHODOLOGY part.

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Inventions related to **Imaging Radar for Autonomous Systems** have been selected as follows:

### Included

- Patents claiming fundamental techniques, architectures and signal processing applied to imaging radar (e.g., FMCW, MIMO, beamforming, range-Doppler processing).
- Inventions describing imaging radar hardware platforms, such as integrated radar SoCs, RFICs, analog front-ends (AFE), and automotive-grade chipsets.
- Imaging radar related inventions applied to multi-sensor fusion, such as camera-radar or lidar-radar fusion for autonomous navigation.
- AI-based imaging radar processing: deep learning networks for object classification, denoising, super-resolution, etc.
- Imaging radar software stacks for SLAM, mapping, obstacle detection, and motion tracking in dynamic environments.
- Automotive and non-automotive autonomous applications of imaging radar, including robotics, aerial, marine, space, and defense use cases.

### Excluded

- Inventions describing only non-imaging radar, e.g., long-range radar (LRR) or short-range radar (SRR) without angle/elevation resolution.
- Patents specific to optical, LiDAR, Sonar or ultrasonic sensing unless they directly contribute to radar performance.
- Radar applications in fields unrelated to imaging for autonomous systems, such as meteorology, aviation traffic control, industrial logistics, unless clearly cross-deployable.
- Component-level patents not explicitly targeting imaging radar integration or radar signal generation.
- General AI/ML algorithms not dedicated to radar signal enhancement or radar-based perception tasks.

# INTRODUCTION

## Objectives of the report

The report aims to provide a comprehensive view of the **imaging radar for autonomous systems patent landscape** along **6 applications** and **5 technical layers**.

Imaging radar for autonomous systems analyzed in this report extend far beyond traditional automotive use. The patent dataset reveals active deployment across **six high-impact domains**:

- **Terrestrial**: ADAS, autonomous vehicles (L2–L4+) , robotaxi, etc.
- **Aerial**: Airborne platforms like aircrafts, UAVs, and helicopters, etc.
- **Marine**: Surface and underwater sensing via ships, AUVs, and autonomous marine vessels.
- **Space**: Satellite-borne and space vehicle sensing, etc.
- **Robotics**: Articulated robots, AGVs, and indoor navigation in industrial or warehouse settings.
- **Defense**: Military systems for surveillance, targeting, and perimeter security.

This report structures the imaging radar patent landscape along **five progressive technical layers**, reflecting the typical technology development and deployment pipeline, from foundational signal architecture to intelligent fusion for autonomy. These layers represent both functional hierarchy and innovation hotspots in radar systems.



More in details, the patent landscape analysis provides an overview of **imaging radar for autonomous systems**:

- To present **global IP trends** (time evolution of patent filings, geographical evolution of patent filings, etc.).
- To identify the **main IP players** and the **IP newcomers** in the different segments of application and technology;
- To determine the status of their **patenting activity** (active / inactive) and their **dynamics** (ramping up, slowing down, steady);
- To identify **notable patents** and targeted applications and technologies.
- To reveal **IP collaborations** (joint co-owned patents, sub-brands, joint ventures, etc).

In addition, the report includes **IP profiles**, which provide a comparison and an overview of the patent portfolios and the recent patenting activity of **General Motors, Bosch, Huawei-Yinwang, Intel-Mobileye, Magna** and **Alphabet-Waymo**.

# INTRODUCTION

Reading guide: find the right information in the report

SAMPLE

Report sections



Your concern →  
Information you get

## PATENT LANDSCAPE OVERVIEW

- **Ranking of players** (enforceability, current activity, geo/tech coverage, prior-art contribution, etc.)
- **Patent filings dynamics per player**
- **IP collaborations** (co-filings, IPR transfers)
- **Patent litigation/oppositions**

## SEGMENTS ANALYSIS

- **Patent filings dynamics per segment**
- **IP leaders per segment** (enforceability, current activity, blocking potential)
- **Notable patents per segment**
- **Recent patenting activity per segment**

## IP PROFILE OF KEY PLAYERS

- **Patent portfolio summary** (portfolio size, IP activity evolution, patents legal status, geo/tech coverage, strengths/weaknesses, etc.)
- **Key patents**
- **Recent patenting activity**

