

STATUS OF CMOS IMAGE SENSOR INDUSTRY 2020

Market & Technology Report - November 2020

The CIS industry overheated in 2019 reaching \$19.3B. Are we heading to a soft landing in 2020-2021?

WHAT'S NEW

- 2019-2025 forecast
- 2019 M&A activity
- Ecosystem update 2018-2020
- Multiple and 3D camera trend for mobile
- Mobile application and technology update
- Consumer, Automotive, Security applications

KEY FEATURES

- 2019 CIS revenue breakdown by market
- 2019 CIS revenue ranking by player
- 2019 CIS production ranking by foundry
- 2015-2025 CIS volume shipment forecast by application
- 2015-2025 CIS revenue forecast by application
- 2015-2025 CIS average selling price forecast by application
- 2015-2025 CIS wafer production forecast by application

REPORT OBJECTIVES

Ecosystem identification and analysis:

- Determination of the application range
- Technical market segmentation
- Market trends and forecasts
- Key players, by market and analysis

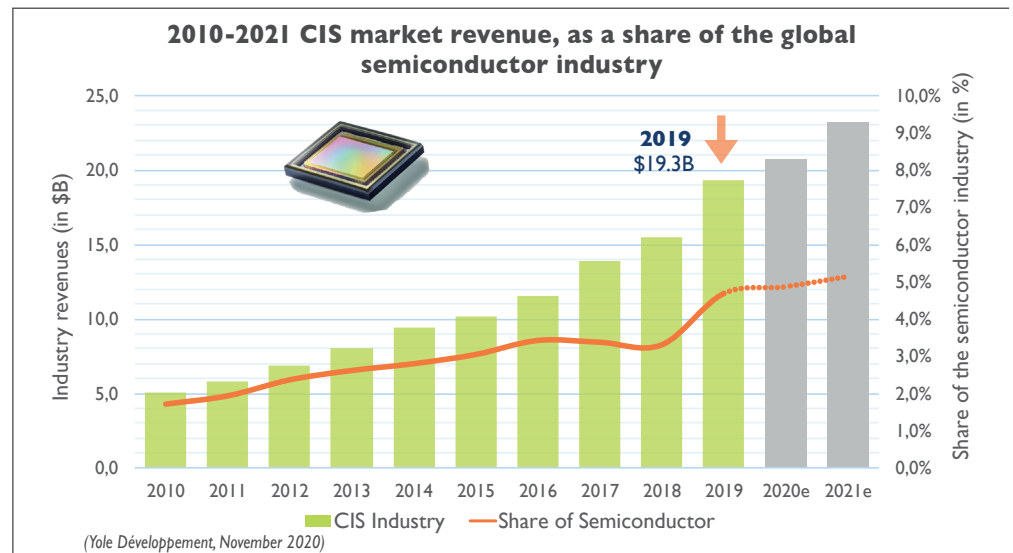
Analysis and description of markets and technologies involved:

- Detailed applications per market segment
- Major global actors
- Technology trends
- Main technical challenges

THE CIS INDUSTRY IS OVERHEATING

2019 and 2020 saw the combination of high demand for cameras and sanctions on Huawei contributing to additional inventories. This raised the industry output to its structural limit, which in turn increased prices by about 10%. Overall, the industry increased at a 25% Year-over-Year (YoY) rate in 2019, when Yole Développement (Yole) had expected growth in the range of 10% to 11%. This situation mostly benefited the large established players, Sony, Samsung and Omnivision. They were able to increase output quickly, having the right product portfolio ready to market. The Covid-19 situation was a mere back-story in 2020. Most key consumer electronic products were only temporally affected by disrupted logistics. Even automotive imaging and industrial imaging have been temporarily halted amid a multi-year double-digit annual growth trend. The

