

LiDAR for Automotive

Patent Landscape Analysis – January 2022

Who are the key LiDAR players and what recent IP developments strategies are they adopting?

REPORT OUTLINE

- LiDAR for Automotive
- Patent landscape analysis
- January 2022
- PDF >140 slides
- Excel file >24,000 patents
- Ref.: KM22001
- €4,990 for a multi-user license



KEY FEATURES OF THE REPORT

- **IP trends**, including time evolution of published patents and countries of patent filings.
- Ranking of **main patent assignees**.
- **Newcomers** in the IP landscape.
- Patent categorization by **type of LiDAR** (mechanical, MEMS micromirrors, OPA, flash, ToF, FMCW, phase-shift, etc.).
- **IP position of key players**, and relative **strength** of their patent portfolios.
- **Current main technological approaches**.
- **IP profiles of 35+ key players** (tier one suppliers, LiDAR pure players, robotaxi/autonomous vehicle makers), including **IP dynamics**, **legal status** and **geographical coverage** of patents, **IP strategies**, **key patents** and **recent IP developments**.
- **Excel database** with all patents analyzed in the report, including technology segmentation and hyperlinks to an **updated online database**.

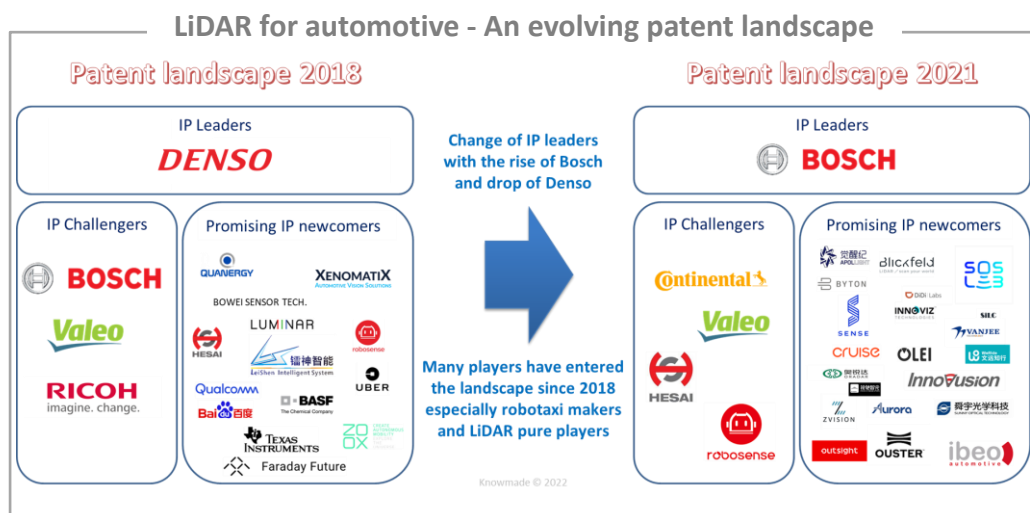
RELATED REPORTS

- [LiDAR for automotive patent landscape 2018](#)
- [VCSEL Patent Landscape 2018](#)
- [MEMS Sensors & Actuators Patenting Activity 2019](#)

The LiDAR-related patent landscape is very dynamic, with numerous newcomers

Over the last 7 years, the automotive industry has strongly believed that LiDAR would be one of the key sensors to develop high-level Advanced Driver Assistance Systems (ADAS) and 3D mapping solutions, unlocking the door to autonomous vehicles and robotaxis. Today, the market for LiDAR in automotive is divided between ADAS and robotic vehicles. Both applications show a high expected compound annual growth rate (CAGR) of 111% and 33% respectively over the 2020-2026 period, according to Yole Développement's [report](#). Players that can provide automotive-grade LiDAR with advanced 3D mapping would be in a good position to take a nice slice of the million-dollar cake. Being able to protect their position with strong intellectual property (IP) can be a big asset in this highly competitive industry.

In this context, **Knowmade is releasing a new patent landscape report** covering the whole supply chain of **LiDAR for automotive applications**, from electronic components, optical systems and LiDAR devices to systems using LiDAR and computing. Patent landscape analysis is the perfect complement to market research, to fully comprehend the competitive landscape and technology roadmap, keep up with new technology developments, anticipate future technology adoption, and understand the different competitors' strategies. This kind of patent landscape report reveals the companies, technical solutions and strategies not identified through standard market analysis.



