

# 5G'S IMPACT ON RF FRONT-END AND CONNECTIVITY FOR CELLPHONES 2020

Market & Technology Report - September 2020

*An intensifying US-China competition for RF technology supremacy.*

## WHAT'S NEW

- Covid 19's impact on the RF front-end and connectivity business
- Ecosystem analysis and US/China trade war analysis
- Baseband and RF transceiver market forecast and shares added
- Market forecast and shares extracted at die level
- Connectivity market extended to ultra wideband

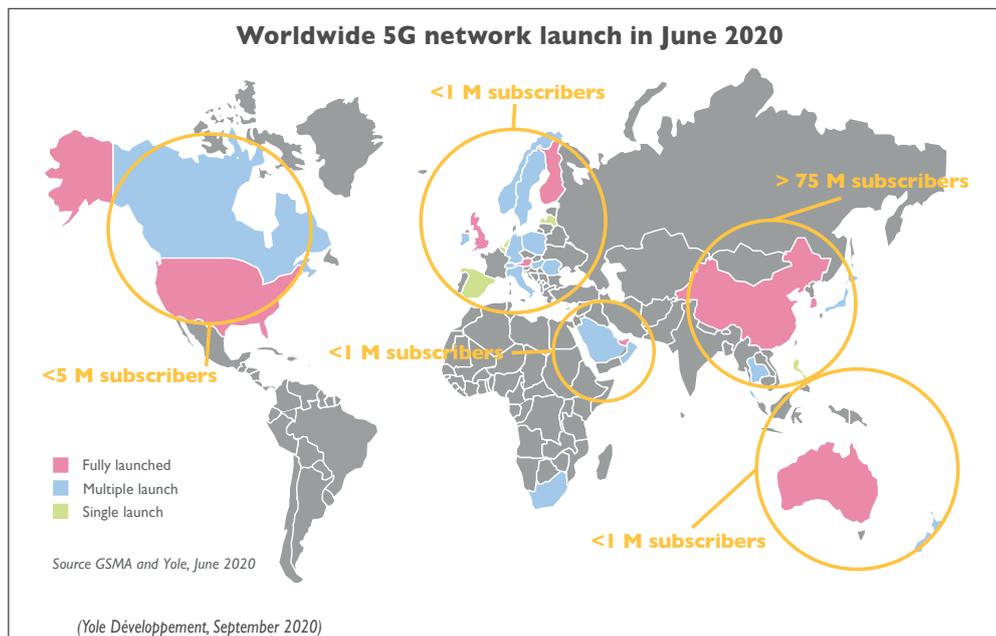
## KEY FEATURES

- RF front-end market forecast 2015 – 2025, in Mu and \$M
- Connectivity market forecast 2015 – 2025, in Mu and \$M
- Market share \$M and ecosystem analysis
- RF front-end and connectivity technology breakdown forecast
- Wafer-start forecast per year 2015-2025
- 5G market trends and key features
- Connectivity market trends and key features

## 5G AND WI-FI 6 BENEFIT FROM THE COVID19 PANDEMIC

Consumer appetite for data has not been reduced by the Covid19 pandemic. In fact, it's the opposite. People realized the importance of being connected during lockdown. Most of the data traffic increase has been handled by fixed networks, but mobile networks also have been affected. Many service providers had to adapt to the situation. Whether fixed or mobile, service providers have a great window for migrating consumers to broadband internet access and to the new 5G and Wi-Fi6 plus fibre standards. The benefit at the network operator level is the efficiency of the new technologies, which would reduce cost of operation. And as early adopter consumers are ready to pay extra fees for the improved network and compelling data plans,

the return on investment for the carrier will come sooner. China, South Korea and USA are early adopter countries of 5G where all major carriers have launched their network, as depicted in figure 1, and where consumers are technology enthusiasts. In Japan, in Europe and for the rest of the world, 5G network rollout is moving forward at a slower pace. The Chinese market will pull most of the demand for 5G smartphones in 2020. The US government is putting a strong emphasis on 5G and Wi-Fi 6 with unprecedented spectrum auction plans to accelerate the technology adoption at a broader scale. Indeed, these technology transitions contribute greatly to gross domestic product (GDP) in a context where nations are looking for growth more than ever.



