



IHS Markit™

Safety Challenges in Operating Drones Beyond the Visual Line of Sight



Key Market Barriers

The background of the slide features a blurred financial chart with white lines on a dark blue grid. A prominent white line shows a sharp upward trend. In the upper right, there is a white circle containing the text '1J'. Above it, the numbers '13.15' are visible. The entire chart area is overlaid with a semi-transparent dark blue layer. At the bottom center, there is a solid black rectangular redaction box.

Key Market Barriers

Wide range of market barriers hinder growth of drones market



Lack of harmonized standards or regulations

is considered to be the main barrier to the drone market further development



Misuse assurance

use of drones by both individuals or companies that have the risk of being subject to liability or privacy claims resulting to unpredictable cost



Technical barriers

for new entrants to utilize the existing know-how and expertise already developed by established vendors

IHS Markit has been researching Drone Markets and Regulations since its infancy

| COUNTRY* | LEGISLATION IN PLACE | COMPLEXITY | PRECONDITIONS |
|-----------------------|----------------------|------------|---------------|
| Argentina | Yes | Average | High |
| Australia | Yes | Average | High |
| Brazil | Yes | Low | Low |
| Canada | Yes | Average | Average |
| China | Yes | High | High |
| France | Yes | Low | Average |
| India | Yes | - | - |
| Indonesia | Yes | High | High |
| Italy | Yes | Average | High |
| Japan | Temporary | Low | Average |
| Mexico | Yes | High | Average |
| Poland | Yes | Average | High |
| Russia | Yes | Average | High |
| South Africa | Yes | High | High |
| United States | Yes | High | High |
| United Kingdom | Yes | Average | High |

- IHS Markit has been researching drone legislation across the World since its infancy and has a track record of delivering this information with in depth analyses to drone manufacturers, governments and other interested parties
- By interacting with aviation authorities we have mapped the current picture of UAV regulation in the top countries who are paving the way for commercial use of UAV's in the future
- The following topics are the main issues which have yet to be answered by any aviation authority:
 - Beyond Line of Sight operations
 - Collision avoidance (DAA – detect and avoid) and its types
 - UAV air space classification - altitude
 - Wireless connectivity – spectrum bands, e.g. radar, video stream

Drone Usage – Industry Analysis (2017)

AGRICULTURE AND FORESTRY

| Feature | IHS Markit Valuation |
|-----------------------------|----------------------|
| Technology strength | High |
| Applications availability | High |
| Number of service providers | High to Low |
| Price of models (flex) | High to Low |
| Future potential | Promising |

AUTOMOTIVE AND AUTONOMOUS TRANSPORTATION

| Feature | IHS Markit Valuation |
|-----------------------------|----------------------|
| Technology strength | Average to High |
| Applications availability | Average |
| Number of service providers | Low |
| Price of models | Low |
| Future potential | Average to High |

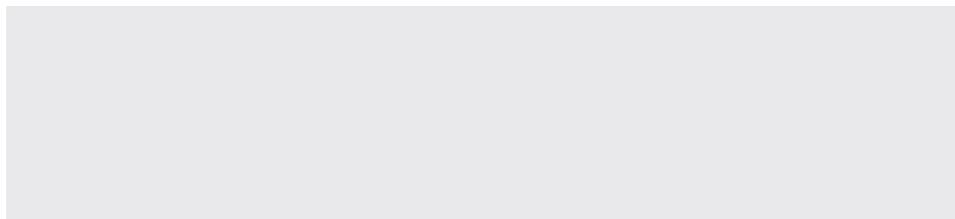
CONSTRUCTION, MAINTENANCE AND DEMOLITION

| Feature | IHS Markit Valuation |
|-----------------------------|---------------------------|
| Technology strength | High |
| Applications availability | High |
| Number of service providers | High |
| Price of models | High |
| Future potential | Average (widely in place) |

Remaining Industries Covered

- Energy and Mining
- Finance
- Government, defence
- Retail
- Maritime
- Media
- Science + Research
- Space and Aeronautical
- Telecoms
- Transportation and logistics

Our industry research is reinforced by IHS Markit's other areas of focus, outside of Technology. This knowledge has allowed us to assess the potential usefulness of UAV's and likelihood that these vehicles becoming prominent in each of the listed industries



Safety has been the key topic for opening up new opportunities with Drones

Safety is the key topic for regulators and vendors and comes up in every discussion with various industries looking at specific utilization of all features and advantages developed and developing technologies associated with drones

