ANNUAL REPORT 2019



Philippe Garreau CEO of MVG

This year has been one like no other. A moment in modern history, in which we all played our part. Before I discuss business performance, I feel it imperative to first of all extend my well wishes to you all, as countries around the world begin their recovery from the challenges of the COVID-19 pandemic. econdly, a message of thanks, to MVG's 350 plus employees for reacting immediately and appropriately, with consideration for one another and the business, as Coronavirus swept across the globe. It is these people, guided from the helm by our exceptional geographical management teams, who have steered our business through unprecedented times. Serving our mission critical customers, doing all they can, within the confines of ever-changing safety guidance to keep your industries moving and your businesses in operation.

With locations worldwide, MVG has been able to react to the pandemic, tracking the crisis, anticipating its geographical affect, and reacting in a timely fashion. Because of this, we have suffered minimal financial loss or disruption to our performance or service delivery.

Whilst economies worldwide were forced to work remotely on vast scales, the mission critical sectors of civil telecommunications as well as aerospace and defense, have maintained a dynamic pace. Reliable connection for wireless devices and the launch of internet satellites has been a necessity during global shutdowns, meaning strategic and essential sectors such as these have experienced sustained demand with budgets largely unaffected. Because of this, the Group's assets in these areas remained secure.

In recent months, the automotive industry has slowed, but with the introduction of autonomous vehicles remaining an important goal for industry, we anticipate investment in this sector will soon pick up, and our teams remain dedicated to supporting this exciting sector in its recovery.

Thanks to a dedicated, skilled and passionate global workforce, assets in critical industries, sector exposure, geographical positioning and rigorous cost management strategies, I can report that despite the challenges of 2020, the MVG Group has maintained a strong position. I am proud to announce that our global research and development facilities have continued their work towards the production of future technologies and our order book is buoyant, with ongoing orders from our major customers in Asia, Europe and the United States.

MVG is committed to agile working and, like many organizations big and small, we will evaluate key learnings from this complex period. Namely, for us, the value of interacting remotely, which has been an important goal of ours since the conception of our Group. As the world emerges from this society-shaping period in history, we will seek advice, listen, and play our part for the good of our people and our customers in the ongoing fight against Coronavirus. I can confirm, that whilst we will continue to work hard for the health of our employees and customers, MVG's objective remains the same – continued, virtuous growth with a further increase in sales and a gradual improvement of our financial performances.



CONTENTS

Editorial	Ρ
A bit of history	Р
Our values	Р
Our key figures for 2019	Р
Stock exchange & shareholding	Р
Unique technological know-how	Р
Innovator's DNA	Р
Identified growth areas • The antenna measurement systems department • The electromagnetic compatibility department • The environmental and industrial control department	P P1 P2 P3
Key assets	Р
Results and perspectives	Ρ



A BIT OF HISTORY...

Since its creation in 1986, MVG's success has developed on the international market by combining organic growth based on continuous innovation and the integration of companies opening up new markets. This path of profitable growth has also been made possible thanks to the confidence of its customers, the involvement of its employees, and the support of investors who have accompanied it throughout its development.





OUR VALUES

Innovation, technological excellence, team spirit, boldness, involvement, and diversity are the values shared by MVG's employees.

In the dynamic, complex, changing sectors in which MVG operates, what makes the difference is our human capital, our culture, how we work together, and understanding how our values will best serve our customers.

Philippe Garreau, CEO of MVG

• Innovation

MVG's offering consists of highly innovative, distinctive products. This positioning guarantees the Group's margins. These margins allow us to maintain a high level of R&D investment and thus develop new innovative products. It is this virtuous circle of value creation that constitutes MVG's DNA.

• Team Spirit

As a team, MVG meets its customers' needs through a commitment to service, fed by the diversity of each team member's areas of expertise and knowledge. This team spirit is based on listening, transparency, respect for others and rules, creativity, solidarity in implementing major decisions, and mutual support, particularly in difficult times.

Involvement

MVG strives to involve its employees in its corporate strategy, mobilize them around a common culture, and have them contribute to its overall performance. In return, the Group expects high level of involvement from its employees when working with customers and around its strategic projects.



• Excellence

Excellence is a cornerstone of MVG's worldwide reputation. It characterizes the Group's ability to transform innovations into robust, scalable, industrialized products and to make every effort to exceed the expectations of its customers.

Boldness

confidence in our The know-how and our capacity to innovate gives us the boldness to undertake, propose, and always consider that a more efficient solution can be found. MVG pushes its managers to delegate particularly large tasks, so that they can develop their own skills even further. The Group encourages those who try, even if it means failing, rather than those who attempt nothing.

• Diversity

MVG hires people of different backgrounds, religions, countries, genders, sexual orientations, physical conditions, and professional careers. The Group believes that mixing the skills, cultures, training, and talents of each individual is an asset and contributes to the innovation and success of its projects.

OUR KEY FIGURES FOR 2019 (€M)

2019 performance confirms the strong attractiveness of the solutions developed by the Group, perfectly in line with market trends. In particular, MVG continues to position itself on large-scale tenders, as in the case of the major contracts already won in the Aerospace/Defense fields, and confirms the strong competitiveness of its products.



In 2019, Group revenues came in at €87.4 million, an increase of 17.1% at constant exchange rates (+12.9% at current exchange rates), marking a 24^{th} consecutive year of growth.

The civil telecommunications sector was particularly dynamic, driven by the rise in 5G orders, and accounted for 53% of revenues. Geographical distribution remained fairly balanced (US 45%, Europe 30% and Asia 25%).

Good control of operating expenses thus made it possible to limit the impact of the one-off drop in gross margin during the year. Reported EBITDA was €12.6 million at December 31, 2019, representing an EBITDA margin of 14.4%. The application of IFRS 16 (related to leases as of January 1, 2019) had a positive impact of €1.9 million on this aggregate. Excluding IFRS 16 and IFRS 2, the EBITDA margin was 13.4%.



