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TITLE

Data flying on the future: Integrating Unmanned Aerial Vehicles (UAV) and Artificial Intelligence (AI) for Autonomous driving implementation

SUPERVISOR

Prof.ssa Federica Ceci

CANDIDATE

Cristina De Simone

CO-SUPERVISOR

Prof. Tommaso Federici

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Introduction

Drones are growing tremendously in their importance in nowadays lives and applications. They are currently used in agriculture, industries, oil & gas, real estates, public safety, energy, delivery, and the next frontier is to use them in the automotive industry.

This flight will change the landscape of the automotive sector that we currently know, allowing Here to collect enough data needed to build an integrated map at high definition (42 Megapixel) of almost all the cities in the world, for the new frontier of the automotive world: the autonomous driving. These surveys will be executed by Dronus, that will become a strategic partner in the collection of data for the implementation of this innovative, potentially worldwide, project. Dronus has the potentiality to shape the technological trajectory of the future in multiple sectors being the first mover on this type of experimentation and having even reached strategic agreements with the National and International legislation entities.

A completely new landscape that will be fully addressed through the following chapters in a rational timeline from the very first idea, to the implementation of all the documents need to authorize the project, to the process of Dronus data through the value chain, to the Here post elaboration of data.

Chapter 1: The importance of data

Big data characteristics

The volume of data available is growing exponentially, arriving at more than 44 zettabytes (44 Trillion GB) of useful data in 2020. We live in a time where every device is connected, where sensors are ubiquitous in our world generating streams of data continuously, where data available and consumed on Internet will increase by orders of magnitude, where the Internet of Things will shape inevitably the world as we know it. Innovative new ways of extracting value have been made possible thanks to the technological field of Big Data, which highlights the tsunami of new information available. The current frontier on which competitors are fighting to establish the best performer and to gain competitive advantage is the ability to effectively manage information and extract powerful knowledge from them. Big Data adoption in fact, is not something that you can transcend, but is an imperative that must be inserted into organizations' core business in order to survive and enhance the establishment. The massive impacts of Big Data go far beyond the commercial world; the proliferation of disposable data is creating the so-called Data Science (Hey et al. 2009) in scientific literature. This new world is a comprehensive approach that shows data as an innovative factor of production, in the same way as physical assets and human capital. The Internet of Things, Sensor Networks, Open Data on the Web, data from mobile applications, social network data is creating a new layer of data environments that requests innovative management strategies which can comply with the birth of this incredible amount of disposable data. (Manyika et al. 2011).

This chapter has the aim to examine concepts and literature related to big data. The chapter starts by describing the different definitions of "Big Data" useful to better understand the literature context. The Big Data Value Chain is then introduced to describe the information flow as a path made by a series of following steps within a broader system and how data are embedded in the framework in order to extract value and gain useful insights.

In the modern literature it is useful to see how big researchers define such a vast world that Big Data represents (*Cavanillas, Wahlster Editors, R 2016. New Horizons for a Data-Driven Economy. Springer Open: C3, P 31*):

- Big data is high volume, high velocity, and/or high variety information assets that require new forms of processing to enable enhanced decision making, insight discovery and process optimization". - Laney (2001), Manyika et al. (2011)
- "A collection of large and complex data sets which can be processed only with difficulty by using on-hand database management tools". - Mike 2.0 (2014)
- "Big Data is a term encompassing the use of techniques to capture, process, analyze and visualize potentially large datasets in a reasonable timeframe not accessible to standard IT technologies." By extension, the platform, tools and software used for this purpose are collectively called "Big Data technologies". - NESSI (2012)
- "Big data can mean big volume, big velocity, or big variety". - Stonebraker (2012)

The 3 Vs of Big Data are posing challenges in the new and complex set of data management that is featuring advanced specific characteristics:

- Volume (amount of data): dealing with a big amount of data within data processing (es. Global Supply Chains, Global Financial Analysis, Large Hadron Collider);
- Velocity (speed of data): dealing with streams of the high frequency of incoming real-time data (es. Sensors, Pervasive Environments, Electronic Trading, Internet of Things);
- Variety (range of data sources): dealing with data using differing syntactic formats (es. Spreadsheets, XML, DBMS), schemas, and meanings.