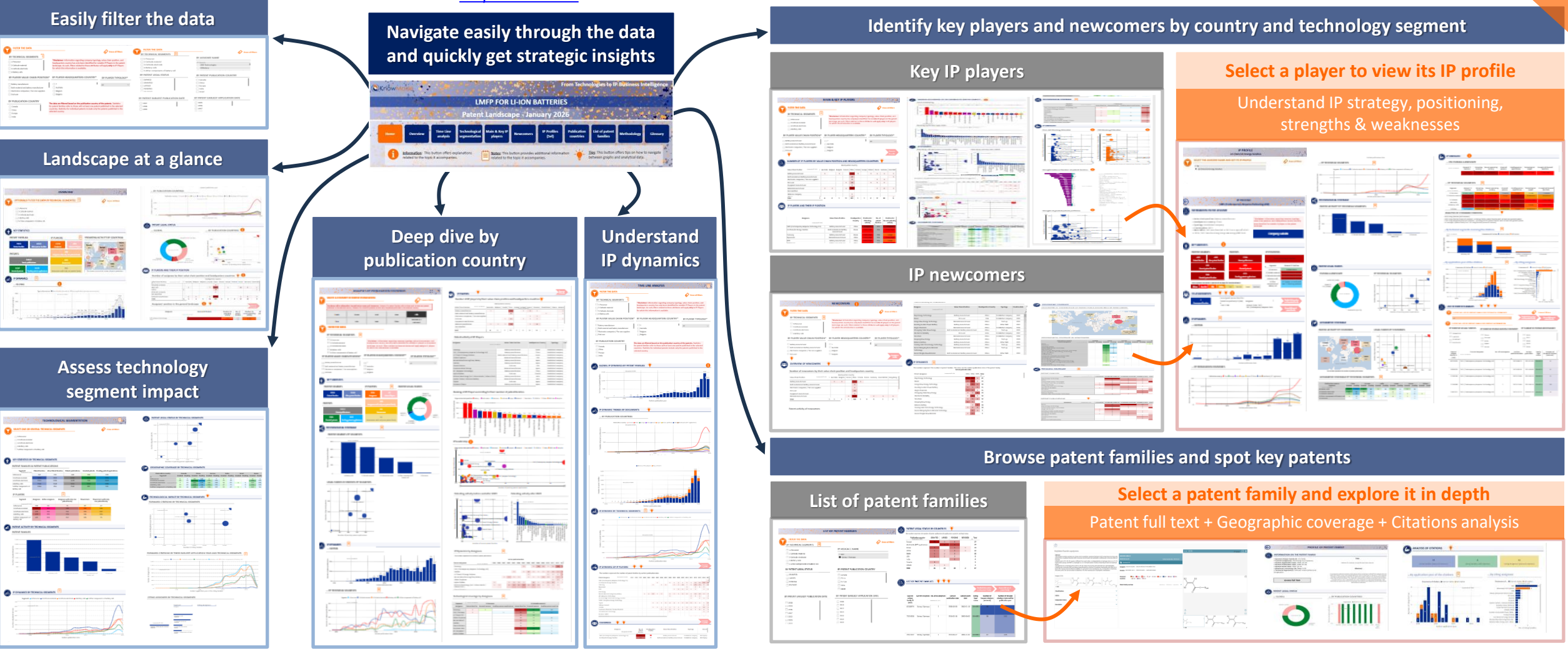
	<b>TECHNOLOGY</b> <i>For R&amp;D teams, engineers, scientists</i>	<b>IP</b> <i>For IP teams, patent attorneys</i>	<b>MARKET</b> <i>For executives, business developers</i>	<b>PLAYER</b> <i>Zoom in a competitor / partner</i>
<b>Innovators</b>	Main patent owners IP risks/opportunities	Ecosystem (competitors, newcomers, partners, clients) Main trends IP vs Market	IP position vs Market position Player relationships (collaborations/ dependencies)	
<b>Technology trends Technology mapping</b>	Blocking players IP risks/opportunities in each segment (FTO, litigation, licensing)	Benchmarking Markets of interest Future developments	IP position and level of investment in each segment Key IP developments	
<b>Current R&amp;D activities Technology roadmap</b>	Blocking patents Geo/Tech coverage Link between patents and products	Future products Potential partners Potential targets	R&D investment level Key inventions Current IP activities Strengths / Weaknesses	



# INTERACTIVE DASHBOARD (optional)

An optional [interactive dashboard](#) can be provided with this report, transforming the analysis into a true decision-support tool that puts you in control. It enables you to dynamically explore the patent landscape by players, technologies, countries, dates, or legal status, and to instantly drill down into key insights, from high-level trends to individual players and patents. Tailored to the specific needs of R&D, IP strategy, and business development teams, the dashboard delivers immediate visual answers to critical questions, enabling faster and more informed strategic decision-making across your organization.