Operating income is virtually stable. It amounts to 6.3 M€ compared to 6.4 M€ on 31 December 2018. It includes a non-recurring expense of €0.6 million, partly related to legal fees in China.



After taking into account a tax charge of \in (1.3) million, net income was \in 4.6 million on December 31st, 2019, compared with \in 4.8 million on 31 December 2018. Excluding IFRS 16 and IFRS 2, net income was \in 5.8 million at the end of December 2019.

Shareholders' equity amounted to 76.1 M€ on December 31st, 2019 compared to 68.9 M€ on December 31st, 2018. Cash flow from operations before tax rose sharply to € 12.8 million at the end of 2019 compared with € 9.6 million at the end of 2018. Working capital requirements were perfectly controlled in this growth context, with a limited increase of €0.9 million on December 31st, 2019 compared with €(8.7) million on December 31st, 2019 activities rose sharply to €12.0 million at December 31st, 2018, compared with €(0.6) million at December 31st, 2018, enabling MVG to largely finance its investments (€3.6 million), and its Free share allocation plan (€1.0 million).

Free cash flow is at a good level and stands at €8.4 million on December 31st, 2019. Available cash increased at the end of December 2019 to €22.1 million compared to €14.7

million on December 31st, 2018. On December 31st, 2019, gross financial debt amounted to €13.6 million. Restated in accordance with IFRS 16, they amounted to 4.2 M€ compared to 4.7 M€ on December 31st, 2018.

At the end of 2019, the Group had a net cash position (excluding IFRS 16) of €17.9 million compared to €10.0 million on December 31st, 2018.

In 2019, the Group recorded a record level of order intake of €124.1 million compared to € 78.0 million in 2018, a very significant increase of + 59% (+52% at constant exchange rates compared to FY 2018). This order intake includes in particular the recent €6.6m contract won at the end of the year in the Aerospace/ Defense sector for the supply of a large antenna measurement system for the development of satellites.

This commercial performance confirms the strong attractiveness of the solutions developed by the Group, perfectly in line with market trends. In particular, MVG continues to position itself on large-scale tenders, as in the case of the major contracts already won in the Aerospace/Defense fields, and confirms the strong competitiveness of its products.

STOCK EXCHANGE & SHAREHOLDING

B y investing in MVG's capital, you benefit from the momentum of a high-tech company whose unique know-how brings the multitude of invisible electromagnetic waves to an unprecedented level of visualization for analysis.

These waves are at the heart of our day-to-day lives. Smartphones, computers, tablets, cars, trains, aircraft – all these devices would not work without them. **By making "the invisible visible"** thanks to its testing and measurement equipment, MVG enables its customers to develop ever more efficient products. Building on this expertise, the Group has risen to the top ranks among its market's global players and has acquired international recognition. MVG employs more than 350 people, has offices in 10 countries, and 90% of its revenues arises outside of France.



SHAREHOLDING



MONTHLY MVG SHARE TRADING VOLUME





ANALYST MONITORING

Gilbert Dupont, Euroland Corporate

LISTING

- Listed on NYSE Alternext (ALMIC) since 06/29/2005
- Price at 04/08/2020: €11.45
- Market capitalization at 04/08/2020: ~€129 M
- 2019 average daily volume: 6,651 shares/day

CAPITAL

- 6,486,320 shares
- 8,619,092 voting rights
- 8,545,266 voting rights net
- Share capital: €1,256,433.20

FINANCIAL CALENDAR

HY1 results publication: September 22, 2020

CERTIFICATION

Bpifrance's "Innovative Enterprise" Certification

ELIGIBLE FOR THE EQUITY SAVINGS PLAN FOR SMES



UNIQUE TECHNOLOGICAL KNOW-HOW

Lin

Making the invisible visible

Similar to MRI scanners used in hospitals to view the inside of the human body, MVG has developed unique technological know-how: scanners that allow electromagnetic waves emitted by an antenna to be viewed, thus making the invisible visible.

The group mission

MVG's unique expertise makes it possible to view electromagnetic waves. These waves are at the heart of our day-to-day lives: smartphones, computers, tablets, cars, trains, aircraft – all these devices would not work without them. By making "the invisible visible" thanks to its testing and measurement equipment, MVG enables its customers to develop ever more efficient products. The Group's mission is to extend its expertise and unique electromagnetic imaging technology to all sectors where they can provide high added value, satisfying the "adaptation of technology" against "acceptable market cost" equation.

INNOVATOR'S DNA

Innovative solutions serving present & future customer testing needs.

ENERGY

Measure the amount of energy emitted by antennas

This measurement quantifies the efficiency of the conversion.

An antenna converts existing electrical quantities in a conductor or a transmission line to electromagnetic quantities in space (electric and magnetic fields), either in transmission or in reception.

SPACE

Determine in which directions energy is radiated

This involves determining the radiation pattern of the antenna.

In a smartphone, for example, the manufacturer seeks a radiating pattern that is well distributed throughout all directions in space, because it is not possible to predict from the phone's direction given by the user. However, in the case of a radar, the manufacturer aims to focus maximum energy in one direction in space to measure with the utmost precision where detected devices may be located.

INTEGRATION

m

Integrate the antenna into structure

This involves integrating developed antennas into a structure, such as a mobile phone, a car, or aircraft.

To this end, MVG has developed a line of high-value-added post-processing software and systems specifically designed for integration analysis, coupled with simulation software, enabling this detailed, essential study.

FUNCTIONAL TESTING

innovation ++

l est the device in real conditions

These tests determine how a device will react in its real environment.

Will its performance be deteriorated by or can it take advantage of the barriers and disruptive objects that separate it from emission sources?