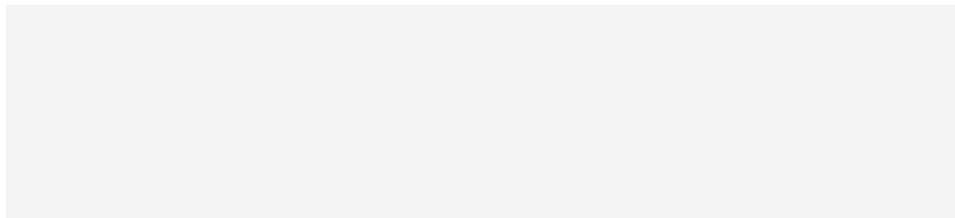
Most of organizations globally are trying to answer to these specific questions:

How to enhance flight autonomy?

How to provide automatic collision and accident avoidance?

When will the ability (and legislation supporting it) to operate in BVLOS operations emerge?

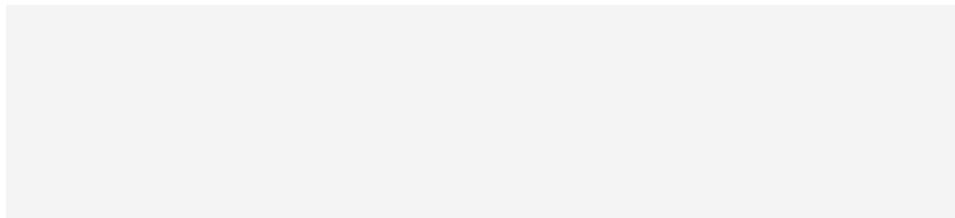
Is there a possibility for the UAVs to be embedded into the national airspace of countries without causing trouble or disrupting any ongoing operations?



Ensuring safety of beyond the line of sight flights is key factor to opening up new opportunities

IHS Markit's capabilities can be applied to various scenarios and research agendas:

- Highlighting the most influential research projects, and their industry applications, that have been concluded or are still ongoing across the globe aimed at ensuring implementation of UAVs into a wider airborne ecosystem with maximum efficiency and safety to all participants, e.g. MIDCAS, TCAS, LATAS and other research projects sponsored by DARPA, FAA or NASA amongst others
- Furthermore our deep roots within the drone industry enable us to understand the complexities of line of flight and what steps are still needed to verify that all participants can securely guarantee the safety of a large number of drone flights that would be conducted simultaneously in wide ranges and with no actual real time observation by human factor in field.
- IHS Markit consulted several Governments and decision makers on the state of drone BVLOS flying as well as their connectivity options either via terrestrial or satellite networks.



Top companies working on CA technologies

| COMPANY | CA SYSTEM |
|------------------------|----------------------|
| Echodyne | MESA-DAA |
| Arbe Robotics | Imaging radar system |
| DJI | Flight Autonomy |
| Intel | RealSense |
| Iris Automation | Iris system |
| Aerotenna | Sharp |
| Parrot | SLAMdunk |



IHS Markit can offer details for these companies and their technologies such as:

- Sensors used for the DAA system (radar, camera, etc.)
- Detection distance of the DAA system
- Main detected objects of the DAA system (Manned aircraft, unmanned aircraft, obstruction(buildings, trees, etc.)).
If main detected objects of the DAA system are manned aircraft or unmanned aircraft, what kind of features do they have? (size, weight, class, etc.)
- System dimensions
- Weight or class of the aircraft and feature of object targeted by the DAA system
- The detail of the airspace class or altitude targeted by the DAA system based on ICAO, International Civil Aviation Organization standards
- Type of system and its relationship with air traffic control or UTM

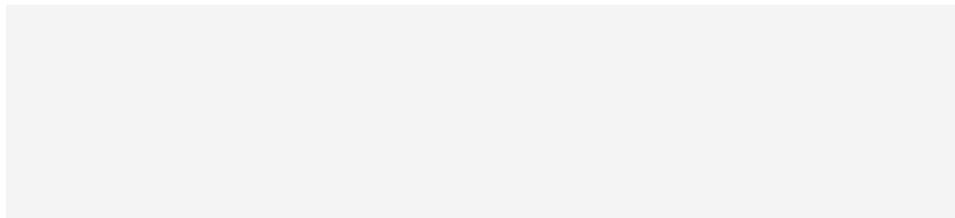
European Detect & Avoid Project Case Study - MIDCAS

Technology:

The Detect and Avoid system tested, performs collision avoidance and traffic avoidance using data fusion for various combinations of the included detection technologies, i.e. the cooperative identification, friend or foe (IFF) interrogator and automatic dependent surveillance broadcast (ADS-B) equipment and the non-cooperative electro-optical, infrared and radar sensors, elements that collect the signals emitted by other aircraft with data on positioning, height, speed, etc. All of this information is processed, in turn, by the part of MIDCAS that is responsible for “avoidance”, estimating the paths followed by aircraft and deciding on whether the risk of collision exists and if an avoidance maneuver is required.