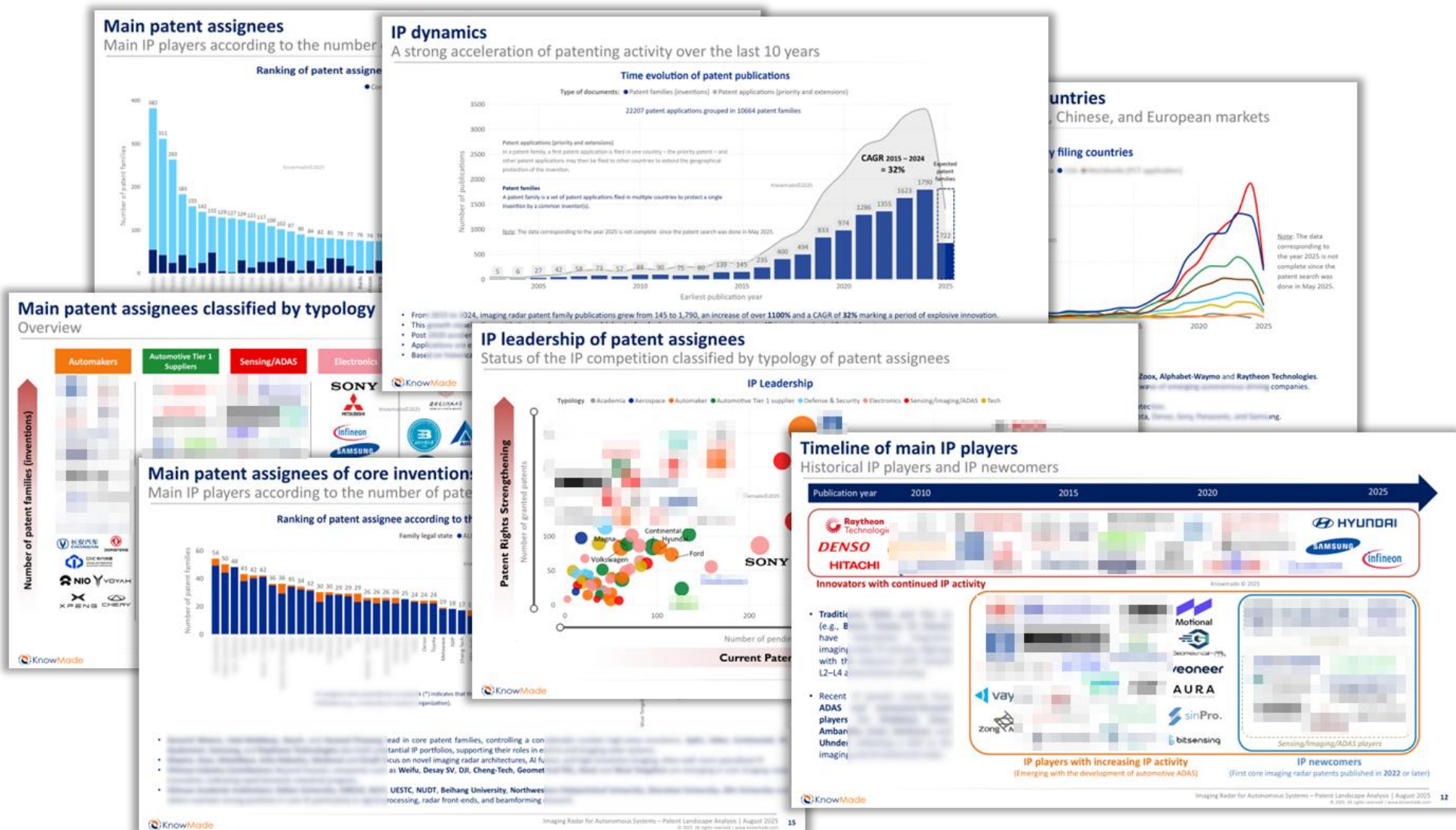
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# PATENT LANDSCAPE OVERVIEW

General trends, main patent assignees and new entrants

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# PATENT LANDSCAPE OVERVIEW

IP leaders, IP strategies, IP collaborations, licensing agreement, litigations

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**High-impact patent assignees**  
Citations and strength index for granted patents