INFORMATION

/G

Monitor the information carried by the signal

This involves transmitting data from several directions in space and reducing the level of energy emitted until communication with the device is no longer possible. 3 operational departments

80% of revenue by the AMS branch

17% growth in 2019





Since 2012, MVG has structured its activities into three operational departments: AMS, EMC, EIC. This organization makes it possible to pursue a strategy of creating distinctive added value in each of the branches.



UPDATE ON NSH (NATIONAL SECURITY & HEALTHCARE)

END 2019

Completion of recruitment and testing of 25 patients with palpable breast cancer, non-cancerous cysts, benign solid lesions.

Microwave imaging scanner for the detection of mammary pathologies

- Encouraging preliminary results
- Group analysis and writing of the final clinical study report
- Working on second generation prototype
- Study of legal options

AMS The antenna measurement systems departement

Activity & Markets

This is the Group's core business. It brings together MVG's activities in the field of antenna measurement. MVG has acquired a position as technological player of reference in this field at the European and global levels. It addresses two sectors: Civil Telecommunications and Aerospace/Defense.

Key achievements

Strong contribution from Aerospace/Defense (impact of the major contract for €6.5M)

Good momentum in 5G

Strategy

- Provide products and turn-key solutions customized on the basis of standard technological blocks to a diversified customer portfolio
- Maintain its technological lead
- Offer support services (software upgrades, preventative maintenance contracts, relocations of facilities, etc.)

Offering

The market's most extensive range:

- turnkey antenna measurement systems (near-field and far-field, single-probe and multi-probe, radome test, RCS
 – Radar Cross Section – measurements).
- Associated software for equipment control, data acquisition, and post-processing.
- All solutions are designed, manufactured, marketed, installed, and maintained by MVG.

Price Range

From €100 k to several million euros.

NEWSPACE

The emergence of a private commercial space industry

New launchers, constellations of micro- and mini-satellites, communication and tracking systems, which all involve sophisticated antennas

A global development, starting from the United States and reaching China. More than fifty startups already positioned in this market. **284 billion invested in the production and launch of 2000 satellites over the next 10 years.**

("EuroConsult, Nov 2018, « \$284 Billion Market for 3,300 Satellites to be Built & Launched Over Next Decade" http://www.euroconsult- ec.com/13_November_2018)

Structurally growth-geared markets

Satellites, planes, mobile phones, computers or touch tablets, GPS navigators, medical instruments or wireless home technology... All these increasingly ubiquitous appliances have something in common: they have antennas, designed to convert electrical signals into radio signals. MVG's role is to design and manufacture systems allowing manufacturers to test and measure the radiation pattern of these antennas. MVG markets a range of constantly evolving antenna measurement systems to increasingly diversified markets, supported by strong growth in the space, military, automobile, and civil telecommunications industries:

- the wireless market, stimulated by increasingly sophisticated terminals, integrating multiple communication protocols (4G, WiGig — very high-speed Wi-Fi, 5G in development in several countries, etc.),
- land, space, and air surveillance through radars, drones, etc.,
- newspace,



The electromagnetic spectrum is an essential – and invisible – part of modern military and civilian life. Military forces use wireless networks to communicate and coordinate their operations, radar and sensors for guidance and to detect enemy forces, and electronic jammers to blind enemy radar or disrupt communications.

- newspace LEO satellite constellations,
- space travel
- internet-of-things,
- connected or self-driving vehicles,
- data protection.

MVG's products have won over the biggest names in the aerospace (NASA, ESA), aeronautics (Boeing), automobiles (Renault, BMW), as well as electronics (Ericsson, Nokia, Panasonic, Huawei) industries.

This expertise in electromagnetic wave measurement tools has been a driving force in the company's international growth since its creation. It also encourages MVG to constantly renew its offering to follow the development of protocols and permits diversification to new markets.

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What is 5G?

5G is the first-generation of wireless mobile standard developed for more than voice and data use. 5G networks will allow ten times higher bandwidth, manage a very large number of connection and ensure quick and reliable transmissions. Based on user experience, system performance, enhanced services, business models and management operations 5G connections will depends on the development of three cornerstones:



All this backed up by central and local Clouds through the 5G networks, enabling a multitude of services to be efficiently rolled out. There is a broad spectrum of ways the 5G standard can be adapted to handle all the application cases of the connected world.

Ensuring wireless connectivity performance is fundamental for realizing the vision of 5G

What is critical for enabling all of this to work as expected is the wireless link. Radio performance is the parameter that is most difficult to control, as this performance is heavily device and installation dependent. It is of paramount importance to be able to accurately secure the desired wireless performance in the products and services rolled out on the market, in order to fulfill the expectations of the service. The promise of 5G is based on lab results in ideal conditions, while the performance achieved in real life will depend on how well the radio performance actually works. This needs to be tested for each development of device and application.

Over-The-Air (OTA) testing challenges for the 5G network

Tests and measurements of 5G enabled devices and base transceiver stations (BTS) will differ significantly from what is done today. From a technical perspective, introducing mmWave devices into our telecommunications network poses a number of testing challenges. The RF architecture in 5G devices and the higher frequencies used will require tests traditionally performed through coaxial cables in RF labs to be tested OTA, as there won't be any physical connectors available in the devices. In addition to antenna testing, all other RF system performance and radio resource management parameters need to be tested OTA instead of through cables.

5G uses dynamically steerable beams to maximize connectivity by directing as much of the signal towards the devices as possible. To handle the high throughputs needed, a much larger and widely available contiguous spectrum has been identified for 5G evolution in the centimeter and milimeter-wave bands above 24 GHz (around 28 GHz and 39 GHz). With a frequency up to 100 GHz, BTS antennas are evolving from passive antenna to active antenna systems enabling the implementation of Massive MIMO.

