

STATUS OF THE RADAR INDUSTRY: PLAYERS, APPLICATIONS AND TECHNOLOGY TRENDS 2020

Market & Technology Report - May 2020

Worth more than \$20B in 2019, the radar industry is experiencing a major transformation prior to entering the commercial era.

WHAT'S NEW

- Automotive radar imaging market forecast provided
- Automotive radar market forecast extended to in-cabin occupancy detection
- Defense, security and aerospace market forecast added
- Industrial market forecast added
- Consumer market forecast added
- Medical market forecast added

KEY FEATURES

- Market forecast per segment
- Market trend per segment
- Technology trend per segment
- Supply chain and market share analysis per segment

RADAR TECHNOLOGIES ARE UNDERGOING MAJOR TRANSFORMATIONS

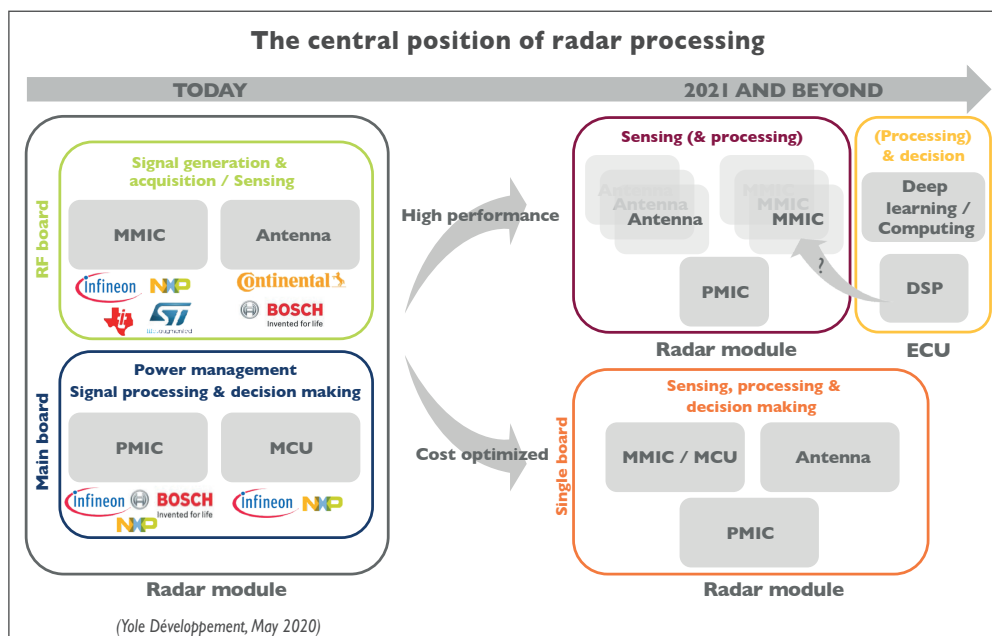
In many ways the radar industry has seen drastic changes in the past decade. In the military field, the need for improved survivability, low probability of intercept and longer detection range has oriented the industry towards active antenna arrays using solid state technologies. Indeed, the possibility to use more integrated and lighter devices together with the advanced capabilities offered by multiple beam shaping and steering, for example, motivated the transition from vacuum tubes to solid state solutions.

In the automotive field, radars have now become standard equipment. Following more stringent test scenarios, two trends are emerging. One consists of moving forward with imaging radar capable of more accurately describing the scene in front of and around the car. The other is to increase the number of sensors around the car and coordinate it to improve scene perception.

In both cases, a strong emphasis on signal processing and computing is emerging, while cost issues particularly matter in automotive. Multiple questions have been raised about where to move the signal processing and how better to exploit radar sensor inputs. This will likely contribute to a major transformation of the automotive radar industry.

Nevertheless, one of the most game-changing evolutions is the potential acceptance of radar for human machine interfaces (HMIs) through penetration in consumer electronics, where cost, integration and resolution are most challenging. Here again, this asks a lot of computing and software.

All these factors have induced strong technological changes in this market that was slow paced several years ago.



SIGNIFICANT GROWTH FOR AN ALREADY LARGE MARKET

Prior to automotive penetration, the radar industry was a huge, mature market. But today, it is expected to show a 5% Compound Annual Growth Rate (CAGR) between 2019 and 2025. This is high given its large size and formerly slow growth.