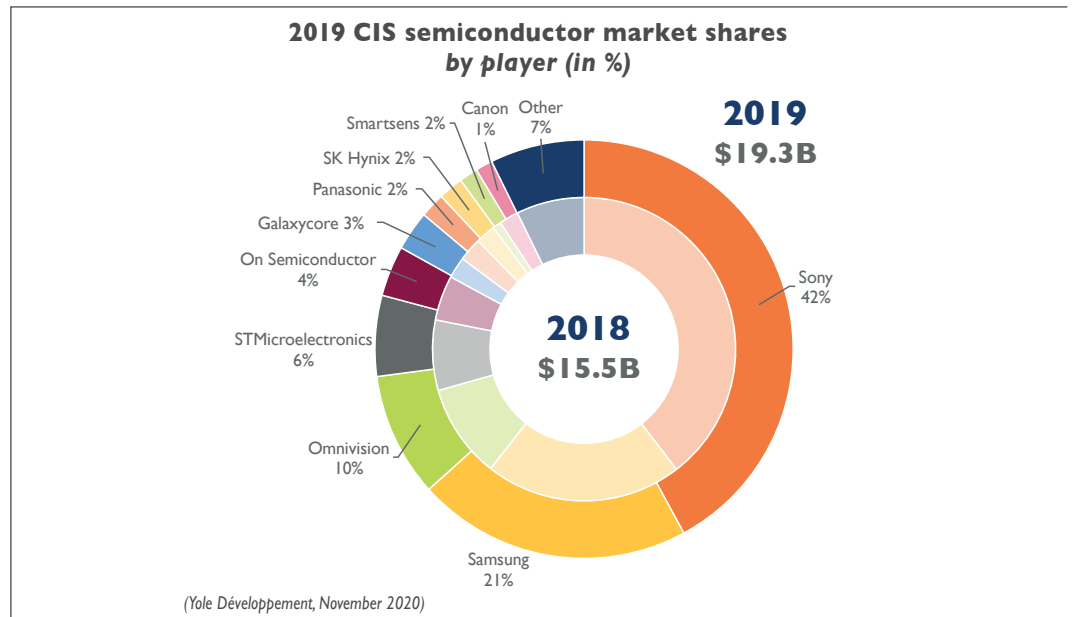
years to come will see the market hopefully go back to its original track, with a soft landing in 2021 and 2022. The uncertainties of the geopolitical landscape, compounded by the worldwide health-related lockdowns can wreck forecasters' nerves. If we add to this picture the mandate for all industries, and in particular semiconductor companies to curb their CO₂ emissions in the next decade, the outlook based on "business as usual" gets interesting. Nevertheless, imaging and sensing applications are thriving in most markets and there is no reason for this to disappear overnight. The CIS industry size is approaching \$21B in 2020. The growth should therefore slow down to 5.7% Compound Annual Growth Rate (CAGR) until 2025. CIS technology will represent 5.1% of global semiconductor sales in 2021, which is already an exceptional achievement.



CHINESE PLAYERS ARE POISED FOR GREATER MARKET SHARE

At the top of the market, player trajectories are a consequence of the smartphone market situation. Sony and Samsung are first and second and Omnivision third. ST Microelectronics is in fourth position, making a comeback thanks to its near infrared (NIR) sensing imagers for Apple handsets and tablets. Sony and Samsung have subsequently updated their product portfolio in line with the 3D sensing trend. Indirect Time-of-Flight (iToF) and direct Time-of-Flight (dToF) arrays are the immediate response, showing the great technical innovation driving those

top players. On the other side of the market, emerging players to watch are coming from China. Omnivision has been acquired by Will Semiconductor, the Shanghai-based company. Two other Chinese players, Galaxycore and Smartsens, are also experiencing thriving growth. They have mostly benefited from their domestic market ecosystem in mobile and security cameras. Their growth is currently fuelled by massive capital injections at time of greater US sanctions limiting their access to technology. CIS might be among the first



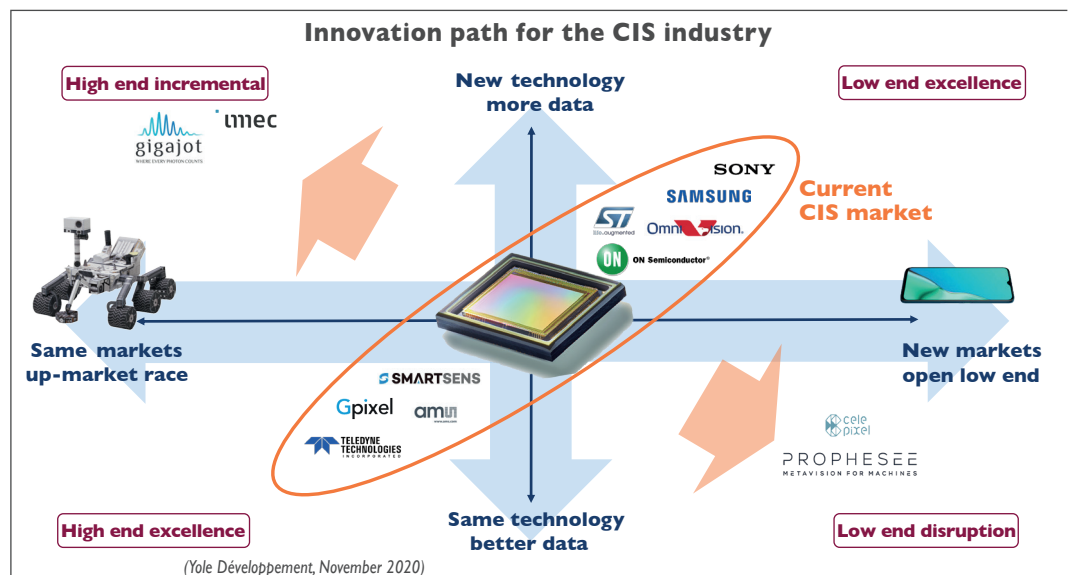
semiconductor product categories in which China could become technologically independent since the required wafer foundries are widely available in mainland China. The next era will involve robotics, Augmented Reality (AR) and smart