As a result, 5G devices and networks have to be tested in different configurations at the system level and over the air (OTA). To date, three OTA testing methodologies have been approved by 3GPP for conformance testing of mmWave user equipment and base stations: direct far-field, indirect far-field and near-field to far-field transformation.



Healthcare services Remote surgery Virtual reality



Autonomous cars Transportation services



Smart factories Industry 4.0 Massive data

IMPACT – Product development towards the 5G era

5G is an evolving standard, and most importantly, the amount of applications and use cases are expected to increase over time as 5G is deployed in new industries and markets. This will drive a continuous need for new test solutions, as well as adaptations of existing solutions to be introduced.

One of the bigger challenges in the 5G markets is the test capacity increase needed for 5G product development, as most tests will be done OTA instead of through cables. We can see already now that companies are starting to transform their labs from purely conducted test labs to OTA-based test labs. Those tests will include the agility of the devices to network communication, including handovers in dynamic RF environment scenarios representing real environments.

Another challenge on the market is that companies that never have created wireless products before now need to become capable of performing wireless testing. In order to stay competitive, adding wireless connectivity to products that in the past were not connected is needed. Wireless connectivity will be as natural as the Internet is today, and this is a big change.



SOLUTION – Portfolio of test solutions for 5G

MVG offers a wide selection of solutions based on near-field, far-field and compact range measurement techniques for Antenna, EMC, RCS, and Radome testing. Our solutions support the measurement needs at R&D level of the Aerospace & Defense, Telecommunications, and Automotive industries, as well as Academic and Research institutes.



MVG will benefit from 5G technology as our technological expertise is a trusted asset to both the Telecom and Aerospace & Defense markets. Technologies traditionally applied in our products mainly used in A&D markets can be used for high frequency 5G applications, bringing efficiency and fast time-to-market for customers. In combination with state-of-the-art multi-probe technology and advanced software applications for data processing and analysis, we are optimizing our technologies for 5G applications.



StarWave

Shaping the future of 5G mmWave OTA testing

Introducing StarWave, a compact, accurate and flexible far-field OTA testing solution for 5G devices





Shaping a connected society with 5G

The dawn of 5G is upon us and unlike transitioning between previous generations of mobile networks, this will be an all-encompassing global leap towards a digitally enhanced, completely connected, largely automated way of living. It is, to all intents and purposes, a dramatic overhaul and harmonization of the radio spectrum.

This networked society promises revolutionary improvements in data rates and latency, as well as considerably enhanced network capacity and notable reductions in operational and infrastructure costs for network operators. However, realizing and meeting the evolving needs of such developments requires complete radical change of how we, as an industry, design, develop and test an everbroadening portfolio of 5G devices.

WIRELESS CAPABILITY: The fundamental component for 5G success

Realizing the global 5G vision depends on delivering efficient and powerful wireless connectivity – without that, the expectations and seemingly limitless ability of 5G are lost. And it is for that reason, best practice antenna testing of any 5G device, great or small, is to be optimized at R&D level.

This section will explore the theme of effective, best practice 5G device testing with a keen focus on direct far-field testing to mark the launch of StarWave by MVG, a dual-polarized, wideband plane wave generator for the compact, flexible, fast and accurate direct far-field OTA

testing of 5G antennas.



The dawn of 5G antenna testing and its key challenges

The magnitude of what is deemed capable as we face the dawn of 5G is nothing short of inspiring, with autonomous factories and agricultural processes, self-driving cars, the convenience and comfort of a connected home, and even remote medical surgeries.

Concepts such as these demonstrate the critical importance of full-system performance testing and, in particular, the accurate evaluation and analysis of antenna testing in order to deliver the wireless connection required for such revolutionary applications.

To better understand the OTA testing challenges for the 5G network, it is vital to first appreciate the three cornerstones of 5G development:

- (1) Enhanced mobile broadband speed and capacity Increased bandwidth and capacity for mobile data able to handle the ever-increasing amounts of wireless data traffic.
- (2) Scalability for massive data and Internet of Things Reduced overheads for massive applications such as sensor networks consuming very little bandwidth and power.
- 3 Ultra-reliability, low-latency for mission critical services

Real time critical connectivity such as self-driving cars, robotics, automated factories and medical applications.



WHAT ARE THE FOUR KEY CHALLENGES **TO 5G OTA TESTING?**

CHALLENGE ONE: Dynamically steerable beams and the evolution towards Massive MIMO BTS

Unlike previous generations of telecommunications standards, 5G uses dynamically steerable beams which maximize connectivity by directing as much of the signal toward the device as possible. This shift eliminates traditional antenna testing methods, whereby a device is evaluated once over a full sphere in order to measure its total sensitivity and total radiated power.

These steerable beams are created by phased array antennas which need to be calibrated and measured in a large number of configurations to ensure the connectivity of the device is adequate.

To make steerable beams a viable and reliable method of transmission, base transceiver station (BTS) antennas are evolving from passive antenna to active antenna systems (AAS) with the integration of the remote radio head. The most favored AAS is the Massive MIMO concept, which many providers are already evolving towards in order to multiply the capacity of a wireless connection without the need for increased spectrum.

CHALLENGE TWO: Wide bandwidths and mmWave frequencies

To allow higher throughput and fully realize the 5G vision will mean harnessing the power of spectrum which has, until now, been 'untapped'. Whilst additional spectrum below 6 GHz has already been allocated for cellular communications in some countries, much larger contiguous spectrum has been identified for 5G evolution in the centimeter and millimeter-wave (mmWave) bands above 24 GHz; with frequency bands around 28 GHz and 39 GHz fueling the majority of 5G NR development at the present time.