The intellectual property (IP) landscape also confirms the strong enthusiasm for LiDAR. Indeed, since 2018 we have witnessed the **entrance of many LiDAR pure players** that contribute to the very strong acceleration in patenting activity. Furthermore, the low number of academics among patent applicants attests to the maturity of the technology. These players are today competing against **well-established tier one suppliers** that benefit from their early activity related to low-level ADAS systems back in the 2000s.

The strong competition has already led to **significant changes** in the LiDAR-related patent landscape over the last 2 years. Indeed, **Denso** lost its leading IP position to **Bosch**. Chinese LiDAR pure players **Hesai Technology** and **Robosense** became the new IP challengers, while many smaller IP players just entered the game or closed the gap. In addition, as the LiDAR automotive market is just beginning to grow, many collaborations are occurring, and mergers and acquisitions (M&A) may happen to consolidate the players' market and IP position.

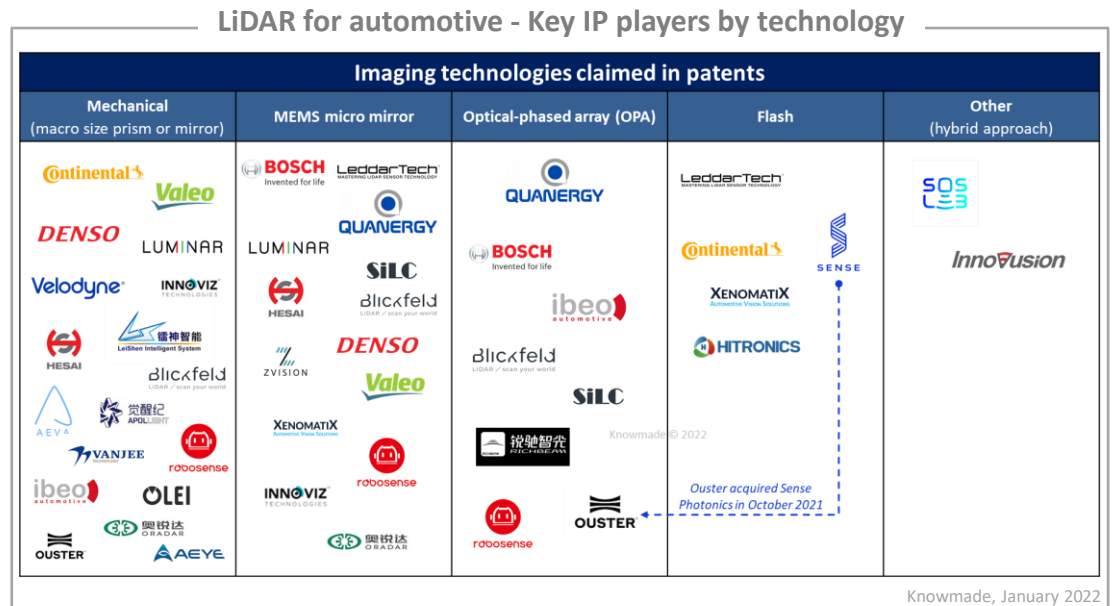
LiDAR-related patents published worldwide and covering the whole value chain

Knowmade's analysts have selected and analyzed more than 24,000 patent applications published worldwide up to July 2021 and corresponding to **11,900+ patent families** (inventions) related to **LiDAR for automotive applications** (ADAS and robotic cars). This report includes patents describing LiDAR components (laser, lenses, mirrors, etc.), LiDAR devices and systems using LiDAR (anticollision system, autonomous vehicles, 3D mapping systems, etc.). We have identified more than **2,000 different patent assignees** involved in the LiDAR for automotive.