Assignees	www.knowmade.com	www.knowmade.com	www.knowmade.com	www.knowmade.com
332	332	81	0.72	45
74	332	1.38	84	33
84	134	1.48	47	33
78	30	1.15	35	33
304	19	0.37	38	33
135	57	0.41	38	33
179	117	0.69	44	33
48	48	1.00	35	33
305	132	1.07	39	33
54	77	1.33	37	33
32	17	0.33	35	33
45	39	0.87	21	33
31	80	2.58	38	33
42	40	0.95	17	33
21	41	2.90	31	33

**Main patent assignees**  
Domestic vs. Global IP Strategies

**Geographic coverage of alive patents**  
Granted and pending patent applications in different regions

**Main co-owned patents**  
Main actors mutualizing R&D strength through IP collaborations

**Patent assignees: joint ventures - shared IP ownership**  
Main actors mutualizing R&D strength through JVs

**Case study: Panasonic vs. Icon Radar**  
Litigation on March 30, 2021, at Texas Western District Court

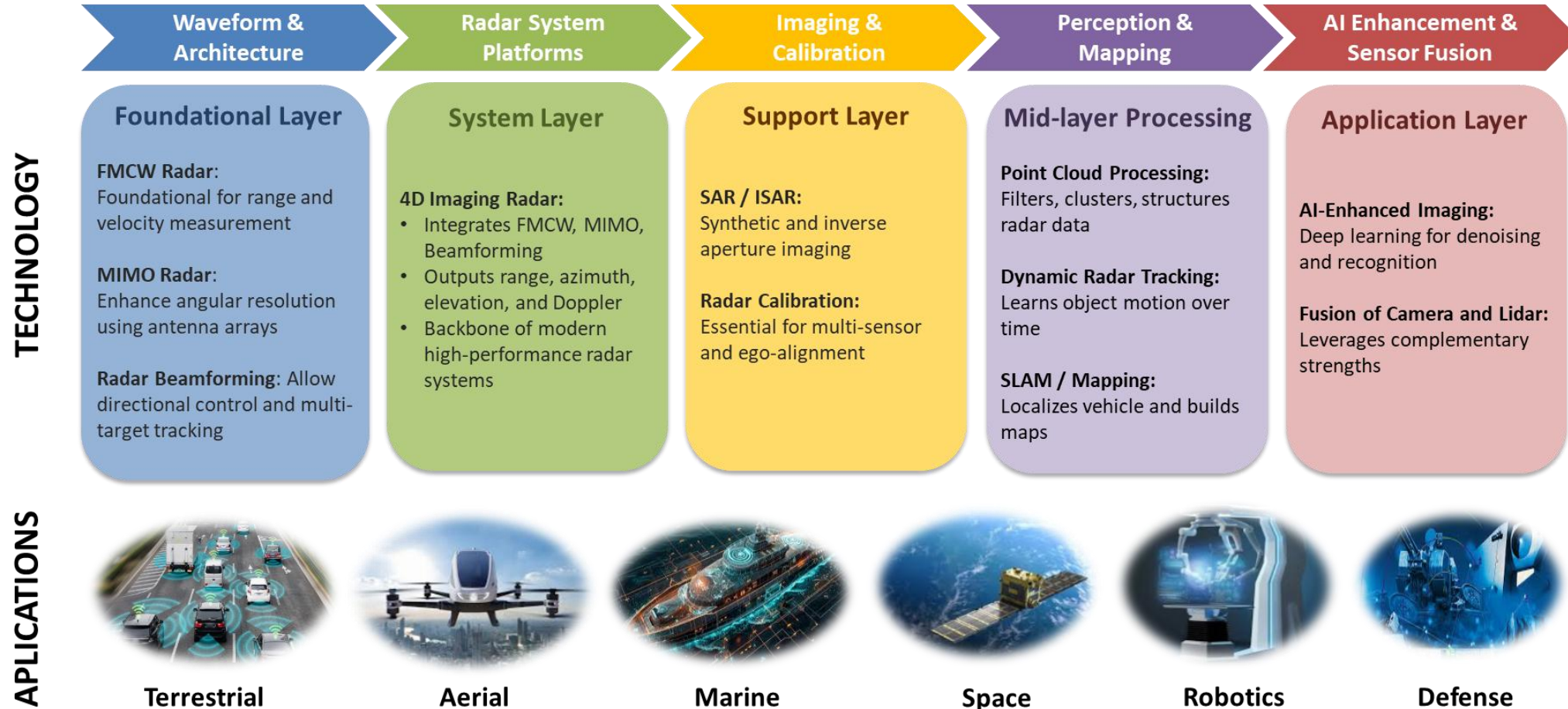
**Main actors mutualizing R&D strength through sub-brands and internal**  
Brand / Parent: Huawei, Waymo