Introducing mmWave devices into our telecommunications network poses a number of testing challenges. The higher frequencies and the RF architecture within 5G devices eliminate the possibility for RF connectors and lab-based performance testing, with the industry now turning to Over-The-Air alternative test methods for RF system performance, radio resource management parameters and antenna testing. 3GPP has outlined OTA testing for conformance testing of mmWave user equipment and base stations (BTS)¹. To date, three OTA testing methodologies have been approved by 3GPP, direct far-field, indirect far-field and near-field to far-field transformation².

1 the references for conformance testing are 3GPP TR 38.810, 3GPP TS 38.521-2 (SA- Standalone), 3GPP TS 38.521-3 (NSA- Non-standalone), and 3GPP TS 38.903. (https://www.3gpp.org/ftp/Specs/ 2 March 2019, "Test & Measurement Industry Tackles 5G Over-the-Air Testing", Microwave Journal, Issue 62, Page 20-38

CHALLENGE THREE: mmWave omni-directional antenna OTA testing

Due to their size and limited number of embedded antennas, 5G devices present radiation patterns that remain mainly omni-directional, at least in one plane. Measuring mmWave omni-directional antennas requires a smart setup to optimize the acquired data accuracy. No matter the quality of the radiocom tester, the communication channel is largely limited by the operational test setup. **No solution on the market today offers accurate far-field OTA testing conditions for mmWave devices.**

CHALLENGE FOUR: Live end-to-end testing of a device while being worn and/or operated by a user

Live testing of devices in general is absolutely mandatory - A device cannot be launched to market unless it has been extensively tested in realistic conditions. This is even more true for 5G FR2 where ultra-reliability of the connection is mandatory. At those frequencies, the human body easily absorbs eletromagnetic waves and can greatly modify the lab-measured/theoretical radiation pattern of the embedded antenna. Hence, the connectivity performances of the device can be highly impacted. But at mmWave frequencies, it is not possible to test those performances in near-field conditions - the slightest movement, like a person breathing, will impact the quality of the measurements and hence the accuracy of test results. Therefore, testing in far-field is the only available option. However, the test conditions must also be able to take into account humans under test with a device, not only phantoms. Today, the products available on the market are not able to provide live end-to-end testing solution.

Best practice for 5G mmWave OTA testing

5G devices require an over-the-air (OTA) test method which creates a number of challenges in both the near-field and far-field when testing the latest antenna technology.

5G testing in the near-field may benefit from smaller chamber sizes. Nevertheless, the near-field technique does not allow for measurement of some performance parameters such as the Error Vector Magnitude (EVM) figure, according to the standard procedure today. In addition, the near-field technique requires near-field to far-field transformation and depends on phase and magnitude readings which are challenging for modulated signals. Direct far-field testing, whilst capable of delivering magnitude data, is, at such high bandwidths, a spacehungry test method, (see table far-field distance) thus financially prohibitive, which renders it an unsuitable solution for many manufacturers.

In other words, when measuring a regular smartphone for example, which measures approximately 15 cm in size, using the far-field Fraunhofer distance equation, we can denote that the far-field distance and therefore the size of the required anechoic chamber will increase dramatically with antenna size and frequency, requiring a far-field distance of between 4.2 m and 5.9 m (see far-field distance table).



D = The minimum diameter of the sphere enclosing the antenna λ min = The wavelength of the highest frequency measured R = Measurement far-field distance > 2D² / λ min

Far-field distance R (m)

Device size	Frequency		
(cm)	28 GHz	39 GHz	
5	0.5	0.7	
10	1.9	2.6	
15	4.2	5.9	
20	7.5	10.4	
25	11.7	16.3	
30	16.8	23.4	

In conclusion, best practice theory recommends 5G OTA testing of antennas under far-field conditions, which, given the expansive nature of such test facilities, poses the question: How to perform OTA testing in far-field conditions facing the four challenges mentioned previously?

COMPACT ANTENNA TEST RANGE (CATR)

Well known in the industry, this method approximates a A Plane Wave Generator (PWG) is an array of elements plane wave in the Quiet Zone in which the amplitude and phase variation is below a user-specific tolerance. A CATR allows electrically large antennas to be measured at a significantly shorter distance than would be necessary in a traditional far-field test range. Compact ranges use a source antenna (feed) to radiate a spherical wave in the direction of a parabolic reflector, collimating it into a planar wave for aperture illumination of a Device Under Test (DUT).

PLANE WAVE GENERATOR (PWG)

with suitably optimized complex coefficients, generating a plane wave over a finite testing volume (the quiet zone). The PWG enables direct measurements of far-field performance of the DUT in a controlled indoor environment as an alternative to CATR.



MVG compact antenna test range - A full turnkey solution made for PitRadwar



Example of PWG radiating pattern

Generic Compact Antenna Test Comparison Parameter Generic PWG Range (CATR) $\mathbf{:}$ Size of Radiating Surface 1.1*QZ 1.5*QZ <u>..</u> \cdot Distance to QZ from the Radiating Surface ~1.5-2*QZ ~5*QZ Spill-over from Feed N/A $\mathbf{\cdot}$ Yes ••• **QZ** Uniformity Yes $\mathbf{:}$ Yes :: ••• Yes Wideband Operation Yes :: **Dual Polarisation** $\mathbf{:}$ Yes Yes Live End-to-End Testing No No **High Directivity Antenna** $\mathbf{:}$ Yes Yes :: Low/ Medium Directivity Antenna 22 No No Large DUT Size Yes •• Yes

The table above shows the advantages and disadvantages of the existing testing methodologies. Neither of them meets all four challenges of 5G mmWave OTA testing. To meet the evolving needs of the telecom industry, MVG has developed an innovative testing solution.

PROS AND CONS OF THE CURRENT METHODS: PWG VS CATR

INTRODUCING STARWAVE BY MVG A new era of 5G mmWave OTA testing



MVG brings to market a new generation of 5G mmWave OTA testing solutions, combining smart mechanical positioners with PWGs to create accurate direct far-field conditions in a compact system.