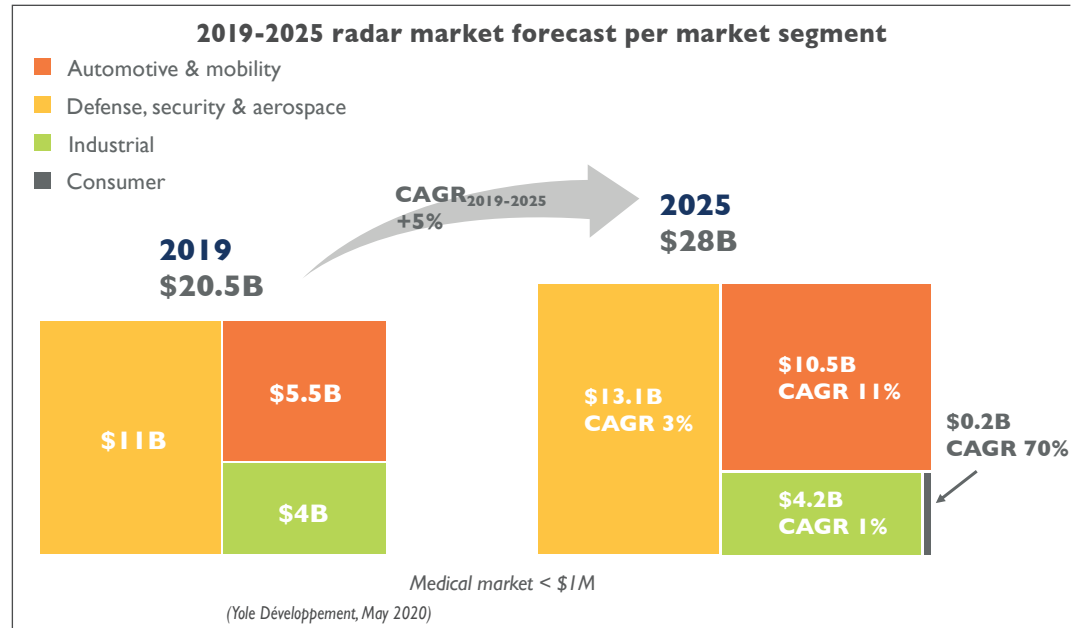
On the military radar side, which represents more than half of the total radar market, there

will be a moderate 3% CAGR. This is in line with its mature dynamics and nations' budget constraints.

On the other hand, the automotive market is expected to grow at an 11% CAGR, and the consumer market at up to 70% CAGR. This is due to the recent development of radar for the automotive market, and the nascent nature

of consumer applications. These two fast moving markets are the radar industry's growth drivers. The industrial radar market will suffer a decline at first. Nevertheless, new demand coming from

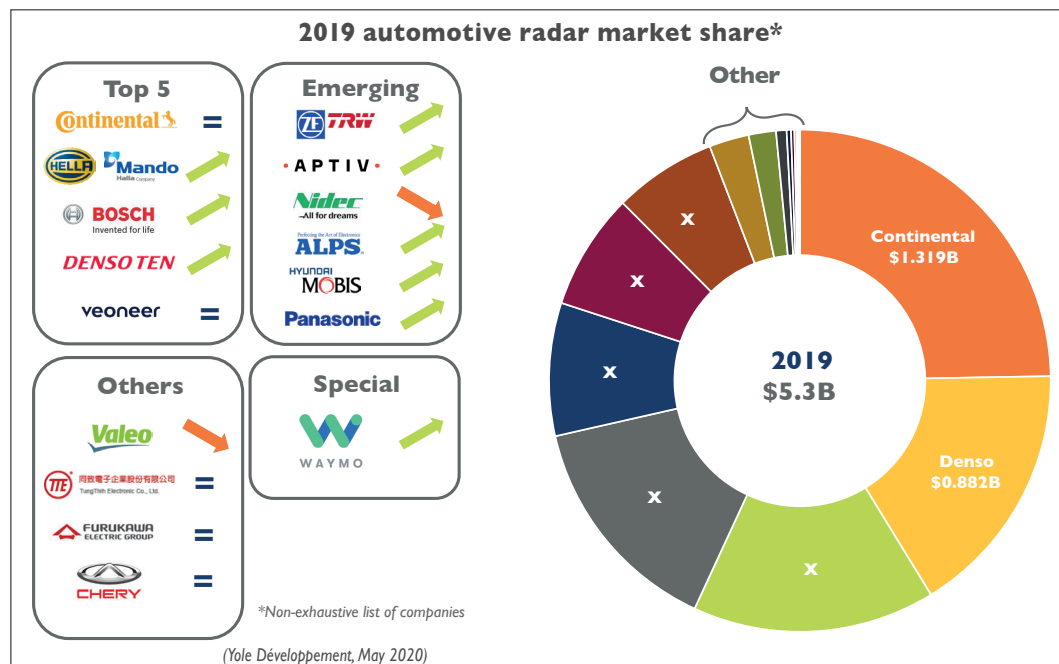
building automation will dampen the losses and actually result in a 1% CAGR during the 2019-2025 period. The medical market is still in the incubation stage.