**Main actors mutualizing R&D strength through IP collaborations**  
Co-owned IP: DENSO, Infineon, Volkswagen

# PATENT SEGMENTATION

## Patent Categorization by Technical Layers and Deployment Scenarios

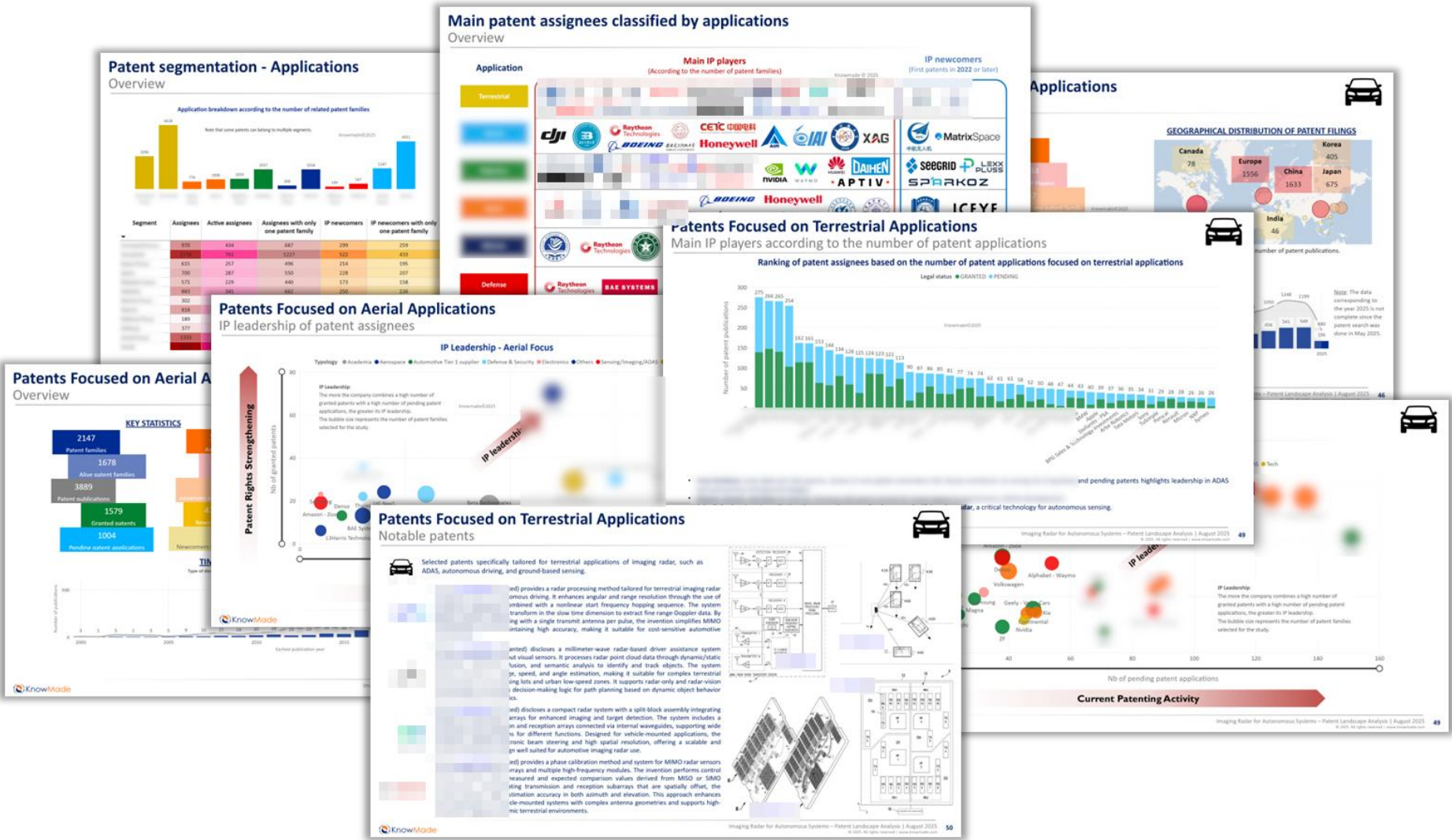
The patents selected for this report have been categorized into 6 application domains and 5 technology layers comprising 11 technique segments