StarWave, is composed of one or several (up to seven) PWG(s) attached at a 90° angle to a vertical disk, which rotates. In front of the disk, an electromagnetically transparent mast is mounted on an azimuth positioner to support and rotate a DUT. The interface used between the mast and the DUT depends on the device, with the possibility of inserting a chair for a person holding a device.

StarWave rotates the plane wave generator(s) around the device or antenna under test to perform the elevation plane measurement. The DUT/AUT can turn in azimuth on the mast to perform the azimuth plane measurement*. The combined movements of the PWG and the DUT achieve a measurement on a complete sphere around the DUT with a minimum truncation area. This configuration improves test speed and accuracy of OTA testing. This set up also allows a device to be end-to-end tested while being worn and/or operated by a user, either standing or sitting.

Composed of hundreds of elements, the PWG has been specifically designed to create a QZ in front of its radiating surface at a distance corresponding to the radius of StarWave. The diameter of the QZ is given according to a set of parameters of the PWG. The PWG has been designed to allow wideband signal measurement and is dual-polarized for fast, accurate measurement of antenna performance criteria.

The most compact solution brought to market, StarWave offers flexible, accurate and efficient testing of 5G devices.

KEY TAKEAWAYS

1 Smart positioner system – fast and simple

The multi-axis positioning systems used for 3D radiation pattern measurements in far-field and CATR systems are not well suited for low gain antenna measurements. StarWave rotates the PWG in elevation around the DUT, using only a single-axis azimuth positioner for the DUT. This enables 3D measurement of 5G devices with medium or low gain antennas with minimum scattering caused by the positioning system, resulting in more accurate measurements.

2 Efficient operation

Mounting the DUT on the flat-top interface of the positioner mast is fast and easy as the DUT rotation is azimuth only.

3 Live end-to-end testing

Devices can also be end-to-end tested while being worn and/or operated by a person.

4 A single testing solution for all your antennas

Scalable to suit different devices and capable of accurately testing all 5G bands, eliminating the need for multiple testing solutions.

5 Minimal electronic parts for stable operation

Designed and constructed with few electronic components, sensitivity to temperature fluctuations is minimized for the stability of operation and ease of maintenance.

6 Test multiple frequency bands at once

Choose to test different bands at the same time with several plane wave generators surrounding the DUT.

The perfect setup for MIMO environment testing

Up to seven plane wave generators can be mounted on StarWave for MIMO testing to simulate multiple paths.

Is Flexible design options to suit your requirement

A scalable, flexible system design means MVG can work with you to deliver a Starwave system customized for your testing requirements.

StarWave parameters at a glance				
Size of Radiating Surface	$\mathbf{:}$	Live end-to-end testing	$\overline{\mathbf{c}}$	
Distance to QZ from the Radiating Surface	$\ddot{}$	High Directivity Antenna	$\overline{\mathbf{c}}$	
QZ Uniformity	$\mathbf{:}$	Low/ Medium Directivity Antenna	$\overline{}$	
Wideband Operation		Large DUT Size		
Dual Polarisation	$\mathbf{:}$	Smart Positioning System	$\overline{}$	

EMC The electromagnetic

compatibility department (EMC)

Activity & Markets

The MVG-EMC division was created in 2012, thanks to the unique combination of AEMI's expertise in absorbing materials and Rainford's expertise in Faraday cages. The EMC division provides solutions to test the ability of devices to operate in electromagnetic environments and avoid generating disruptions themselves. This activity also extends to the EMC certification of electronic devices, protection against strong fields (data, people), and protection against eavesdropping.

Key achievements

Dense activity in North America and Europe



Strategy

Integration of the value chain through strategic acquisitions, positioning as a supplier of turn-key systems.

Offering

A range of EMC test chambers, mode-stir chambers, shielded rooms (control rooms, embassies), shielding for data centers, and shielding for MRI installations.

- EMC test chambers
- Absorbing materials
- Antenna measurement chambers
- Faraday cages
- Doors
- Accessories (masts, positioners, controllers, etc.)

The EMC division also provides project management, maintenance, certification, reinstallation, and installation upgrade services.

Price Range

From €10 k to several million euros.



The environmental and industrial control department

Activity & Markets

The EIC division brings together the devices used for monitoring electromagnetic waves, quality control on production lines, and the NeptuLink by MVG dedicated to Internet connectivity in coastal environments.



Growth in the United States on small products (+21%)

> A SAR market on stand-by



Go from "follower" to "challenger" by relying on a modernized portfolio of distinctive products.

Offering

A wide range of products:

- Portable RF exposure meters (EME Guard, EME Guard XS, EME Spy)
- Fixed RF exposure meters (FlashRad)
- Software for 3D simulation of exposure to electromagnetic waves (EMF Visual)
- Control system for rock wool and glass wool on production lines (Dentro)
- 4G modem to optimize land/sea connections (NeptuLink by MVG)

Price Range

From €350 to €180 k.





Since 1996, the year that marked an industrial turning point for the Group when it decided to move forward by turning its unique design office into an industrial manufacturer, MVG has developed two main assets:

- a solid business model, including a high proportion of recurring revenue,
- a multi-country/multi-sector positioning.

A solid business model

MVG proposes, to R&D centers, systems with high added value, designed from standardized technological blocks, guaranteeing controlled margins. Its know-how extends from the analysis, sales, and design stages to production, integration, installation, and support. These systems accounted for 61% of new orders in 2019. Alongside these systems, MVG develops, manufactures, and markets off-the-shelf products, such as the SG 24 and the StarLab 50 GHz.

These projects require little adaptation from one customer to another and can be put into service quickly. They represented 24% of new orders in 2019. Lastly, the Group offers engineering and maintenance services. These represented 15% of orders. Service, engineering, and maintenance contracts, associated with the products, represent 39% of sales and are not significantly affected by adverse market conditions. This solid business model is reinforced by a diversified customer portfolio: the top customer accounted for 10% of the Group's 2019 revenue and the top five customers accounted for 29%.