AN EXTREMELY ACTIVE ECOSYSTEM – FOR NON-MILITARY RELATED APPLICATIONS

In the military field, the industrial landscape is well established. A few companies are exporting worldwide, such as Raytheon, Lockheed Martin and Northrop Grumman. A multitude of local players also exist for obvious strategic reasons. Due to the very peculiar nature of this market, no drastic changes have been seen in the past years. For non-military-oriented applications, on the other hand, the market is extremely active. The automotive market is today dominated by five players at the final module level, Continental, Denso, Bosch, Hella and Veoneer. It sees emerging players such as Aptiv, ZF-TRW, Alps,

Hyundai Mobis and Panasonic and new entrants like Waymo coming in with innovative approaches. At the semiconductor level, the situation is very similar, with three players dominating the market, Infineon, NXP and STMicroelectronics. New entrants such as Arbe and Uhnder are offering disruptive approaches. The strong growth and market potential are attracting players from other fields, such as mobile phone industry companies like Huawei or Qualcomm. The perspective of a potential opening up of the consumer market is also motivating players like Infineon to look at consumer electronics and to try to adapt its



approach to completely different dynamics. In the next five years, thanks to the evolution of Advanced Driver Assistance Systems (ADAS) and the opening up of the consumer electronics market, the non-military radar landscape is expected to move rapidly.

In this report, Yole Développement looks at all these different markets and offers its vision of technology evolution as well as the industrial landscape, while offering market forecasts for the 2010-2025 period.

COMPANIES CITED IN THE REPORT (non exhaustive list)

ABB, Acconeer, Acura, Ainstein, Airbus Defense Group, Alfa Romeo, Alps Electric, Analog Devices, Anzhi Auto, Apollo, Aptiv, Arbe, Arqana, Asahi Kasei Microdevice, Astyx, Autoroad, Audi, BAE systems, BAIC, Baumer, Baron, BAW, BMW, Boeing, Bosch, Brose, Bugatti, Buick, BYD, Calterah, Caterpillar, Capella Space, CETC, Changan, ChengTech, Chevrolet, Chery, Chrysler, Cohda Wireless, Continental, Cradar, Cruise, Daihatsu, Degreane, Denso-Ten, DJI, DongFeng, EEC, Echodyne, e-geos, Faurecia, FAW, Fiat, FLIR, Ford, Furukawa Electric, Geely, General Atomics, GM, GlobalFoundries, GMC, Google, Great Wall, Hella, Hensoldt, Hexagon, Hitachi, Honda, Honeywell, Huawei, Hyundai, Hyundai MOBIS, IAI, Iceye, IEE, IDT, IMSemi, IMS Systems, IMST, InnoSent, Infineon, Infinity, Intel, IntiBeam, Invap, Inxpect, Jaguar, Jeep, JRC, Kaikutek, Kia, Kiwi, Knowles, Krohne, Kuka, L3Harris, LeoLabs, Leonardo, Lexus, LG Innotek, Lincoln, Linde Material Handling, Lite ON, Lockheed Martin, Lyft, Magna, Mando, MediaTek, Mercedes, Metawave, MicroChip, Mini, Mitsubishi, Mitsubishi Electric, Mobil Eye, Morgina, Nanoradar, NavTech Radar, Nanya, NDK, Nidec Elesys, NIO, Nissan, Norinco, Northrop Grumman, Novel IC, Nuro, Nvidia, NXP, Oculii, Olea, Omnicar, Ondosense, ON Semiconductor, Panasonic, Peugeot, Porsche, Qorvo, Qualcomm, Radiometrics, Range Rover, Raytheon, Renault, Renesas, RFISEE, Saab, Sakura Tech, Samsung, SAIC, SEAT, Siemens, Silicon Radar, Sixth Sensor, Skyworks, Skoda, Smart Radar System, Socionext, SpaceEyes, Starship, Starsky, STMicroelectronics, Subaru, Sumitomo Electric, Symeo, Terma, Tesla, Texas Instruments, Tata, Thales, TomTom, Toshiba, Toyota, Tower Semiconductor, TSMC, TTTech, TungThih Electronics, TU Simple, Uber, Umbra, Uhnder, United Monolithic Semiconductors, Valeo, Vaisala, Vayyar, Veoneer, Volkswagen, Volocopter, Volvo, Waymo, WHST, Wistron Neweb Corporation, XeThru, Xilinx, Zendar, Zenuity, ZF-TRW, Zox, and more.