# FOCUS ON TARGETED APPLICATIONS

IP dynamics, main patent assignees, IP leaders, and notable patents by segment

SAMPLE

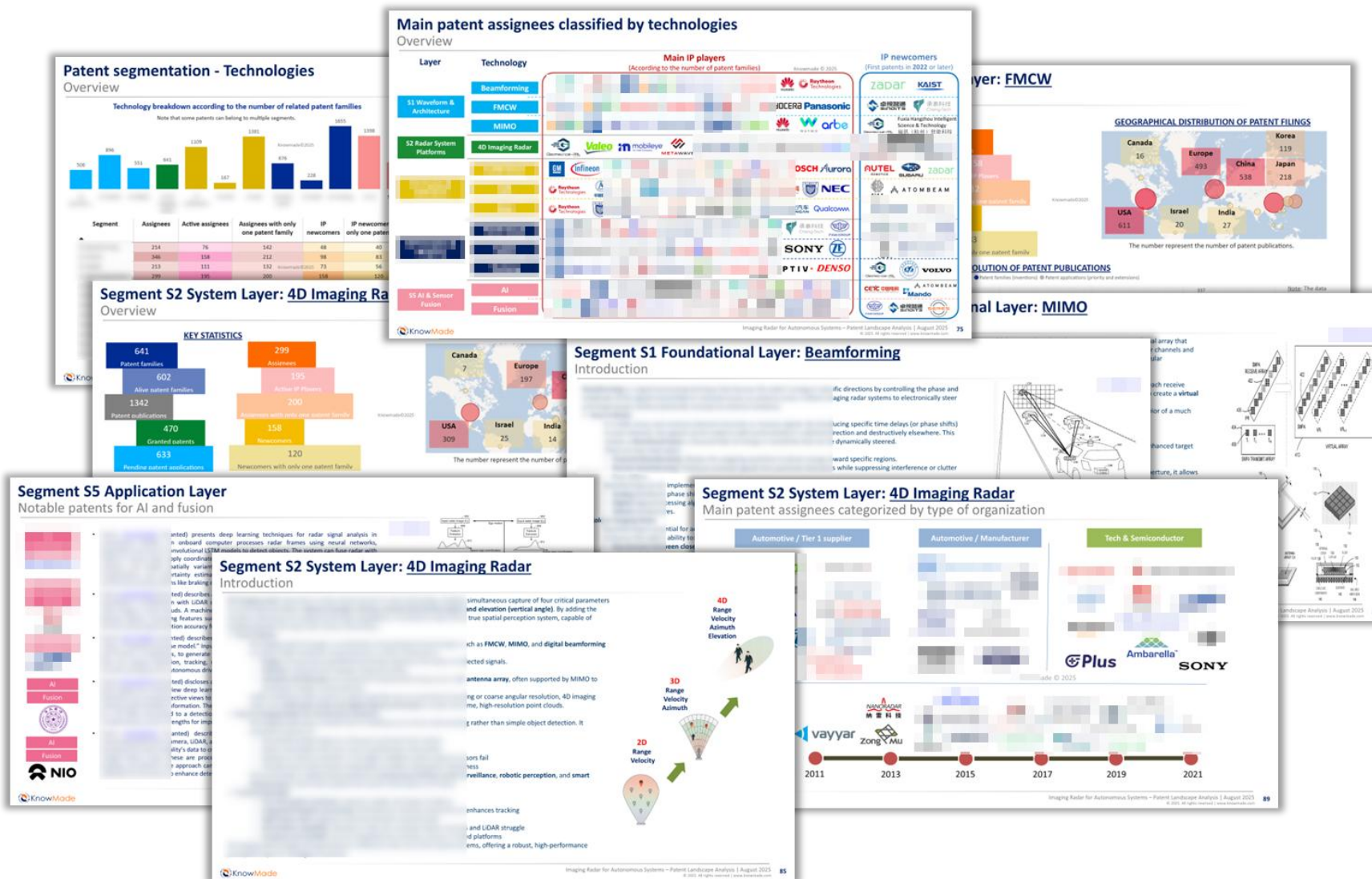


The categories to which each patent belongs are available in the Excel file provided with the report

# FOCUS ON TECHNICAL SEGMENTS

IP dynamics, main patent assignees, IP leaders, and notable patents by segment

SAMPLE



The categories to which each patent belongs are available in the Excel file provided with the report