IP players' positions, current developments & IP strategies

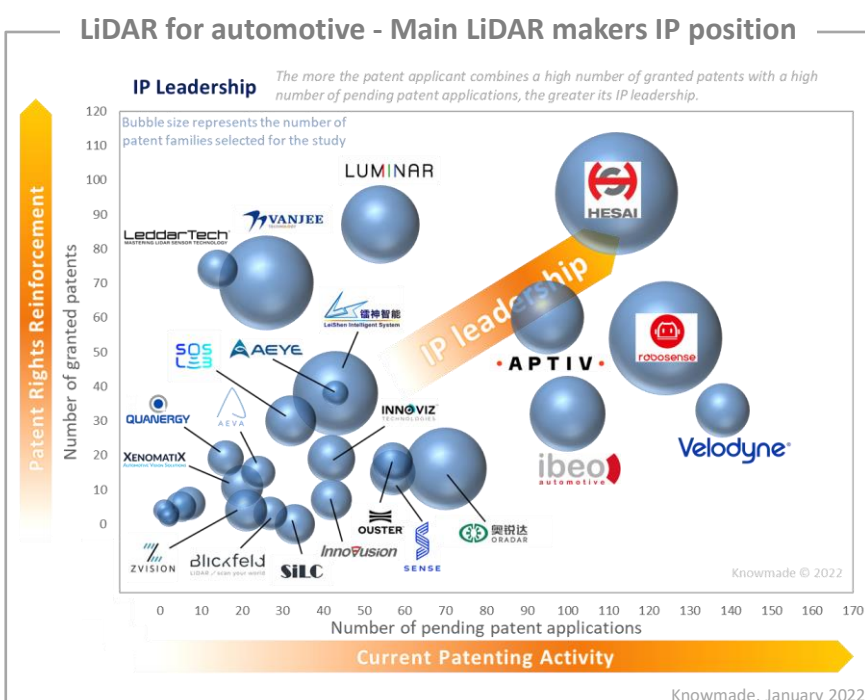
The report provides a clear overview of the **most active patent applicants** as well as a presentation of **newcomers** to the patent landscape. Furthermore, patent segmentation reveals the **IP position of patent assignees by LiDAR technology**. The IP landscape analysis shows that where major IP players are involved, the competition is mainly focused on **mechanical LiDAR**.

In addition, recent inventions indicate that LiDAR is a mature technology where the main innovations are no longer related to LiDAR itself but to **LiDAR assembly**, as well as **control or calibration methods**. Technologies providing **embedded software** to reduce interference and parasitics (including environmental hazards) and maintain LiDAR performance in all conditions are the main technologies described in recent patent applications. Despite their advantages and promises, **solid-state LiDAR** solutions (OPA, flash) remain very small IP segments where a limited number of IP players are competing.



Focus on key players' patent portfolios

The report provides a detailed analysis of **36 key IP players and most promising IP newcomers**: Bosch, Denso, Valeo, Continental, Quanergy, LeddarTech, XenomatiX, Luminar, Velodyne, LeiShen, Hesai, Robosense, Ibeo, Ouster, Sense Photonics, Aptiv, Innoviz, Aeva, Aeye, Innovusion, SOSLAB, Zvision, SiLC, Oradar, Blickfeld, Richbeam, Apollight, Hitronics, Olei, Vanjee, Waymo, Baidu, Uber, Cruise, Zoox and Aurora. For each player, we summarize their **IP portfolio** and **key patents**, make the links between patents and products to highlight the protected LiDAR systems, and unveil their **IP strategies** by analyzing their **recent patents** and **IP collaborations**.



Understand the current dynamics and technological trends

Current **patenting activities, geographical coverage and technological segments** are analyzed. In this report, Knowmade highlights the **main technical challenges faced by the industry** to enhance the LiDAR and sensing systems' performances. The report focuses especially on LiDAR architecture and hardware solutions such as optical path arrangements, VCSEL array and detector arrangements. Methods to drive the emitter to enhance the LiDAR field of view, reduce power consumption or enhance detector sensitivity are described.

Useful Excel patent database

The report also includes an **Excel database** with the 11,900+ patent families (inventions) analyzed in this study.

This useful patent database allows for **multi-criteria searches** and includes patent publication numbers, **hyperlinks to an updated online database** (original documents, legal status, etc.), priority dates, title, abstract, patent assignees, patent's current legal status, and **segments** (mechanical, MEMS micromirrors, OPA, flash, ToF, FMCW, phase shift, etc.).

