

ARTIFICIAL INTELLIGENCE COMPUTING FOR AUTOMOTIVE 2020

Market & Technology Report - May 2020

Artificial Intelligence paves the way to full autonomy.

KEY FEATURES

- Artificial intelligence (AI) technologies used in automotive
- Hardware for ADAS (Advanced Driver-Assistance Systems), robotic vehicles, and infotainment
- Ecosystems, market forecasts, and trends
- AI software and hardware design, and players' strategies

WHAT'S NEW

- With electrification as the main budget priority for investments in Europe, Yole Développement (Yole) expects that autonomy will take longer since cash is not available this year due to COVID-19
- The different strategies chosen by OEMs will be significantly impacted by COVID-19. Tesla is improving its autonomy stack step-by-step, while others are investing strongly in partnerships and R&D. This means that Tesla will retain its lead in the race to autonomy, while other players might remain competitive by using computing hardware and software platforms. Some companies might have to delay their programs completely
- In China, the "COVID-19 effect" will have less impact since substantial investment comes from the government
- For all these reasons, Yole team has taken a more conservative approach in this report compared to last year in terms of AI penetration rate and development of autonomous functionalities
- Reaching Levels 3, 4, and 5 will take longer than expected

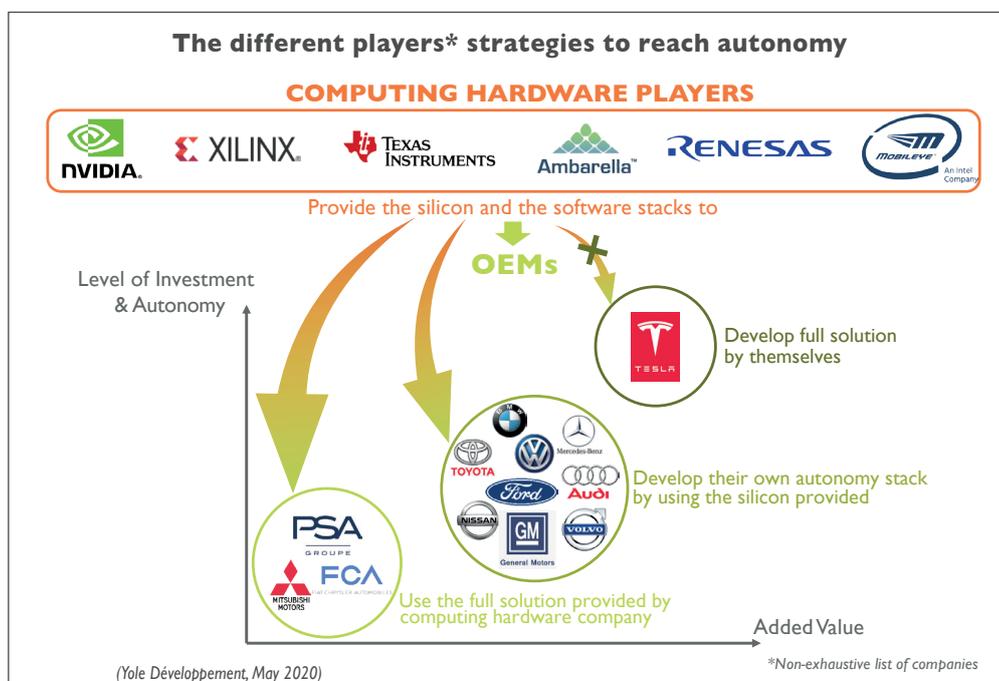
WINNERS AND LOSERS IN THE RACE FOR AUTONOMY

Artificial Intelligence (AI) is gradually invading our lives through everyday objects like smartphones, smart speakers, and surveillance cameras. The hype around AI has led some players to consider it as a secondary objective, more or less difficult to achieve, rather than as a central tool to achieve the real objective: autonomy. Finally, after an initial inventory, the players that have grasped this aspect are already leading the race.

The impact of COVID-19 is still uncertain, but we can already affirm that it will have a profound effect - with autonomy-related research likely to slow down at least this year and next due to cash shortages. For a player like Tesla, which has built all of its autonomous stack internally (software and hardware) and thus holds sole ownership, the strategy of moving forward in small steps will pay off since this strategy is not "side research" but rather an integral part of the Tesla project, just like electrification. In fact, the impact of this crisis will probably

accentuate Tesla's market leadership, which is already estimated at several years.