# IP PROFILE OF PLAYERS

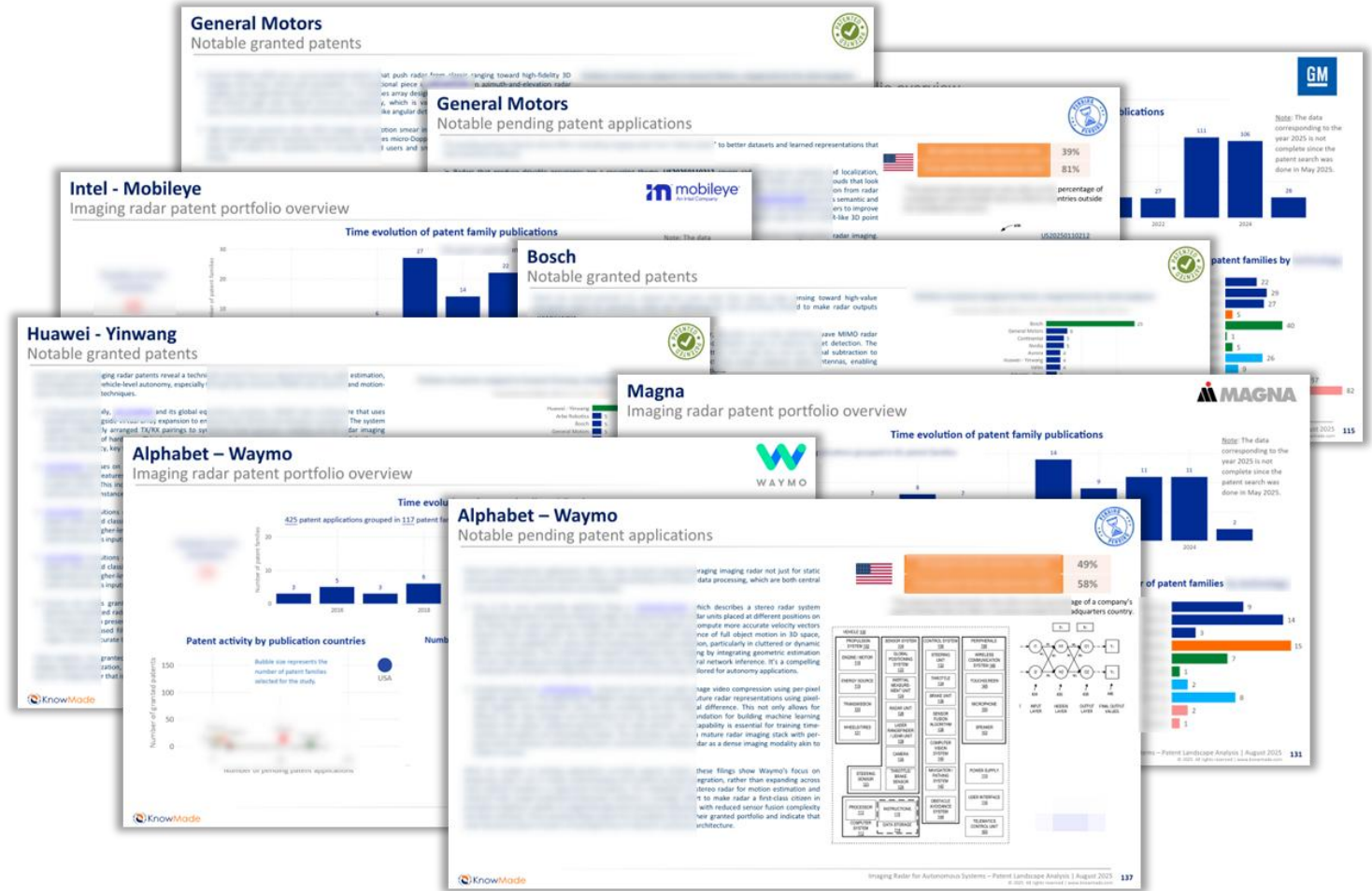
IP portfolio summary, IP strategy, key patents and recent patenting activity

This report includes detailed profiles of **General Motors, Intel-Mobileye, Bosch, Huawei-Yinwang, Magna** and **Alphabet-Waymo**, covering patent portfolio dynamics, notable granted and pending patents, legal status and global coverage.