Year of implementation and Project’s duration:

- 2009 – 2015
- Test flights conducted in 2015
- Currently those results are used to develop related technical standards



We monitor drone service providers across several industries (Energy inspection examples)



| DRONE OPERATOR | PAST PROJECTS | OUTCOME |
|--------------------|--|---|
| Cyberhawk | Live gas flare inspection using a UAS at a height of 100m for a major Scottish gas refinery | Fly a UAS within a few meters of the live flare providing highly detailed images of the condition of the flare tip and associated structure using HD video, still imagery and thermal imaging equipment |
| Cyberhawk | Live offshore flare inspection using a UAS in the North Sea | UAS flied very close to the flare catching Live images; the results were discussed with the client's engineers in real time |
| Sky-Futures | A pre-shutdown UAS inspection to establish the integrity and condition of two of flare tips | Still video imagery taken were reviewed and assessed resulting to a detailed report; This has saved the company an estimated amount of more than US\$4.5m |
| Landpoint | 45 mile pipeline survey including quality control, preliminary routing survey & topographic survey, construction staking, pipeline-as-built survey | Reporting included incorporation of client's data with own collection of all pipe attribution |

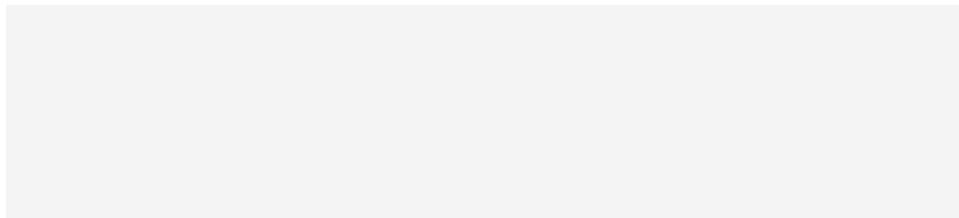
Further examples of industries and applications

Types of infrastructure-based projects that already benefit from drone inspection and maintenance include:

- Distribution facilities – electrical lines and distribution centers, pipes and others
- Infrastructure projects – bridges and dams
- Power generation plants – indoor (boilers and chimney stacks) and outdoor (pipework, cooling towers, dams, wind turbines and grid equipment)
- Pipes and other aerial components in thermal plants and solar plants
- Inspection and maintenance of wind energy generators, and others
- Industrial plants with aerial facilities, including those in the oil, gas and chemical industries
- Offshore plants – offshore oil and gas facilities, oil-drilling platforms, offshore wind plants and wave generation
- Indoor aerial inspection and maintenance of big parts in manufacturing, for example, aeronautical manufacturing.

Type of applications and industries that may benefit from drones in the future include:

- Medical applications by offering a rapid response via drones in various emergency scenarios or regarding the delivery of first aid equipment and materials in isolated areas and scarce population
- First responses on disaster situations such as floods, hurricanes, earthquakes and others
- Taxi drones are a big bet for the future with large companies being keen on the project like Airbus
- Networking and connectivity issues could also be assisted with drones acting as receivers and transmitters in the sky



Global UAV Deployment CAGR 2015 – 2020



Consumer drone market

2015 CAGR 22.1% 2020

Consumer drone market is more established than professional services and thus the growth rate of deployment is lower than the professional use rate

Companies like DJI, Parrot and 3D Robotics have a significant market share as pioneers in the industry but low end Chinese manufacturers that offer highly competitive pricing terms are gaining ground

Connectivity of drones with other smart devices like watches, smartphones and tablets will open up new opportunities