A Global Group

90% of MVG revenues are recognized outside of France. The Group spans Europe, Asia, and America through 20 locations in 10 countries.

In 2015, a reorganization resulted in a centralization of its mechanical production in Israel, an almost fully sales and service-oriented structure in the United States, and ultimately a more productive, more efficient Group focused on the future. It currently consists of two large major production centers: one in France, focusing on electronics and multi-probe technology, and one in Israel, focusing on mechanics and single-probe technologies, working in perfect synergy. These two production centers rely on three skill satellites: one producing Faraday cages (Rainford - England), one manufacturing absorbing materials (AEMI - USA), and one that designs reference antennas necessary for system acceptance (MVG - Italy). With its local offices, the Group is closer to customer cultures and is therefore better able to follow through with customer needs and with higher understanding, in turn limiting travel and transport expenses.



A multi-country/multi-sector positioning

The Group is strengthened by a diversified and balanced sector and geographic presence. The sectoral breakdown of the activity is as follows: 53% in Civil Telecommunications, continued strong activity in Civil Telecoms driven by very strong demand from mobile phone manufacturers (5G) and 47% in Aerospace & Defense. The geographical distribution of revenue remains balanced with 45% in North America, 30% in Europe and 25% in Asia (Good momentum in Aerospace/Defense, most in evidence in the United States).

A DIVERSE CUSTOMER BASE THAT PROTECTS THE GROUP FROM ANY DEPENDENCY ON ITS MAIN CUSTOMERS

MVG's business model relies on a diversified customer portfolio. From year to year, the share of the top customer and the top five customers remains contained. The top customer's share in the Group's 2019 is thus 10% and the top five customers accounted for 29% of the revenue for the year.

Share of revenue in €K	2013	2014	2015	2016	2017	2018	2019
No. 1 customer	3,790	5,665	4,480	5,970	2,782	5,061	9,205
Top 5 customers	10,942	15,149	10,534	13,464	10,130	16,925	25,569







Business unit growth

Within 36 months, the Group pursued an active policy of renewing its various sites. MVG has moved 7 of its sites, including four production sites. The sites in Manchester, Munich, San Diego, Philadelphia, Atlanta, Paris and Brest are more modern, bright, functional and in optimal working order to support the Group's growth over the coming years. The relocation of one of the Group's major production sites to Tel Aviv is under study and should be completed in 2022.









The MVG Group has published excellent results for 2019, with a very strong second half in particular. The Group is reaping the rewards of its innovative product offer, its sales momentum and the measures to optimize productivity undertaken by the management in the last few years, and 90% of its revenues arises outside of France.



Activity

24th year of growth

At the end of the 2019 financial year, the Group recorded sales of \in 87.4 million, up 17.1% at current exchange rates (+12.9% at constant exchange rates), driven by a good fourth quarter (+27% at current exchange rates).

In terms of sectors, the Civil Telecommunications business was very dynamic (53% of revenue). Aerospace Defense was also well oriented (47% of sales), particularly in the United States.

The geographical breakdown of sales is as follows: United States (45%), Europe (30%), Asia (25%).

EBITDA margin: 14.4%

SIMPLIFIED STATEMENT OF COMPREHENSIVE INCOME	2018	2019	% variation
REVENUE	74,637	87,401	+17.1%
Purchases consumed	(26,459)	(34,149)	
GROSS MARGIN	48,178	53,252	+10.5%
Marge	64.5%	60.9%	
Other external expenses	(12,809)	(12,203)	-
Payroll expenses	(24,176)	(26,631)	-
EBITDA	10,201	12,612	+23.6%
Marge	13.7%	14.4%	
RECURRING NET OPERATING	6,863	6,899	+0.5%

Consolidated data - IFRS - €k

Marge

Gross margin amounted to €53.2 million compared with €48.2 million on December 31, 2018, up by + 5,0 M€. It stood at 60.9% on December 31, 2019 compared with 64.5% at the end of 2018. This change is due to (i) a product mix effect, with a higher proportion of all-mechanical contracts over the period (versus all-electronics contracts) and more sales of anechoic chambers and absorbents, and (ii) recognition of a non-linear gross margin on the major contract of over €30 millions (progress billing), which is less favorable in 2019 but will be higher in 2020 and 2021.

9.2%

7.9%

Current operating expenses are well under control and perfectly in line with the budget in this context of business growth. Personnel expenses increased by +10% (\in 26.6 million on December 31, 2019 compared with \in 24.2 million at December 31, 2018). The average number of employees increased from 352 at the end of 2018 to 378 at the end of 2019. In addition to these expenses, the Group recognized an amount of \in 1.0 million related to the free share plan for management and employees (IFRS 2).

Good control of operating expenses thus made it possible to limit the impact of the one-off drop in gross margin during the year. Reported EBITDA was €12.6 million at December 31, 2019, representing an EBITDA margin of 14.4%. The application of IFRS 16 (related to leases as of January 1, 2019) had a positive impact of €1.9 million on this aggregate. Excluding IFRS 16 and IFRS 2 (AGA), the EBITDA margin was 13.4%.

Consolidated data - IFRS - €k

SIMPLIFIED STATEMENT OF COMPREHENSIVE INCOME	2018	2019	% variation
RECURRING NET OPERATING INCOME	6,863	6,899	+0.5%
Marge	9.2%	7.9%	
Non-current operating expenses	(477)	(596)	
NET OPERATING INCOME	6,386	6,303	-1.3%
Net finance costs	(592)	(402)	
Income tax	(824)	(1,290)	
NET INCOME	4,970	4,611	-
NET INCOME GROUP SHARE	4,762	4,611	-3.2%

After accounting for depreciation, amortization, and provisions for \in (5.7) million, including \in (1.9) million related to the application of IFRS 16, current operating income came to \in 6.9 million, equivalent to last year's published figure. Excluding IFRS 16 and IFRS 2, current operating income was \in 7.9 million. Operating income is virtually stable. It amounts to 6.3 M \in compared to 6.4 M \in on 31 December 2018. It includes a non-recurring expense of \in 0.6 million, partly related to legal fees in China.