Internet of Things (IoT). All of these are markets in which Chinese companies are well positioned. The ranking of CIS players will eventually change along these new lines.

EXPLOSION IN DIVERSITY OF CIS TECHNOLOGY

Sensing has opened Pandora’s box. For many years the key aspect of competition was to electronically capture photographic and/or video images, the benchmark being film invented 150 years ago. Most of the industry has now switched to much broader endeavours. There is one part of the competition that is trying to push the limits of the current paradigm, by converting each available photon into an electron. This is the quantum imaging effort, exemplified by single photon avalanche photodiodes found in 3D sensing lidars from established players such as Sony, STMicroelectronics and On Semiconductor. There are also innovative pixels from startups such as Gigajot, Actlight and SeeDevice. On the other end of the spectrum there is the neuromorphic imaging effort, which is reinventing the notion of image capture by using biomimicking

event-driven data, led by Samsung, Sony, Prophesee and Celepixel. This endeavour is currently seeking to solve the limitations in capturing and processing motion pictures. This could have a major impact for machine vision but also in the art of video capture. The future will not be a straight line and the big bet for all these innovations is how they integrate with the implementation of embedded Artificial Intelligence. Smart image sensors are under way. Sony and Omnivision have already made headway in that direction. New technologies will mean opportunities for new entrants to beat the incumbents. Nevertheless, a new market cycle will be necessary. This will probably involve robotics and augmented reality as well as the smart IoT market... Here at Yole Développement, we will make sure to keep you posted.



COMPANIES CITED IN THE REPORT (non exhaustive list)

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TABLE OF CONTENTS (complete content on i-Micronews.com)

Glossary	2	Ecosystem	81
Report methodology and definitions	6	> 2019 M&A activity in CIS	
Companies cited in this report	5	> CMOS image sensor – M&A historical timeline	
What we got right, what we got wrong	8	> CMOS image sensor – noteworthy news of the last two years	
Executive Summary	13	> CMOS image sensor – ecosystem	
Context	28	> CMOS image sensor - supplychain	
> Historical perspective and global market		> CMOS image sensor - competitive landscape	
> CIS market segmentation		> CIS foundries - geographic mapping	
> Huawei ban timeline		Mobile market trend	90
> Global CO ₂ emission intensity		> Mobile market dynamics	
> CMOS image sensor landscape, by player (2019)		> Mobile market volume forecast, by player	
> CMOS image sensor landscape, by application (2019-2025)		> Market drivers	
> CMOS image sensor technology shift - CMOS vs. CCD		> Mobile phone market trend	
> CMOS image sensor technology shift - BSI vs. FSI		> Mobile resolution mix - forecast	
> CMOS image sensor technology shift - 300mm vs. 200m		> 3D camera applications	
CIS market forecast	50	> Mobile 3D sensing camera trend	
> 2019 CIS revenue breakdown, by market, by player		> Mobile optical fingerprint market trend	
> CIS volume shipment forecast 2015 - 2025		Consumer market trend	117
> CIS revenue forecast 2015 - 2025		> Consumer market dynamics	
> CIS average selling price forecast 2015 - 2025		> Consumer photography volume forecast	
> CIS wafer production forecast 2015 - 2025		> Consumer home IOT volume forecast	
Players and rankings	67	> Consumer market trend	
> 2019 CIS revenue rankings, by player		Consumer market trend	126
> 2019 CIS production rankings top 10, by foundry		> Computing market dynamics	
> 2019 CIS player activity breakdown		> Computing volume forecast	
> 2019 CIS mobile market revenue breakdown, by player		> Computing market trends	
> 2019 CIS consumer photography market revenue breakdown, by player		Automotive market trend	126
> 2019 CIS consumer home market revenue breakdown, by player		Medical market trend	146
> 2019 CIS consumer computing market revenue breakdown, by player		Industry market trend	162
> 2019 CIS automotive market revenue breakdown, by player		Security and surveillance market trend	171
> 2019 CIS medical market revenue breakdown, by player		Defense and aerospace market trend	179
> 2019 CIS security and surveillance market revenue breakdown, by player		Technology trends	184
> 2019 CIS industry market revenue breakdown, by player		> Pixel/resolution/optical format	
> 2019 CIS defense and aerospace market revenue breakdown, by player		> BSI opened the way to 3D semiconductor	
		> In-pixel hybrid stack technology	
		> In-pixel hybrid stack technology	
		> 3D imaging and sensing	
		> Other technology trends	
		> High dynamic range (HDR) with LED flicker mitigation (LFM)	
		> NIR imaging and sensing	
		Conclusion	216
		Company profiles	220
		Yole Group of companies	235