Companies mentioned in the report (Non-exhaustive)

Bosch, Denso, Mitsubishi, Nissan, Toyota, Sick, Daimler, Omron, General Motors, Valeo, Ford, Honda Motor, Hyundai, Continental, Mazda Motor, Sanyo, Ricoh, BMW, Daihatsu, Waymo, Hitachi, Volkswagen, Xenomatix, NEC, Panasonic, Google, Audi, Nikon, Fujitsu, Changan University, Omron Automotive Electronics, Kansei, Ibeo Automotive, Volvo, Chery Automobile, Shenzhen Leishen Intelligent Systems, Raytheon, Sharp, Hokuyo Automatic, Shiny Technology, Uber, Nippon Soken, Velodyne, Qualcomm, Shanghai Slamtec, BASF, Philips, Fraunhofer, Zoox, Quanergy Systems, Apple, Texas Instruments, LG Innotek, Scania, Qinetiq, Luminar Technologies, Hesai Photonics, Robosense, AEYE, AEVA, HITQZ, Richbeam, Fexa, Nvidia, Huawei, Nuro, Pony AI, Vanjee, Innovusion, Blickfeld, Aptiv, etc.

TABLE OF CONTENTS

INTRODUCTION	5	TIER ONE SUPPLIERS	55
• Market data		• IP leadership of patent assignees	
• Definition & principle		• Main trends & dynamics	
SCOPE OF THE REPORT	11	• IP profile of <i>Bosch, Continental, Valeo, Denso</i>	
• Scope of the report		IP portfolio overview, IP strategy, IP collaborations, key patents and related technologies, recent patenting activities, etc.	
• Key feature of the report			
• Objectives of the report		LIDAR PURE PLAYERS	67
METHODOLOGY	18	• IP leadership of patent assignees	
• Patent search, selection and analysis		• Main trends & dynamics	
• Terminologies for patent analysis		• IP profile of <i>Quanergy, LeddarTech, Xenomatix, Luminar, Velodyne, LeiShen, Hesai, Robosense, Ibeo, Ouster, Sense Photonics, Aptiv, Innoviz, Aeva, Aeye,, Innovusion, SOSLAB, Zvision, SiLC, Oradar, Blickfeld, Richbeam, Apollight, Hitronics, Olei, Vanjee</i>	
EXECUTIVE SUMMARY	24	IP portfolio overview, IP strategy, IP collaborations, key patents and related technologies, recent patenting activities, etc.	
PATENT LANDSCAPE OVERVIEW	36	ROBOTIC CAR MAKERS (ROBOTAXIS)	124
• Time evolution of patent publications		• IP leadership of patent assignees	
• Main patent assignees and their typology (tier-1 suppliers, car makers, LiDAR pure players, robotaxis makers, electronics company, R&D labs)		• Main trends & dynamics	
• Well-established IP players and IP newcomers		• IP profile of <i>Waymo, Zoox, Uber, Baidu, Cruise, Aurora</i>	
• IP landscape evolution from 2018 to 2021		IP portfolio overview, IP strategy, IP collaborations, key patents and related technologies, recent patenting activities, etc.	
• Current legal status of patents		CONCLUSION	140
• Main countries of filings for granted patent and pending applications			
• Geographical coverage of main patent assignees' patent portfolio			
• Technical segmentation (mechanical, MEMS micromirrors, OPA, flash, ToF, FMCW, phase shift, etc.)			
• Main patented technologies for automotive LiDAR pure players and tier one suppliers			

AUTHORS**Dr. Paul Leclaire**

Paul works for Knowmade in the field of MEMS, Sensors and RF technologies. He holds a PhD in Micro and Nanotechnology from the University of Lille, France, in partnership with IEMN in Villeneuve-d'Ascq and CRHEA-CNRS in Sophia-Antipolis.

Contact: paul.leclaire@knowmade.fr

**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 Electronics & Telecom department. He holds a PhD in Physics from the University of Nice Sophia-Antipolis, and a master's degree in Intellectual Property Strategies and Innovation from the European Institute for Enterprise and Intellectual Property (IEEPI Strasbourg), France.

Contact: nicolas.baron@knowmade.fr

ABOUT KNOWMADE

Knowmade is a Technology Intelligence and IP Strategy consulting company specialized in analysis of patents and scientific information. The company helps innovative companies and R&D organizations to understand their competitive landscape, follow technology trends, and find out opportunities and threats in terms of technology and patents.