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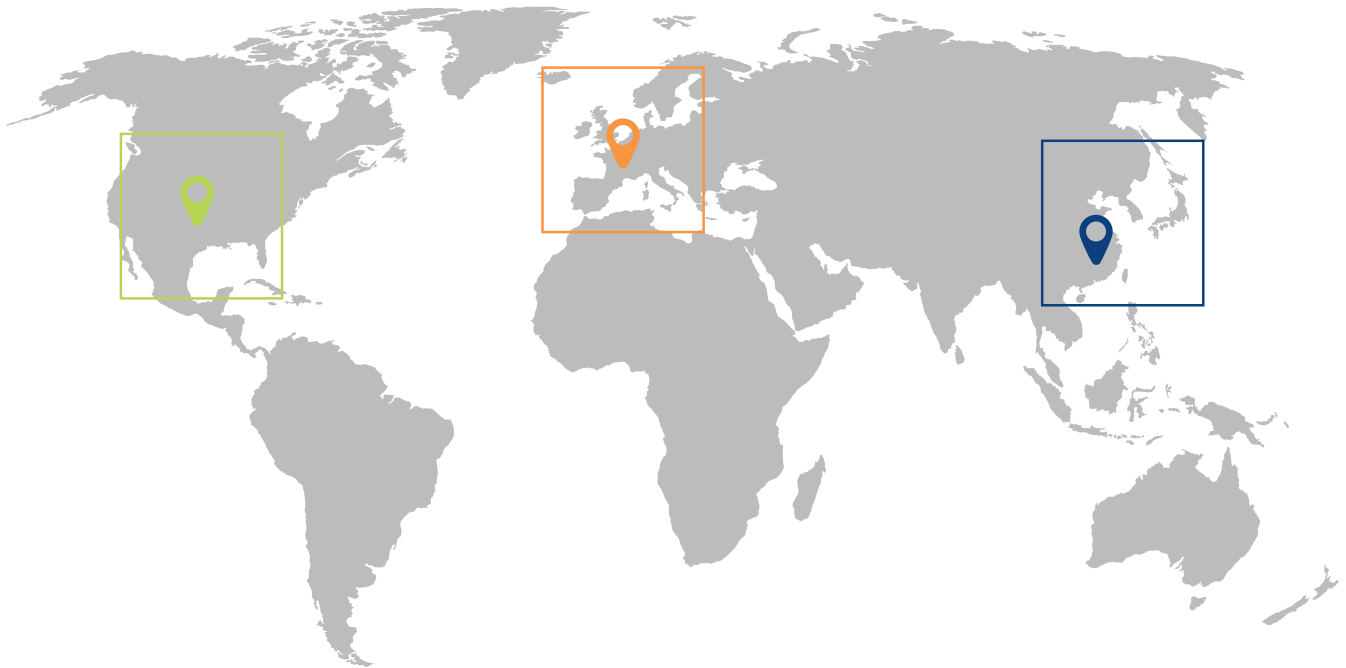
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ABOUT YOLE DEVELOPPEMENT

Founded in 1998, Yole Développement (Yole) has grown to become a group of companies providing marketing, technology and strategy consulting, media and corporate finance services, reverse engineering and reverse costing services. With a strong focus on emerging applications using silicon and/or micro manufacturing, the Yole group of companies has expanded to include more than 120 collaborators worldwide covering MEMS and Image Sensors, Compound Semiconductors, RF Electronics, Solid-state Lighting, Displays, Software, Optoelectronics, Microfluidics & Medical, Advanced Packaging, Manufacturing, Power Electronics, Batteries & Energy Management and Memory.

The “More than Moore” market research, technology and strategy consulting company Yole Développement, along with its partners System Plus Consulting, PISEO and Blumorpho, supports industrial companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to grow their business.