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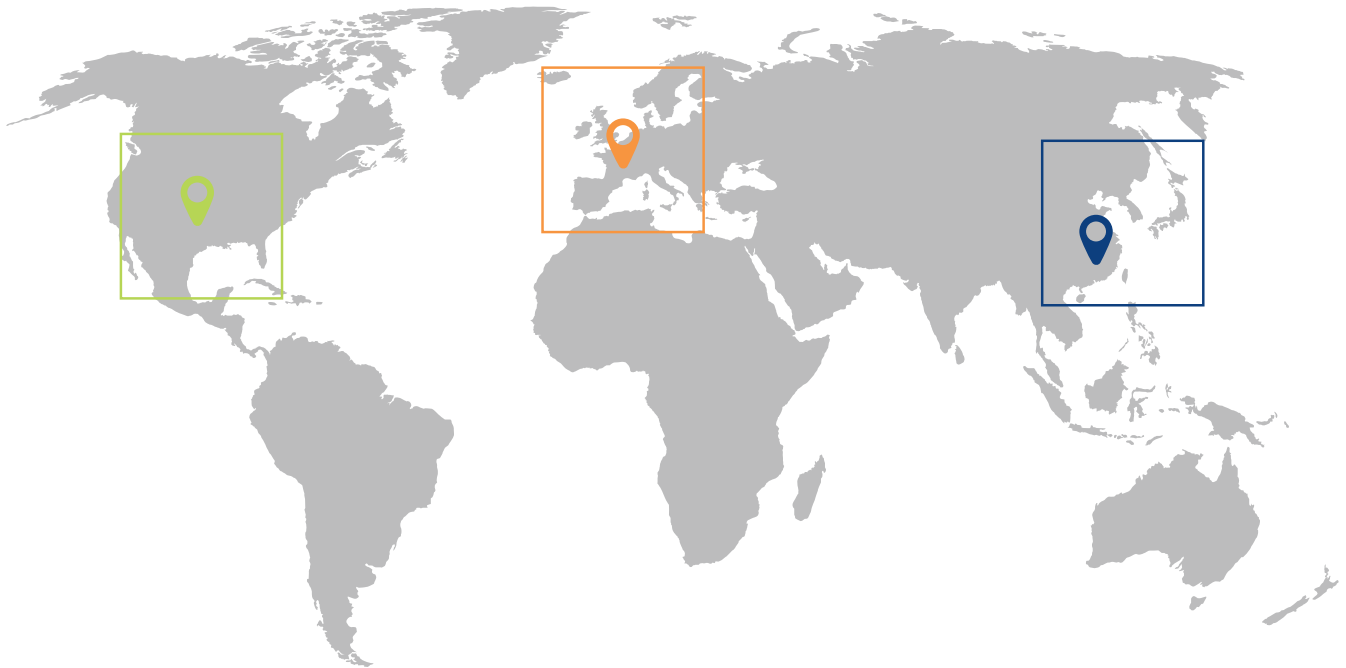
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ABOUT YOLE DEVELOPPEMENT

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
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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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1. SCOPE

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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.

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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.

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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.

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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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- 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.

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.