## RF FRONT-END AND CONNECTIVITY MARKETS POISED FOR DOUBLE-DIGIT GROWTH

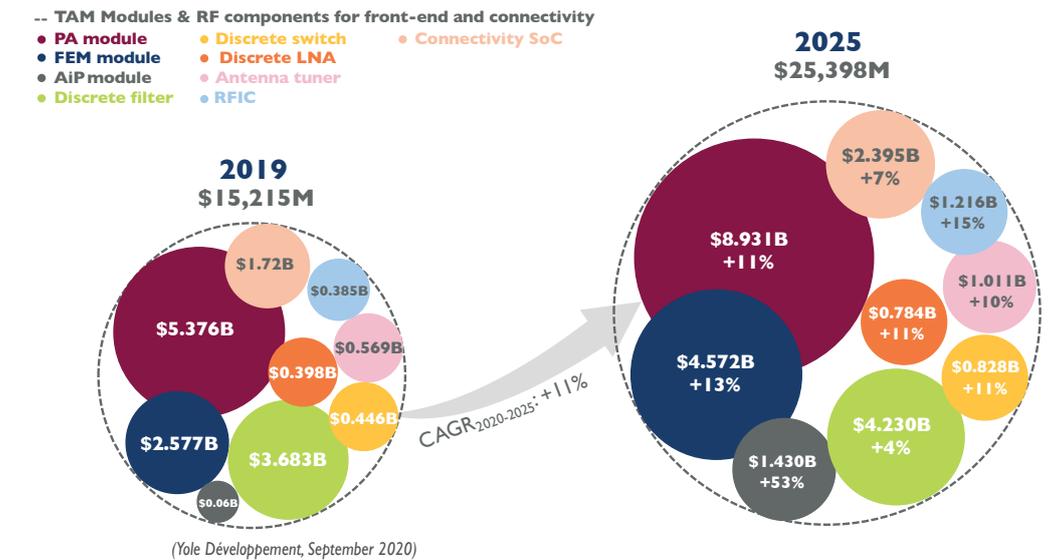
When we purchase a smartphone, we often look at the battery lifetime and the photographic performance. Then come system performance and connectivity, which is attributed to System-on-Chip (SoC) performance. One must also notice the fundamental role of the radio frequency (RF) front-end in the system performance. It directly impacts the device power consumption and is essential for routing, filtering and amplifying signals to and from the antennas. LTE and LTE-Advanced and Wi-Fi 5 standards have contributed to the rising

complexity of RF front-ends in handsets. 5G and Wi-Fi 6 are no exception as both standards introduce new features that will increase the RF content and complexity. Indeed, to cope with more stringent requirements in data transmission speed and better spectral efficiency, a 5G handset will feature a 4x4 Multiple Input Multiple Output (MIMO) downlink for frequencies above 2.5 GHz. It will also have New Radio (NR) frequency bands along with Dual Connectivity (EN-DC) of 5G with LTE. There will be a 2x2 MIMO uplink

in some cases and likely a diversity transmit link. Sounding reference signals will also be mandatory in 5G handset to optimize the radio link with an active antenna system within range. On top of that, 5G devices will have to meet the definition of high power user equipment for Time Division Duplex (TDD) NR bands and to be capable of operating with at least 100 MHz of bandwidth. Carrier Aggregation (CA) will be applied to 5G as it was for LTE. Other features will be evaluated, such as supplementary uplink, which could affect the RF content. Wi-Fi 6 will essentially democratize the use of 2x2 MIMO for up and

downlink. Wi-Fi 6E will extend the frequency coverage of Wi-Fi signals to 6 GHz. New use cases such as file sharing or augmented reality and smart remote control are driving the need for a precise positioning technology. Thus, a new UWB radio will be added in handsets, further increasing the RF content. Overall, the RF front-end and connectivity market was valued at \$15.2B in 2019. It will grow 11% Compound Annual Growth Rate (CAGR) between 2020 and 2025 to reach \$25.4B by 2025. The market will be segmented into multiple major components.