CONSULTING AND ANALYSIS

- Market data & research, marketing analysis
- Technology analysis
- Strategy consulting
- Reverse engineering & costing
- Design and characterization of innovative optical systems
- Financial services (due diligence, M&A)

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- Public Relations: Sandrine Leroy (sandrine.leroy@yole.fr)

Definitions: **“Acceptance”**: Action by which the Buyer accepts these General Terms and Conditions of Sale in their entirety. It is done by signing the purchase order which states “I hereby accept Yole Développement’s General 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) placing an order pursuant to these General Terms and Conditions of Sale, with the exclusion of any individual consumer acting for his/her sole personal interest.

“Seller”: Headquartered in Villeurbanne (France), Yole Développement provides marketing, technology and strategy consulting, media and corporate finance services, reverse engineering/costing services as well as IP and patent analysis. With dedicated teams of technology & market analysts, Yole Développement operates worldwide with the key industrial companies, R&D institutes and investors to help them understand the market and technology trends.

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Our products can be bought either on a unit basis or as a bundled offer (i.e. subscription for a period of 12 calendar months).

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Reports are established in PowerPoint and delivered in a PDF format with an additional Excel file. 30 min of Q&A session with an analyst/author can be included for all purchased reports (except the ones bought as a one user license). More time can be allocated on a fee basis.

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Monitors are established and delivered in Excel. An additional PDF can also be added. Q&A with an Analyst is possible for each monitor (except where specified otherwise). Frequency of the release vary according to the monitor or service (quarterly and monthly). All monitor products are eligible for a Corporate License.

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1. SCOPE

1.1 Both Contracting Parties undertake to comply with these General Terms and Conditions of Sale.

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, ARE DEEMED WHOLLY INAPPLICABLE TO ANY SALE MADE HEREUNDER, AND SHALL NOT BE BINDING IN ANY WAY ON THE SELLER.

1.2 These General Terms and Conditions of Sale shall be deemed valid and enforceable between the Contracting Parties after acceptance of an order from the Buyer by the Seller pursuant to Article 1.3 below. For such purpose, the Buyer, when signing the purchase order which mentions “I hereby accept Yole Développement’s Terms and Conditions of Sale” is deemed to have fully and unequivocally accepted these Terms and Conditions of Sale.

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. In the absence of any confirmation in writing, no order shall be deemed to have been accepted.

2. MAILING OF THE PRODUCTS

2.1 Products are sent by email to the Buyer after Seller’s confirmation:

- Within a few days from the Seller’s confirmation of the order for Products already released and paid; 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 The Seller shall by no means be responsible for any delay pursuant to Article 2.1 above, in particular in cases where a new event or access to new contradictory information would require the Seller analyst to dedicate extra time to compute or compare the data in order to enable the Seller to deliver a high quality Product.

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

2.4. The mailing is operated through electronic means either by email via the sales department or automatically online via an email/password. The Buyer is responsible for ensuring that the Buyers platform has the required capacities and authorisations to receive the Product(s) emailed by the Seller. If the Product’s electronic delivery format is defective, the Seller undertakes to replace it at no charge to the Buyer provided that the Seller 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 with 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 written notification from the Buyer to the Seller, even in case of delayed delivery. Any Product returned to the Seller without the Buyer providing prior notification to the Seller as required under Article 2.5 above shall remain at the Buyer’s risk. In no event shall the Seller incur any liability for Products erroneously ordered by the Buyer, or for any request from the Buyer to replace a Product previously ordered by a different Product.

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 deemed to be inclusive of all taxes applicable in the country where the Seller is based (except for France where VAT will be added). The prices are re-evaluated from time to time by the Seller. 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 Yole Développement, or made by credit card or by electronic transfer to the following account:

HSBC, 1 place de la Bourse 69002 Lyon France
Bank code: 30056
Branch code: 00170
Account n°: 0170 200 1565 87
BIC or SWIFT code: CCFRFRPP
IBAN: FR76 3005 6001 7001 7020 0156 587

To secure the payments due to the Seller, the Seller reserves the right to request down payments from the Buyer. In such case, the need for a down payment will be mentioned on the corresponding order.

3.3 Payment is due by the Buyer to the Seller within 30 days from invoice date, except as otherwise specifically agreed in writing by the Buyer and the Seller. If the Buyer fails to pay at the due date and fails to request and obtain from the Seller a payment extension, 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.

3.4 The Seller publications (reports, monitors, tracks...) are due for delivery only after receipt by the Seller of any payment due by the Buyer prior to delivery.