Knowmade's analysts combine their strong technology expertise and in-depth knowledge of patents with powerful analytics tools and methodologies to turn patents and scientific information into business-oriented report for decision makers working in R&D, Innovation Strategy, Intellectual Property, and Marketing. Our experts provide prior art search, patent landscape analysis, scientific literature analysis, patent valuation, IP due diligence and freedom-to-operate analysis. In parallel the company proposes litigation/licensing support, technology scouting and IP/technology watch service.

Knowmade has a solid expertise in Compound Semiconductors, Power Electronics, Batteries, RF Technologies & Wireless Communications, Solid-State Lighting & Display, Photonics, Memories, MEMS & Solid-State Sensors/Actuators, Semiconductor Manufacturing, Packaging & Assembly, Medical Devices, Medical Imaging, Microfluidics, Biotechnology, Pharmaceuticals, and Agri-Food.

ORDER FORM

LiDAR for Automotive

Patent Landscape Analysis – January 2022

Ref.: KM22001

SHIP TO

Name (Mr/Ms/Dr/Pr):

Job Title:

Company:

Address:

City:

State:

Postcode/Zip:

Country:

VAT ID Number for EU members:

Tel:

Email:

Date:

PAYMENT METHODS

Order online: [Click here](#)

Check

To pay your invoice using a check, please mail your check to the following address:

KnowMade S.A.R.L.
2405 route des Dolines, Le Drakkar
06560 Valbonne Sophia Antipolis
FRANCE

Money Transfer

To pay your invoice using a bank money wire transfer please contact your bank to complete this process. Here is the information that you will need to submit the payment:

Payee: KnowMade S.A.R.L.
Bank: Banque Populaire Méditerranée, CAP 3000 Quartier du lac, 06700 St Laurent du Var
IBAN: FR76 1460 7003 6360 6214 5695 139
BIC/SWIFT: CCBPFRPPMAR

Paypal

In order to pay your invoice via PAYPAL, you must first register at www.paypal.com. You can send money to the KnowMade S.A.R.L. by entering our email address contact@knowmade.fr as the recipient and entering the invoice amount.

RETURN ORDER BY

E-mail: contact@knowmade.fr

Mail: KnowMade S.A.R.L. 2405 route des Dolines, Le Drakkar, 06560 Valbonne Sophia Antipolis, FRANCE

PRODUCT ORDER

☐ **4,990 EUR – Multi user license***

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

For French customer, add 20% for VAT.

All reports are delivered electronically in pdf format at payment reception.

**The report can be shared with the employees of the company purchasing the report. Subsidiaries and joint-ventures are excluded. Please be aware that the report is watermarked on each page, with the name of the recipient and the organization (the name mentioned in the PO). This watermark also reaffirms that report sharing is not allowed.*

I hereby accept Knowmade's Terms and Conditions of Sale
Signature:

TERMS AND CONDITIONS OF SALES

Definitions

“Acceptance”: Action by which the Buyer accepts the terms and conditions of sale in their entirety. It is done by signing the purchase order which mentions “I hereby accept Knowmade’s Terms and Conditions of Sale”.

“Buyer”: Any business user (i.e. any person acting in the course of its business activities, for its business needs) entering into the following general conditions to the exclusion of consumers acting in their personal interests.

“Contracting Parties” or “Parties”: The Seller on the one hand and the Buyer on the other hand.

“Intellectual Property Rights” (“IPR”) means any rights held by the Seller in its Products, including any patents, trademarks, registered models, designs, copyrights, inventions, commercial secrets and know-how, technical information, company or trading names and any other intellectual property rights or similar in any part of the world, notwithstanding the fact that they have been registered or not and including any pending registration of one of the above mentioned rights.

“License”: For the reports and databases, 2 different licenses are proposed. The buyer has to choose one license:

1. Single user license: a single individual at the company can use the report.
2. Corporate license: the report can be used by unlimited users within the company. Subsidiaries are not included.

“Products”: Reports are established in PowerPoint and delivered on a PDF format and the database may include Excel files.