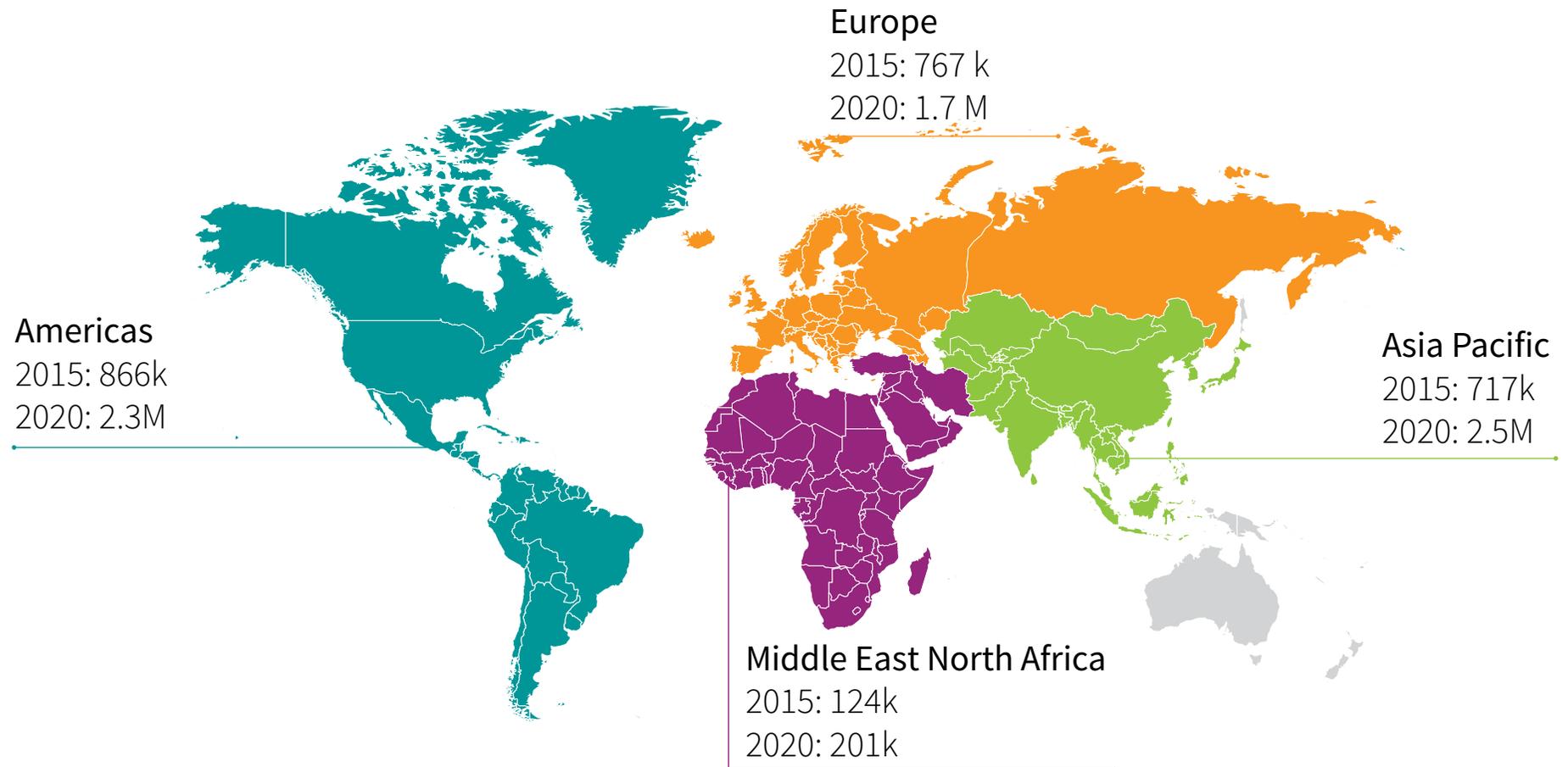
Professional drone market

2015 CAGR 77.1% 2020

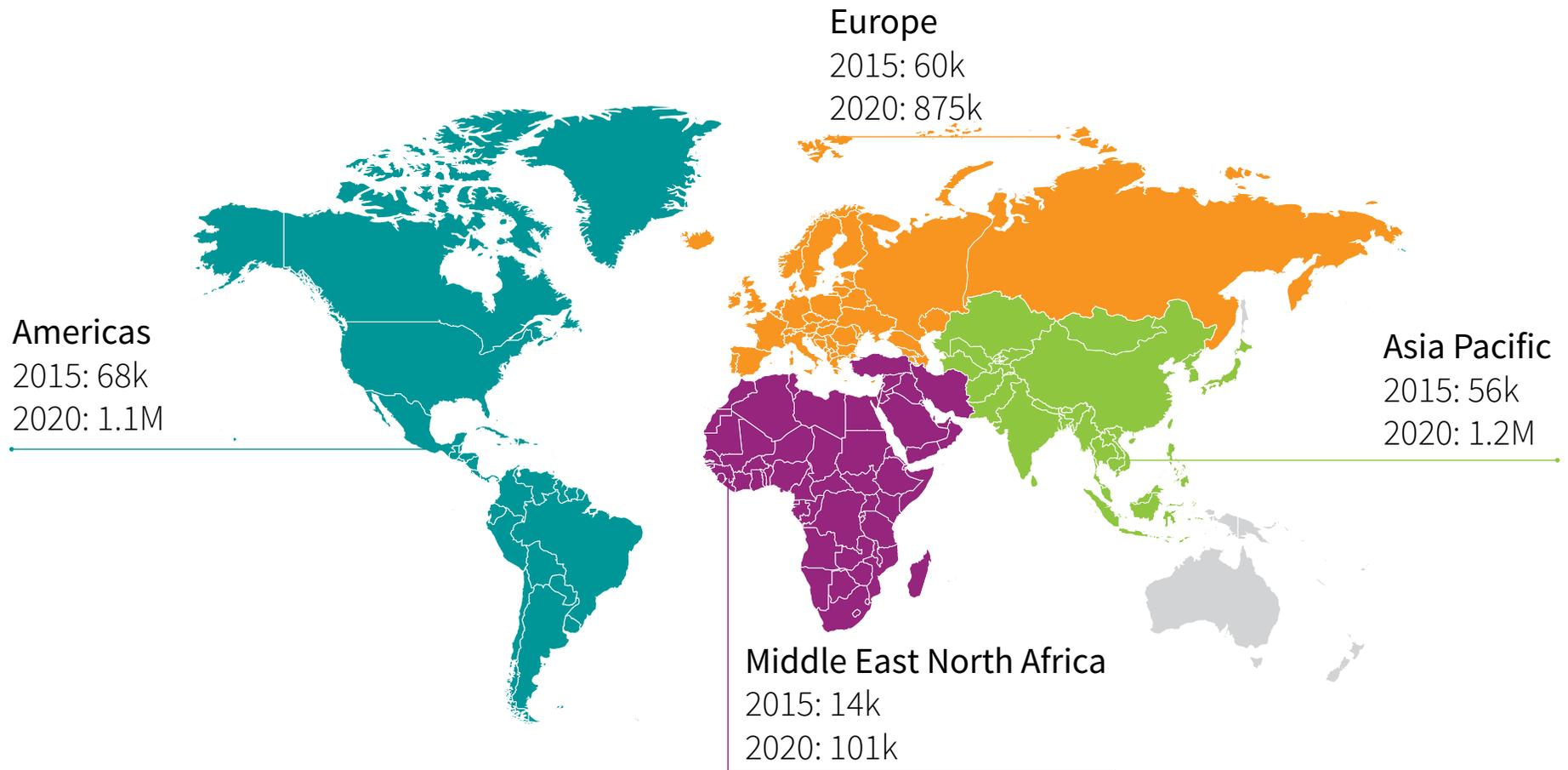
Professional drone market will enjoy a much higher growth rate for the next years as it has already begun being adopted by various industries on a large scale. Agriculture, energy and construction industries will be the main catalysts behind that growth with other industries following

As for manufacturers, IHS Markit expects to see a lot of interest from various companies taking advantage