Net financial expense amounted to \in (0.4) million, including the application of IFRS 16 for \in (0.2) million.

After taking into account a tax charge of \in (1.3) million, net income was \in 4.6 million on December 31st, 2019, compared with \in 4.8 million at 31 December 2018. Excluding IFRS 16 and IFRS 2, net income was \in 5.8 million at the end of December 2019.

Financial position remains sound

Shareholders' equity amounted to 76.1 M€ on December 31st, 2019 compared to 68.9 M€ on December 31st, 2018. Cash flow from operations before tax rose sharply to €12.8 million at the end of 2019 compared with €9.6 million at the end of 2018, an increase of 33%.

Consolidated data - IFRS - €k

SIN	IPLIFIED BALANCE SHEET	12/31/2018	12/31/2019
	NON-CURRENT ASSETS	28,904	37,918
	CURRENT ASSETS	66,969	87,820
ETS	- of which, inventories	10,213	13,924
ASS	 of which, trade receivables 	36,358	41,735
	CASH ASSETS	14,676	22,081
	TOTAL	95,873	125,737
	EQUITY CAPITAL	68,891	76,085
	- of which non-controlling interest	-	-
~	NON-CURRENT LIABILITIES	1,126	12,756
3ILITIE	 of which non-current financial debts 	172	10,795
LIAB	CURRENT LIABILITIES	25,856	36,896
	- of which current financial debts	4,546	2,768
	- of which trade payables	11,801	13,223
	TOTAL	95,873	125,737

As a result, cash flow from operating activities rose sharply to $\in 12.0$ million at December 31^{st} , 2019, compared with $\in (0.6)$ million at December 31^{st} , 2018, enabling MVG to largely finance its investments ($\in 3.6$ million) and its free share allocation plan ($\in 1.0$ million). Free cash flow is at a good level and stands at $\in 8.4$ million on December 31^{st} , 2019.

I Positive net cash position of €18 million

On 31 December 2019, gross financial debt amounted to €13.6 million. Restated in accordance with IFRS 16, they amounted to 4.2 M€ compared to 4.7 M€ on December 31st, 2018. At the end of 2019, the Group had a net cash position (excluding IFRS 16) of €17.9 million compared to €10.0 million on December 31st, 2018.

Consolidated data - IFRS - €k

CASH FLOW TABLE	2018	2019
Consolidated Net Income	4,970	4,611
Group share of net profit	4,762	4,611
Operating cash flow before finance costs and taxes	9,553	12,844
Change in WCR related to operations	(9,009)	923
NET CASH FLOW FROM OPERATIONS	(658)	12,031
Net cash flow from investment	(8,493)	(3,577)
Net cash flow from financing	(1,615)	(1,138)
Impact of currency fluctuations	206	90
CHANGES IN CASH POSITION	(10,767)	7,316
OPENING CASH POSITION	25,236	14,676
CLOSING CASH POSITION	14,676	22,081



Outlook 2020: maintaining the virtuous growth trajectory

The Group's order book reached an all-time high of €110.1 million on January 1, 2020 (compared with €73.4 million last year, an increase of +50% compared to last year). No orders have been cancelled in the context of the current health crisis.

This very good trend has continued at the beginning of the year and the level of order intake for the first quarter of 2020 is very good. In particular, the Group has signed a major order worth over €30 million over a three-year period for the supply of a large-scale system in the Aerospace/ Defense sector, once again demonstrating the competitiveness of its products but also its proven know-how. MVG has also won a number of smaller contracts.

To date, the Company is confident in its ability to produce the orders entrusted to it. The Group has taken all the distancing and safety measures necessary to protect the health of its employees and to be able to ensure the continuation of its production at all of its sites.

However, the measures restricting local and international travel could slow the pace of installations at its customers' sites, although this has not been significantly observed to date. Periodic maintenance operations (low impact on sales, of the order of \in 1 million) are postponed on a case-by-case basis.

MVG has major advantages in this complex period by being mainly positioned in strategic and essential sectors (Defence/Aerospace and Civil Telecommunications) where demand is sustained, and budgets maintained.

On the other hand, the Group is seeing a slowdown today in the Automotive sector, for example, but with investments that remain in the priorities of the executives and will be unblocked at the first signs of recovery.

Under the current conditions, thanks to a very solid order book and rigorous cost management, MVG confirms its objective of continued virtuous growth with a further increase in sales and a gradual improvement in EBITDA.



About MICROWAVE VISION GROUP

Since its creation in 1986, The Microwave Vision Group (MVG) has developed a unique expertise in the visualization of electromagnetic waves. These waves are at the heart of our daily lives: Smartphones, computers, tablets, cars, trains and planes - all these devices and vehicles would not work without them. Year after year, the Group develops and markets systems that allow for the visualization of these waves, while evaluating the characteristics of antennas, and helping speed up the development of products using microwave frequencies. The Group's mission is to extend this unique technology to all sectors where it will bring strong added value. Since 2012, MVG is structured around 3 departments: AMS (Antenna Measurement Systems), EMC (Electro-Magnetic Compatibility), EIC (Environmental & Industrial Control). MVG is present in 10 countries and generates 90% of sales from exports. MVG has over 350 employees and a loyal customer base of international companies. The Group generated revenues of € 87,4 million in 2019. MVG has received the BPI "Innovative Enterprise" award, and is illegible for PEA-PME.

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