“Seller”: Based in Sophia Antipolis (France headquarters), Knowmade is a technology intelligence company specialized in the research and analysis of scientific and technical information. We provide patent landscapes and scientific state of the art with high added value to businesses and research laboratories. Our intelligence digests play a key role to define your innovation and development strategy.

1. Scope

1.1 The Contracting Parties undertake to observe the following general conditions when agreed by the Buyer and the Seller. Any additional, different, or conflicting terms and conditions in any other documents issued by the buyer at any time are hereby objected to by the seller, shall be wholly inapplicable to any sale made hereunder and shall not be binding in any way on the seller.

1.2 This agreement becomes valid and enforceable between the Contracting Parties after clear and non-equivocal consent by any duly authorized person representing the Buyer. For these purposes, the Buyer accepts these conditions of sales when signing the purchase order which mentions “I hereby accept Knowmade’s Terms and Conditions of Sale”. This results in acceptance by the Buyer.

1.3 Orders are deemed to be accepted only upon written acceptance and confirmation by the Seller, within [7 days] from the date of order, to be sent either by email or to the Buyer’s address. In the absence of any confirmation in writing, orders shall be deemed to have been accepted.

2. Mailing of the Products

2.1 Products are sent by email to the Buyer:

- within [1] month from the order for Products already released; or
- within a reasonable time for Products ordered prior to their effective release. In this case, the Seller shall use its best endeavours to inform the Buyer of an indicative release date and the evolution of the work in progress.

2.2 Some weeks prior to the release date the Seller can propose a pre-release discount to the Buyer.

The Seller shall by no means be responsible for any delay in respect of article 2.2 above, and including in cases where a new event or access to new contradictory information would require for the analyst extra time to compute or compare the data in order to enable the Seller to deliver a high quality Products.

2.3 The mailing of the Product will occur only upon payment by the Buyer, in accordance with the conditions contained in article 3.

2.4 The mailing is operated through electronic means either by email via the sales department. If the Product’s electronic delivery format is defective, the Seller undertakes to replace it at no charge to the Buyer provided that it is informed of the defective formatting within 90 days from the date of the original download or receipt of the Product.

2.5 The person receiving the Products on behalf of the Buyer shall immediately verify the quality of the Products and their conformity to the order. Any claim for apparent defects or for non-conformity shall be sent in writing to the Seller within 8 days of receipt of the Products. For this purpose, the Buyer agrees to produce sufficient evidence of such defects.

2.6 No return of Products shall be accepted without prior information to the Seller, even in case of delayed delivery. Any Product returned to the Seller without providing prior information to the Seller as required under article 2.5 shall remain at the Buyer’s risk.

3. Price, invoicing and payment

3.1 Prices are given in the orders corresponding to each Product sold on a unit basis or corresponding to annual subscriptions. They are expressed to be inclusive of all taxes. The prices may be reevaluated from time to time. The effective price is deemed to be the one applicable at the time of the order.

3.2 Payments due by the Buyer shall be sent by cheque payable to Knowmade, PayPal or by electronic transfer to the following account:

Banque Populaire Méditerranée, CAP 3000 Quartier du lac, 06700 St Laurent du Var

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.

3.3 Payment is due by the Buyer to the Seller within 30 days from invoice date, except in the case of a particular written agreement. If the Buyer fails to pay within this time and fails to contact the Seller, the latter shall be entitled to invoice interest in arrears based on the annual rate Refi of the «BCE» + 7 points, in accordance with article L. 441-6 of the French Commercial Code. Our publications (report, database, tool...) are delivered only after reception of the payment.

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.

4. Liabilities

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.

4.2 The Seller shall only be liable for (i) direct and (ii) foreseeable pecuniary loss, caused by the Products or arising from a material breach of this agreement

4.3 In no event shall the Seller be liable for:

a) damages of any kind, including without limitation, incidental or consequential damages (including, but not limited to, damages for loss of profits, business interruption and loss of programs or information) arising out of the use of or inability to use the Seller's website or the Products, or any information provided on the website, or in the Products;

b) any claim attributable to errors, omissions or other inaccuracies in the Product or interpretations thereof.

4.4 All the information contained in the Products has been obtained from sources believed to be reliable. The Seller does not warrant the accuracy, completeness adequacy or reliability of such information, which cannot be guaranteed to be free from errors.