of new technologies and having expertise in underserved segments and thus the current landscape will be altered significantly

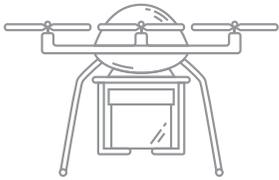
Consumer UAV Global Unit Shipments 2015–2020



Professional UAV Global Unit Shipments 2015–2020



IHS Markit's Drone Research Coverage



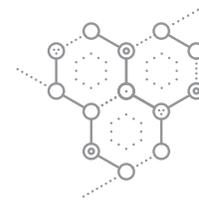
TYPES OF DRONES

- Airships
- Balloons
- Fixed wing
- Multi Rotor



MAIN SEGMENTS

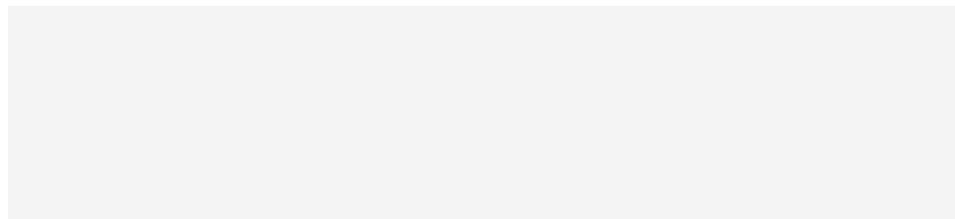
- Consumer
- Professional



INDUSTRY SECTORS (16)