In the second line, we find OEMs which develop their own autonomous software stack, but with hardware provided to them by other industry players. Lack of cash can slow down some programs, but others have been active for several years now and will probably not be stopped. And even if they are delayed, autonomy is an integral part of these OEMs' middle-term strategies – just as it is for Tesla. As for those companies with speculative programs that do not have the quest for autonomy as a cornerstone, it is very likely that these research programs, if they exist, will at best be postponed until the crisis has disappeared completely. These companies will be the big losers in the autonomy race and will have to rely even more on computing players to provide them with full autonomous solutions / functionalities.



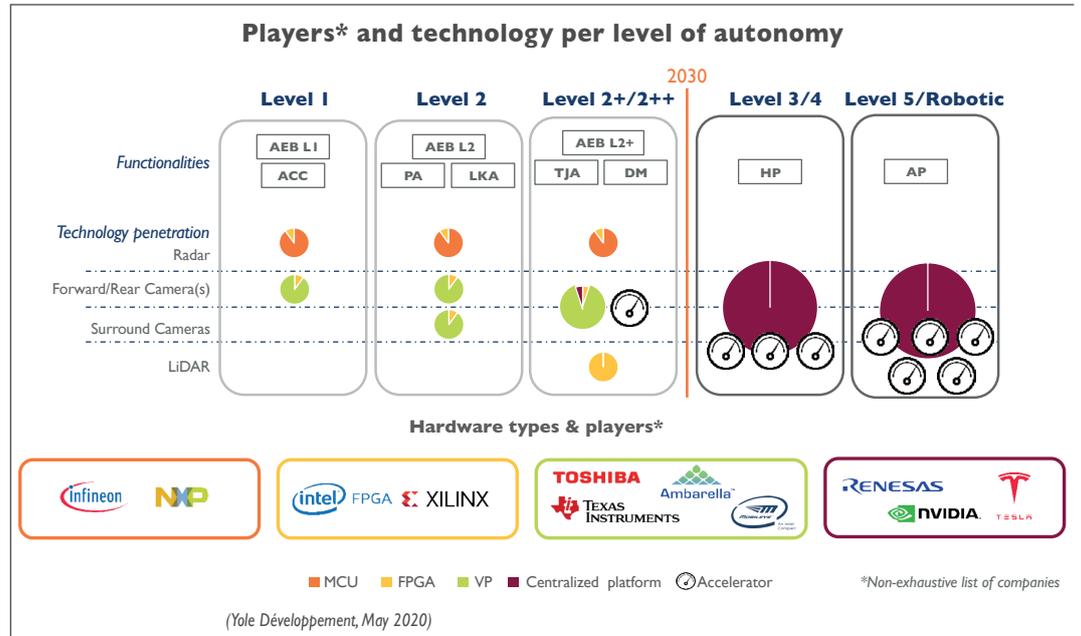
THE MARRIAGE OF AI AND COMPUTING IS THEREFORE AT THE HEART OF THIS RACE

The evolution of the number of functionalities, along with their increased complexity, requires the contribution of dedicated solutions for the software carrying these functionalities. Firstly, in terms of software, it is becoming increasingly

difficult to not provide a touch of neural networks. Even if the "black box" aspect of neural networks is less discussed, it can still remain an obstacle to implementation, particularly in the widely accepted "safety first" trend.

In this report, Yole Développement (Yole) focuses largely on the integration of accelerators (or neural engine / neural processing unit - different marketing names for same type of architecture) in ADAS solutions. These units, which have started appearing in mobile phone processors, are dedicated to the calculation of deep learning algorithms - the most famous of which is an AI method used today for object recognition in images. Tesla integrated these accelerators and

AI into its Full Self-Driving (FSD) chip last year. For most OEMs, this solution will be realized by 2021 – 2022, since these special units are now integrated into all current or future ADAS chipsets at Mobileye, Xilinx, TI, Toshiba, Ambarella, and Renesas. This trend to integrate more and more AI and therefore accelerators follows in a linear fashion the rise in autonomy. Other trends such as centralization will gradually redraw the future of computing.