## IP Profile

- Imaging radar patent portfolio overview
- Notable granted patents
- Notable pending patent applications



# ORDER FORM

## Imaging Radar for Autonomous Systems

Patent Landscape Analysis – September 2025

Ref.:KM25002

### SHIP TO

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Job Title:

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City:

State:

Postcode/Zip:

Country:

VAT ID Number for EU members:

Tel:

Email:

Date:

### PRODUCT ORDER

- REPORT + DATABASE <sup>(1)</sup>: **4,990 EUR**
- REPORT + DATABASE <sup>(1)</sup> + DASHBOARD <sup>(2)</sup>: **7,990 EUR**



For price in dollars, please use the day's exchange rate.

For French customer, add 20% for VAT.

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FRANCE

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IBAN: FR76 1460 7003 6360 6214 5695 139  
BIC/SWIFT: CCBPFRPPMAR

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BIC or SWIFT code: CCBPFRPPMAR

IBAN: : FR76 1460 7003 6360 6214 5695 139

To ensure the payments, the Seller reserves the right to request down payments from the Buyer. In this case, the need of down payments will be mentioned on the order.

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3.4 In the event of termination of the contract, or of misconduct, during the contract, the Seller will have the right to invoice at the stage in progress, and to take legal action for damages.

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4.1 The Buyer or any other individual or legal person acting on its behalf, being a business user buying the Products for its business activities, shall be solely responsible for choosing the Products and for the use and interpretations he makes of the documents it purchases, of the results he obtains, and of the advice and acts it deduces thereof.

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Competitive landscape | Technology trends | Opportunities / Risks | R&D and IP strategy



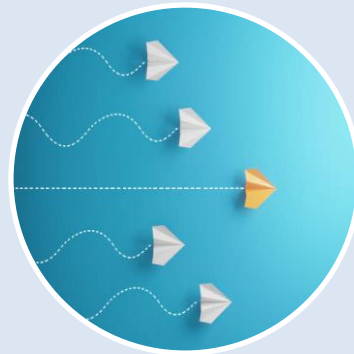
# WHAT INFORMATION CAN YOU GET ?



## INTELLECTUAL PROPERTY

*For IP teams,  
patent attorneys*

- Risks and opportunities (FTO, litigations, licensing)
- Key patents
- Link between patents and products



## TECHNOLOGY

*For R&D teams,  
engineers, scientists*

- R&D activities
- Technological roadmap
- Position on the supply chain



## MARKET

*For executives,  
business developers*

- Identify competitors
- Compare IP with market position
- Evaluate the level of investment
- Future products & target markets

# KNOWMADE OFFER

## CUSTOM SERVICES

(Tailor-made analysis)

*To meet your needs and budget/lead time constraints*

- Specific and dedicated report.
- Prior-art search, literature review, patent landscape, freedom-to-operate, patent valuation, IP due diligence, technology scouting, monitoring service, etc.

Format

- PDF file with analyses.
- Excel file with data.
- Access to the analyst.

## REPORTS

(multi-client product)

*To understand the competitive landscape and explore the emerging ecosystems and new technologies*

- Stand alone report
- Patent landscape.
- Overview on IP dynamics, trends and players.
- Competitor, technology and strategy analysis.
- Benchmark of patent portfolios.
- Key IP players & key patents.

Format

- PDF file with analyses.
- Excel file with patent data.

## MONITORS

(multi-client product)

*To track the latest R&D developments and IP activities, and to be sensitive to weak signals*

- Annual subscription
- Patent monitoring service.
- Quarterly updated patent data and technology trends.
- Current R&D and IP activities.
- Early detect weak signals, opportunities and risks.
- Open discussion with analyst.

Format

- PDF file with analyses.
- Excel file with patent data.
- Direct access to the analyst.

## INSIGHTS

(free article & webinar)

*To get unique information about industry and technology*

- Analyst point of view about industry news (product release, M&A, start-up, fund-raising, etc.) from a patent perspective.

Format

- Knowmade website

# MAIN FIELDS OF EXPERTISE

## SEMICONDUCTORS

- Materials & Substrates
- Power electronics
- RF & Wireless datacom
- MEMS, Sensing & Imaging
- Photonics, Lighting & Display
- Memory
- Packaging

## ENERGY

- Batteries
- Fuel-cells
- Solar PV
- Power management

## HEALTHCARE

- New therapeutic tools
- Medical diagnostics
- Medical devices and imaging
- Drug discovery and delivery

## AGRI-FOOD

- Food processing & formulation
- Vegan food
- Next-gen packaging
- Microbiology







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