**2020-2025 RF front-end and connectivity market forecast - Per type of component**

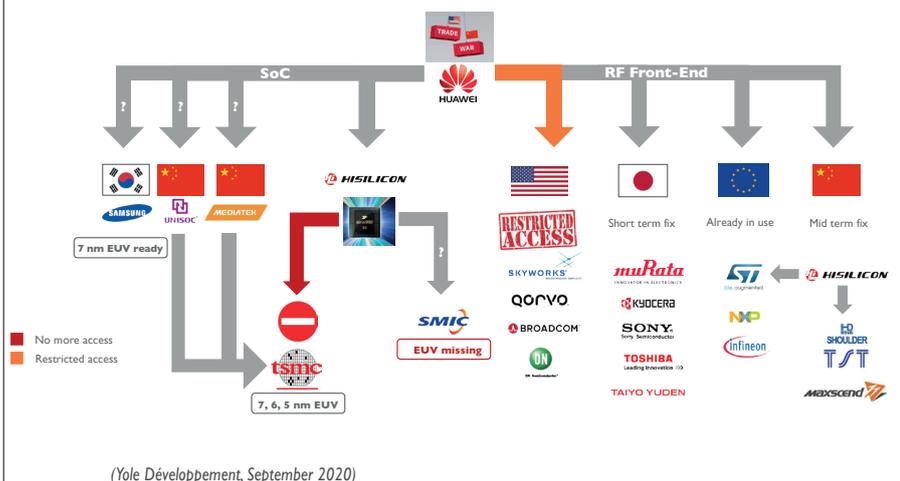


**US/CHINA TRADE WAR TO ACCELERATE THE ECOSYSTEM TRANSITION**

The RF front-end and connectivity market is led by five major companies sharing almost 80% of the overall business. Four out of five are US-based companies. The leading company is a Japanese firm. Decades of experience in the design and manufacturing of all major RF components explain the leading positions of Murata, Skyworks, Broadcom, Qorvo and Qualcomm. All major mobile device manufacturers rely on the expertise of one or more of these five as a

first choice, as these companies provide state-of-the-art RF components. However, a variety of other companies from China, South Korea, Japan and Europe complete the RF front-end offering. Since trade tensions between US and China have risen, this equilibrium will likely evolve. We can expect Chinese mobile device manufacturers to rethink their supply strategy and be more active in building a local ecosystem sooner or later. Indeed, it's already started in Huawei's case. The main difficulty comes from the baseband supply. The company has its own Kirin platform with HiSilicon, which can no longer access state-of-the-art foundries such as TSMC for the manufacturing of its SoCs. Huawei is known to have stockpiled critical components, but will have to either outsource its future SoC developments or develop local foundry capability, as depicted in figure 3. Huawei is likely running both options in parallel. Regarding the RF front-end and connectivity business, the supply of US based technologies is not strictly prohibited, only restricted. Qorvo and Skyworks used to strongly support Huawei, but will reduce their exposure in the future. Like the baseband side, Huawei is placing more orders for RF components to non-US based companies, especially to Japanese and

**USA/China trade war: How Huawei can face new restrictions?**



European companies. Longer term, Huawei will develop the local ecosystem for RF parts by investing and making partnerships with local companies. As Huawei's internal design house, HiSilicon has already extended its technology portfolio from Low Noise Amplifiers (LNAs),

to Power Amplifiers (PAs) and switches and has started to build PA modules. In addition, Huawei has invested in the filter company Shoulder. Advanced filter technology is the missing piece for Huawei to get a complete RF front-end as supplied by US-based companies.

**REPORT OBJECTIVES**

- Early implementation of 5G started end of 2019.
- The technology has a strong potential for RF front-end market growth and is very attractive to many companies across the world.
- Sizing market opportunities and highlighting technology trends appeared to be useful for the semiconductor industry and led us to build this report.
- The RF front-end and connectivity markets involve a substantial amount of technology platforms competing with each other, many of which have a strong market disruption potential. This report provides a comprehensive analysis of each technology's strengths and weaknesses and delivers an ecosystem snapshot as well as detailed market shares.

**COMPANIES CITED IN THE REPORT (non exhaustive list)**

Active Semi, Airoha, Akoustis, Apple, ASE, Asus, AT&T, AwinIC, Broadcom, CanaanTek, Cavendish Kinetics, China Mobile, China Telecom, China Unicom, CoolPad, Cypress Semiconductor, DB-HiTek, EE, Elisa, Ericsson, Etisalat, GlobalFoundries, Global Wafer, Google, HH Grace, HiSilicon, HMD Global, HTC, Huawei, Huntersun, Infineon, Intel, IQE, Jio, JRC, KDDI, KT, Kyocera, Lansus, Lenovo, LG, LG U+, Maxscend, MediaTek, Meizu, Murata, NationZ, Nokia, NSI, NTT Docomo, NXP, ON Semiconductor, OnePlus, Onmicro, Oppo, Orange, pSemi, Qorvo, Qualcomm, RDA, Resonant, Richwave, RoFS, Samsung, Samsung Electro Mechanical, SAWNICS, Shin-Etsu, Shoulder, SK Telecom, Skyworks, Smarter Micro, SMIC, SoftBank, Soitec, Sony, Sprint, ST Microelectronics, Sumitomo, Sunrise, Swisscom, Taiyo Yuden, TCL, TDK EPCOS, Telefonica, Telia, Telstra, TIM, T-Mobile, Toshiba, Tower Semi, Tpsco, TSMC, UMC, Unisoc, USI, Vanchip, Verizon, Vivo, Vodafone, WillSemi, WIN Semiconductors, WIPAM, Wisol, Xfab, Xiaomi, Xpeedic, Yuzhen IC, ZTE and more.