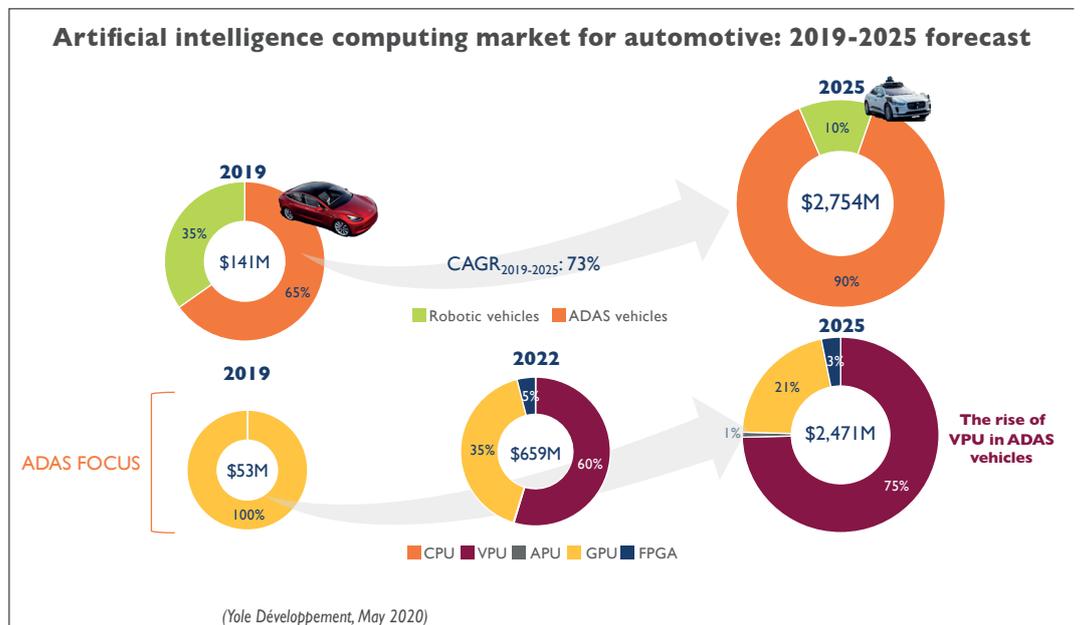


A MARKET DIVIDED BETWEEN CENTRALIZED PLATFORMS AND VISION PROCESSORS

Yole suggests that two paths are available: either a single computer-type NVIDIA or FSD, descending from the high-end segment of robotic vehicles (i.e. the “brain” of a car); or, the number of vision processors incorporating accelerators is multiplied, a path already embraced by several OEMs. Competition will arise between these two platforms and determine the revenue. The 2025

market for AI, including ADAS and robotic vehicles, is estimated at more than \$2.7B - of which \$2.4B will be “ADAS only”.

This is only the beginning, and the challenges surrounding AI and its impact on the automotive industry are already being felt. Some companies have a considerable lead, and it will be difficult to catch



up with them, especially without integrating AI and the computing that goes with it.

So, what are the challenges? Who can keep up? And has the impact of COVID-19 and the

resulting lack of cash permanently wiped some players off the map? This report will give a detailed answers to these questions.

REPORT OBJECTIVES

Provide a scenario for AI within the dynamics of the autonomous automotive market and present an understanding of AI's impact on the semiconductor industry:

- Hardware for AI - revenue forecast, volume shipments forecast
- Systems - ASP forecast, revenue forecast, volume shipments forecast
- Focus on autonomous car - ADAS and robotic vehicles

Deliver an in-depth understanding of the ecosystem and players:

- Who are the players? What relationships exist within the ecosystem? Who will win the "autonomous battle"?
- Who are the key suppliers to watch, and what technologies do they provide?

Offer key technical insights and analyses into future technology trends and challenges:

- Key technology choices
- Technology dynamics
- Emerging technologies and roadmaps

COMPANIES CITED IN THE REPORT (non exhaustive list)

Alphabet, Algolux, Amazon, AMD, Apple, ARM, Baidu, Bosch, BMW, Continental, Delphi, EasyMile, Eyesight Faurecia, Ford, Fujitsu, General Motors, Google, Infineon, Intel, Intel MobilEye, Kalray, Lyft, Melexis, Mercedes-Benz, Microship, Microsoft, Nanya, NEC, Nio, Nissan, Nuance, NVIDIA, NXP, Parrot, PSA, Qualcomm, Renesas, Samsung, Sony Softkinetic, STMicroelectronics, Tesla, Texas Instruments, Toshiba, Toyota, Uber, Valeo, Videantis, Volkswagen, Volvo, Waymo, Xilinx and many more...