3.5 In the event of termination of the contract by the Seller attributable to Buyer misconduct during the contract, the Seller will have the right to invoice all work performed at the time of termination, 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 the choice of the Products purchased as well as for the use and interpretations the Buyer makes of the documents it purchases, of the results the Buyer obtains, and of the advice and acts the Buyer bases thereon .

4.2 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 a Product or the use of or the inability by the Buyer to use the Seller’s website, or any information provided on the website, or contained in a Product;
- b) Any claim attributable to errors, omissions or other inaccuracies in a Product or interpretations thereof.

4.3 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.

4.4 Any Product that the Seller sells may, upon prior notice to the Buyer from time to time be modified by Seller or substituted with a similar Product meeting the needs of the Buyer. Such modification shall not lead to any liability of the Seller, provided that the Seller ensures the substituted Product is similar to the Product initially ordered.

4.5 In the case where, after inspection, it is acknowledged that a Product contain defects, the Seller undertakes to replace the defective product to the extent reasonably feasible and without indemnification or compensation of any kind for labour costs, delays, loss caused or any other reason being due by the Buyer . This undertaking from the Seller shall be effective for a maximum of two months starting from the delivery date but shall not be applicable in the event of force majeure as described in Article 5 below.

4.6 The deadlines that the Seller is asked to provide for the mailing of a Product are given for information purposes only and are not guaranteed. If such deadlines are not met, this shall not, without the agreement of the Seller lead to any claim for damages or right of cancellation of one or more orders by the Buyer, except for non-acceptable delays exceeding [3] months from the stated deadline. In such case only i.e. only in the event of a delay exceeding (3) months from the stated deadline the Buyer shall be entitled to ask for a reimbursement of any down payment previously made to the Seller, to the exclusion of any other damages.

4.7 The Seller does not make any warranties, express or implied, including, without limitation, those of sale ability and fitness for a particular purpose, with respect to any 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 Products available, the Seller cannot guarantee that any Product will be free from infection.

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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, labour difficulties, epidemics, major health event (e.g. Corona virus), equipment failure, late deliveries by suppliers or other difficulties which are beyond the control, and not attributable to the fault of the Seller.

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- 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 a Product or any derivative thereof.

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6.4 The Buyer shall be solely responsible towards the Seller for any infringement of the obligation described in Article 6.3 above, whether such infringement originates from the Buyer’s employees or any person to whom the Buyer has sent the Products. Furthermore, the Buyer shall initiate and personally take care of any related proceedings in coordination with the Seller, and the Buyer shall bear the related financial consequences in their entirety.

6.5 The Buyer shall define within its Company an identified user who shall serve as a contact person for the License purchased by the Buyer. This person will be the recipient of each new report. This person shall also be responsible on behalf of the Buyer, for compliance with all copyrights and other obligations relating to the protection of the Seller’s IP rights and general compliance with the terms of the License purchased by the Company. In the context of Bundle and Annual Subscriptions, the contact person shall decide within the Buyer which person(s) shall be entitled to receive the protected link that will allow the Buyer to access the Products.

6.6 It is acknowledged and accepted by the Buyer that whether purchased in the form of Bundles or Annual Subscription, all unselected reports will be deemed cancelled and lost after a period of 12 month following acceptance of the corresponding order by the Seller in accordance with provisions of Article 1.3 above .

6.7 It is further acknowledged and agreed by the Buyer that any investor in the Buyer Company, any external consultant of the Buyer Company or any joint venture done with a third party in which the Buyer Company is involved , is not entitled to use a Product, without paying to the Seller the full price for a license to the required Product..

7. TERMINATION

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 incurred by the Seller, pursuant to such cancellation or postponement.

8. MISCELLANEOUS

8.1 All the provisions of these General Terms and Conditions of Sale are for the benefit of the Seller, but also for that of its licensors, resellers and agents. Each of them is entitled to assert and enforce these provisions against the Buyer.

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

8.2 The Seller may, from time to time, update these General Terms and Conditions of Sale, and the Buyer, shall be deemed to have accepted the latest version of such General Terms and Conditions of Sale, once they have been duly communicated to the Buyer by the Seller.

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9.1 Any dispute arising out or linked to these General Terms and Conditions of Sale or to any Licenses or Products purchased in application thereof shall be submitted to the French Commercial Court of Lyon, which shall have exclusive jurisdiction upon such issues.

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