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**RELATED REPORTS, MONITORS & TRACKS**



- 5G's Impact on Telecom Infrastructure 2019
- Active and Passive Antenna Systems for Telecom Infrastructure 2019
- RF Front-End Module Comparison 2020 – Volume 2
- RF Front-End Module Comparison 2020 – Volume 1
- Qualcomm's Second Generation 5G mmWave Chipset, from Modem to Antenna

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**AUTHORS**

As a Technology & Market Analyst, specialized in RF devices & technologies within the Power & Wireless division at Yole Développement (Yole), **Cédric Malaquin** is involved in the development of technology & market reports as well as the production of custom consulting projects. Prior his mission at Yole, Cédric first served Soitec as a process integration engineer during 9 years, then as an electrical characterization engineer during 6 years. He deeply contributed to FDSOI and RFSOI products characterization. He has also authored or co-authored three patents and five international publications in the semiconductor field. Cédric graduated from Polytech Lille in France with an engineering degree in microelectronics and material sciences.



**Antoine Bonnabel** works as a Technology & Market Analyst for the Power & Wireless team of Yole Développement (Yole). He carries out technical, marketing and strategic analyses focused on RF devices, related technologies and markets. Prior to Yole, Antoine was R&D Program Manager for DelfMEMS (FR), a company specializing in RF switches and supervised Intellectual Property and Business Intelligence activities of this company. In addition, he also has co-authored several market reports and is co-inventor of three patents in RF MEMS design. Antoine holds a M.Sc. in Microelectronics from Grenoble Institute of Technologies (France) and a M.Sc. in Management from Grenoble Graduate School of Business (France).

## CONTACT



### **Western US & Canada**

Steve Laferriere - [steve.laferriere@yole.fr](mailto:steve.laferriere@yole.fr)  
+1 310 600-8267

### **Eastern US & Canada**

Chris Youman – [chris.youman@yole.fr](mailto:chris.youman@yole.fr)  
+1 919 607 9839

### **Europe and RoW**

Lizzie Levenez – [lizzie.levenez@yole.fr](mailto:lizzie.levenez@yole.fr)  
+49 15 123 544 182

### **Benelux, UK & Spain**

Marine Wybraniez - [marine.wybraniez@yole.fr](mailto:marine.wybraniez@yole.fr)  
+49 69 96 21 76 78

### **India and RoA**

Takashi Onozawa – [takashi.onozawa@yole.fr](mailto:takashi.onozawa@yole.fr)  
+81-80-4371-4887

### **Korea**

Peter Ok - [peter.ok@yole.fr](mailto:peter.ok@yole.fr)  
+82 1040890233

### **Japan**

Miho Ohtake – [miho.ohtake@yole.fr](mailto:miho.ohtake@yole.fr)  
+81 34405-9204

Toru Hosaka – [toru.hosaka@yole.fr](mailto:toru.hosaka@yole.fr)  
+81 90 1775 3866

### **Japan and Singapore**

Itsuyo Oshiba – [itsuyo.oshiba@yole.fr](mailto:itsuyo.oshiba@yole.fr)  
+81-80-3577-3042

### **Greater China**

Mavis Wang – [mavis.wang@yole.fr](mailto:mavis.wang@yole.fr)  
+886 979336809 +86 136 61566824

### **Sales Coordination & Customers Service**

David Jourdan – [david.jourdan@yole.fr](mailto:david.jourdan@yole.fr)  
+33 472 83 01 90

Fayçal El Khamassi – [faycal.khamassi@yole.fr](mailto:faycal.khamassi@yole.fr)  
+33 472 83 01 95

## 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
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- Reverse engineering & costing
- Design and characterization of innovative optical systems
- Financial services (due diligence, M&A)

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- Market and reverse technology quarterly monitors
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### **CONTACTS**

For more information about :

- Consulting & Financial Services: Jean-Christophe Eloy ([eloy@yole.fr](mailto:eloy@yole.fr))
- Reports & Monitors: David Jourdan ([david.jourdan@yole.fr](mailto:david.jourdan@yole.fr)) & Fayçal Khamassi ([faycal.khamassi@yole.fr](mailto:faycal.khamassi@yole.fr))
- Marketing & Communication: Camille Veyrier ([camille.veyrier@yole.fr](mailto:camille.veyrier@yole.fr))
- Public Relations: Sandrine Leroy ([sandrine.leroy@yole.fr](mailto: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”.

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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).

#### “Report”

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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1.1 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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- 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.