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RELATED REPORTS, MONITORS & TRACKS



- Sensing & Computing for ADAS Vehicle 2020
- Sensors for Robotic Mobility 2020
- Imaging for Automotive 2019
- Triple Forward Camera from Tesla Model 3 – by System Plus Consulting
- Nvidia Tegra KI Visual Computing Module - by System Plus Consulting
- Automotive Teardown Tracks - by System Plus Consulting

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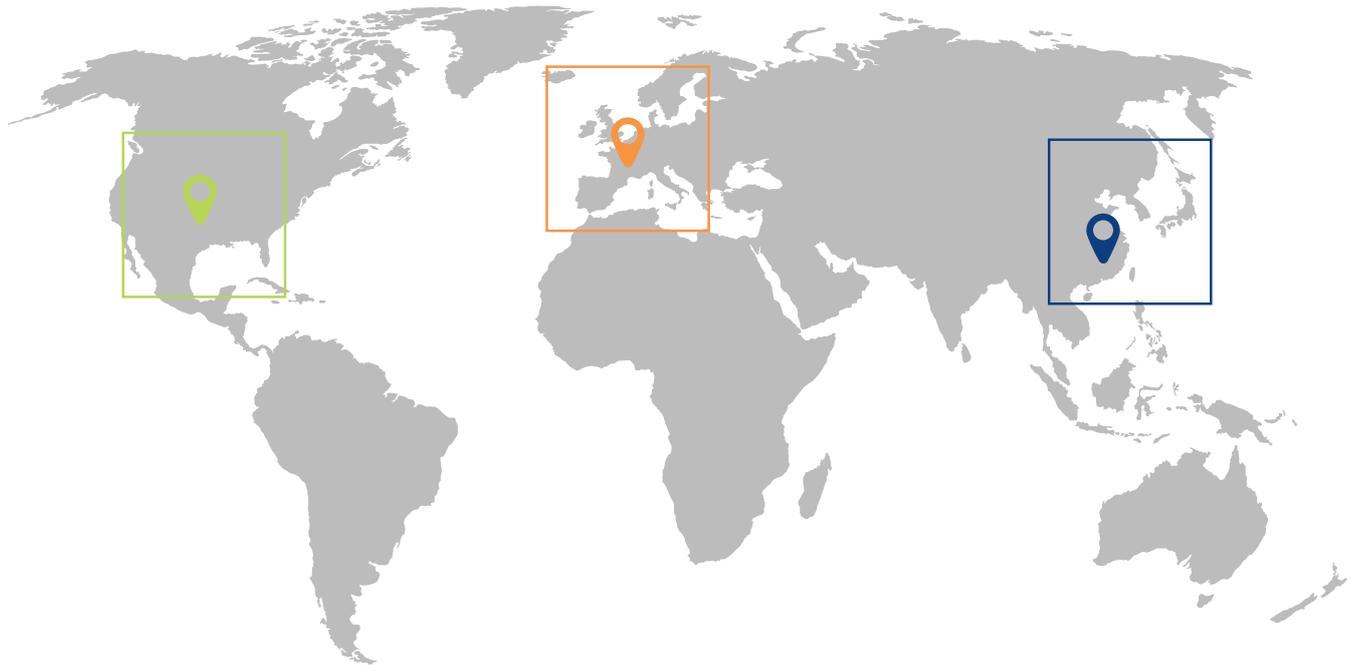


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ABOUT YOLE DEVELOPPEMENT

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)

More information on www.yole.fr

MEDIA & EVENTS

- i-Micronews.com website, application & related e-newsletter
- Communication & webcast services
- Events: TechDays, forums...

More information on www.i-Micronews.com

REPORTS & MONITORS

- Market & technology reports
- Market and reverse technology quarterly monitors
- Structure, process and cost analysis and teardowns
- Cost simulation tool

More information on www.i-micronews.com/reports

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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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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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For the reports 3 different licenses are proposed. Buyer has to choose one license type:
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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.

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, 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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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 a Product, or any part of it to any other party other than employees of the Buyer Company (and only in the country of the Primary User for Multi-User Licenses). The Buyer shall have the right to use Products solely for its own internal information purposes. In particular, the Buyer shall therefore not use any Product for purposes such as:

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- 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 a Product or any derivative thereof.

6.3 If the Buyer would like to use data coming from a Product for presentations, press announcements and any other projects, the Buyer needs to contact Yole Développement’s Public Relations Director (info@yole.fr) to get an official authorization and confirm that the data are up to date. In return the Seller will make sure to provide up-to-date data under a suitable public format.

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.

9. GOVERNING LAW AND JURISDICTION

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.

9.2 French law (without reference to any applicable conflict of law provisions) shall apply to these General Terms and Conditions of sale and any agreement between the Buyer and the Seller made pursuant thereto.