4.5 All the Products that the Seller sells may, upon prior notice to the Buyer from time to time be modified by or substituted with similar Products meeting the needs of the Buyer. This modification shall not lead to the liability of the Seller, provided that the Seller ensures the substituted Product is similar to the Product initially ordered.

4.6 In the case where, after inspection, it is acknowledged that the Products contain defects, the Seller undertakes to replace the defective products as far as the supplies allow and without indemnities or compensation of any kind for labor costs, delays, loss caused or any other reason. The replacement is guaranteed for a maximum of two months starting from the delivery date. Any replacement is excluded for any event as set out in article 5 below.

4.7 The deadlines that the Seller is asked to state for the mailing of the Products are given for information only and are not guaranteed. If such deadlines are not met, it shall not lead to any damages or cancellation of the orders, except for non-acceptable delays exceeding [4] months from the stated deadline, without information from the Seller. In such case only, the Buyer shall be entitled to ask for a reimbursement of its first down payment to the exclusion of any further damages.

4.8 The Seller does not make any warranties, express or implied, including, without limitation, those of saleability and fitness for a particular purpose, with respect to the Products. Although the Seller shall take reasonable steps to screen Products for infection of viruses, worms, Trojan horses or other codes containing contaminating or destructive properties before making the Products available, the Seller cannot guarantee that any Product will be free from infection.

5. Force majeure

The Seller shall not be liable for any delay in performance directly or indirectly caused by or resulting from acts of nature, fire, flood, accident, riot, war, government intervention, embargoes, strikes, labor difficulties, equipment failure, late deliveries by suppliers or other difficulties which are beyond the control, and not the fault of the Seller.

6. Protection of the Seller's IPR

6.1 All the IPR attached to the Products are and remain the property of the Seller and are protected under French and international copyright law and conventions.

6.2 The Buyer agreed not to disclose, copy, reproduce, redistribute, resell or publish the Product, or any part of it to any other party other than employees of its company. The Buyer shall have the right to use the Products solely for its own internal information purposes. In particular, the Buyer shall therefore not use the Product for purposes such as:

- Information storage and retrieval systems;
- Recordings and re-transmittals over any network (including any local area network);
- use in any timesharing, service bureau, bulletin board or similar arrangement or public display;
- Posting any Product to any other online service (including bulletin boards or the Internet);
- Licensing, leasing, selling, offering for sale or assigning the Product.

6.3 The Buyer shall be solely responsible towards the Seller of all infringements of this obligation, whether this infringement comes from its employees or any person to whom the Buyer has sent the Products and shall personally take care of any related proceedings, and the Buyer shall bear related financial consequences in their entirety.

6.4 The Buyer shall define within its company point of contact for the needs of the contract. This person will be the recipient of each new report in PDF format. This person shall also be responsible for respect of the copyrights and will guaranty that the Products are not disseminated out of the company.

7. Termination

7.1 If the Buyer cancels the order in whole or in part or postpones the date of mailing, the Buyer shall indemnify the Seller for the entire costs that have been incurred as at the date of notification by the Buyer of such delay or cancellation. This may also apply for any other direct or indirect consequential loss that may be borne by the Seller, following this decision.

7.2 In the event of breach by one Party under these conditions or the order, the non-breaching Party may send a notification to the other by recorded delivery letter upon which, after a period of thirty (30) days without solving the problem, the non-breaching Party shall be entitled to terminate all the pending orders, without being liable for any compensation.

8. Miscellaneous

All the provisions of these Terms and Conditions are for the benefit of the Seller itself, but also for its licensors, employees and agents. Each of them is entitled to assert and enforce those provisions against the Buyer.

Any notices under these Terms and Conditions shall be given in writing. They shall be effective upon receipt by the other Party.

The Seller may, from time to time, update these Terms and Conditions and the Buyer, is deemed to have accepted the latest version of these terms and conditions, provided they have been communicated to him in due time.

9. Governing law and jurisdiction

9.1 Any dispute arising out or linked to these Terms and Conditions or to any contract (orders) entered into in application of these Terms and Conditions shall be settled by the French Commercial Courts of Grasse, which shall have exclusive jurisdiction upon such issues.

9.2 French law shall govern the relation between the Buyer and the Seller, in accordance with these Terms and Conditions.