- Agriculture & forestry
- Automotive & autonomous transportation
- Construction, maintenance & demolition
- Domestic uses
- Education
- Energy
- Finance
- Government, humanitarian, civic defense and rescue
- Hospitality, retail, hotel & restaurant
- Maritime, shipping, ports & docks
- Media & entertainment
- Medical & care
- Science, research & environment
- Space & aeronautical
- Telecommunications
- Transport & logistics system
- Others

REGIONS COVERED



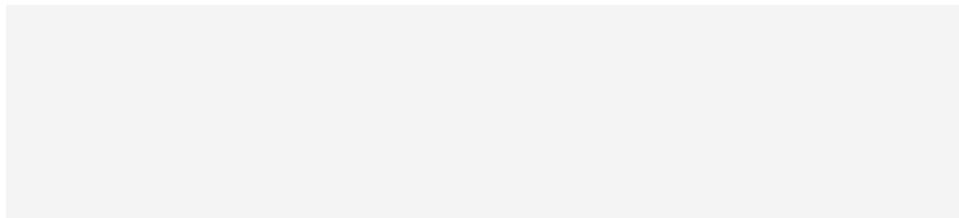
Who we are

IHS Markit (Nasdaq: INFO) is a world leader in critical information, analytics and expertise to forge solutions for the major industries and markets that drive economies worldwide. We deliver next-generation information, analytics and solutions to customers in business, finance and government, improving their operational efficiency and providing deep insights that lead to well-informed, confident decisions.

About our technology, media and telecom expertise

We are the leading source of information, insight and analytics in critical areas that shape today's technology ecosystem—from materials and components, to devices and equipment, to end markets and consumers.

Businesses and governments in more than 150 countries around the globe rely on the deep market insight and expert independent analysis of our 300+ industry analysts in technology sectors spanning IT, telecom, media, industrial, automotive, electronics, solar and more.



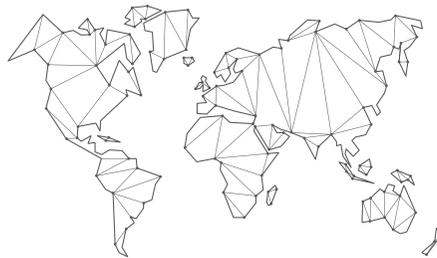
What we do

We provide an unmatched combination of information, insight and expertise, transforming knowledge into data and customizing a solution to meet your greatest strategic and operational challenges.

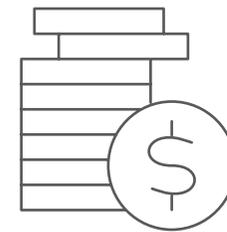
- ✓ **Reduce risk**
- ✓ **Streamline business planning**
- ✓ **Accelerate informed decisions**
- ✓ **Lower operating expenses**



Over **1,000 consulting projects** to date



Serving **34 countries** with over **130 offices**



Serving **85%** of the **Global Fortune 500**

Our methodology

The power of collaboration

We partner with you to produce actionable insights for your company so that you can achieve your most important goals.

Leveraging IHS Markit's wealth of existing research and data—and conducting supplementary research when appropriate—our experts provide meaningful analysis and action-oriented recommendations.

Solid foundation:

Our syndicated research and deep industry understanding allow us to quickly help you find the right approach to gain a competitive advantage.

Objectivity:

We are objective and consistently unbiased as we craft strategies, provide support and guide execution.

Deep-rooted expertise:

The same renowned experts who lead our syndicated research efforts also conduct our custom research and consulting work.

Actionable advice:

Our broad, pragmatic business know-how allows you to remain grounded in the realities of your business environment.



Custom research & consulting

Proven expertise in:

- ✓ Market sizing and forecasting
- ✓ Market entry and development
- ✓ M&A due diligence
- ✓ Customer and competitor research
- ✓ Market and strategic planning
- ✓ Product optimization



1000+
consulting projects

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- ✓ Reduce risk
- ✓ Streamline business planning
- ✓ Accelerate informed decisions
- ✓ Reduce costs

Going beyond “what it means” to help find “what we should do”



Learn more



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