Data Value Chain

Big data need then, to be processed to gain strategic validation and so to be inserted in a Data Value Chain system. A value chain is composed of a series of subsystems each with inputs, processes of transformation and outputs. Rayport and Sviokla (1995) were one of the first in the literature to apply the value chain metaphor to information systems on

Virtual Value Chains. This tool can be used to understand the creation of value given by data's information flow, made explicit by a series of subsequent steps useful to the creation of effective advantage.

The European Commission has acknowledged the Data Value Chain as the "center of the future knowledge economy, bringing the opportunities of the digital developments to the more traditional sectors (es. transport, financial services, health, manufacturing, retail)" (DG Connect 2013).

Big Data value chain is used to manage, integrate and coordinate data through the service continuum from data generators to end users that seek to make decisions. They are fundamental to create a collaborative partnership and effectively manage the multitude of data from different stakeholders thanks to the optimization of service delivery and prime decisions. To allow positive results for all strategic actors, data are wisely streamed to establish a portfolio-management approach that allows companies to invest in people, processes, and technology that will maximize the value of joined data and informed decisions.

The Big Data Value Chain (Curry et al. 2014), as graphed in Figure 1.1, can be used to describe and design the information system and all its strategic level activities, that are:

- Data Acquisition: a process by which the data are gathered, filtered and cleaned to generate an element that can be inserted in the Data Warehouse to carry out the necessary analysis. So to say, before an organization can be able to perform compulsory analysis on data, it needs to clearly know the amount of data available, not only superficially but deeply enough in order to organize and distribute assets. This step is the most difficult in terms of infrastructure needed and require the creation of an inventory of data and metadata that must acquire completeness, validity, consistency, timeliness and accuracy. Then, to establish correct access to the data acquired, they need to be copied into a shared system and companies need to set up control rules of privacy and security. Tools for providing data access include representational state transfer, application programming interfaces, Web Services Description Language, and Open Database Connectivity/Java Database Connectivity;

- Data Analysis: process that involves the exploration, transformation and modelling of data with the aim of making data useful for strategic purpose, thanks to the understanding of what is valuable and what's not for decision-making as well as domain-specific uses. Relevant data are synthesized in order to extract high potential tacit information from a business viewpoint. In order to analyze an enormous amount of data, they need to be structured and organized in order to decide a shared syntax and semantics that will allow the tracking and the metadata repository after they have been studied. Analysts often consider formal data organization of secondary importance because they are more concentrated on their own data needs than on evaluating how to share them. However, being able to send knowledge about the internal technical aspect of the company can provide more tide links with the upstream environment of data providers environments and the downstream consumers' one;
- Data Curation: the process by which involved data management is obtained by ensuring that the required quality of data has been met over the entire life cycle (Pennock 2007). This activity is characterized by different phases in which the content is selected, classified, transformed, validated and preserved for future usage and for correct fitting in the field of application. This task is performed by expert curators, scientific curators, or data annotators, that are responsible for improving the trustworthiness, accessibility and quality of data;
- Data Storage: the process by which the data are correctly clustered and stored in a scalable way in order to be quickly and efficiently accessed by companies and actors that need them. The most revolutionary system for storage purposes in the last 40 years has been the Relational Database Management Systems (RDBMS). However, the complexity of managing data when they grow in volumes, make the ACID (Atomicity, Consistency, Isolation, and Durability) properties, that guarantee database transactions, impossible to be verified consistently.
- Data Usage: activity of proactive integration of the data analysis in the business processes through tools that are aimed at supporting the analysis and the access to storage data. This step is useful in decision-making processes to stimulate the competitiveness into sectors thanks to costing reduction practices and to increase the marginal value in terms of boost performances. Through the usage of cleaned

and structured data, organizations can achieve thoughtful decisions thanks to the combination of human mindset and machines intelligence. Is very important to mention that the use of data goes way beyond the pure reading of them; data are of incredible value because they can be redesign thanks to their modularity to form graphs, charts, photos, interactive application and statistic report that provide key stakeholders with meaningful information. Data are shown in a format that can readily be consumed to take critical decision and to clearly demonstrate their promising implications. Giving value to the information extracted by multiple sources is the final aim of the process, that, thanks to the tracking of the path that data follows, obtain importance due to the perfect traceability that the final user can do on them. Informed data are the future hedge of technology for their ability to change people behaviors and for their detailed capacity to understand problems and implement viable solutions. The proposed Data Value Chain can recognize the relationship between different phases, from raw data to informed decision-making, and how these stages are interdependent with each others.

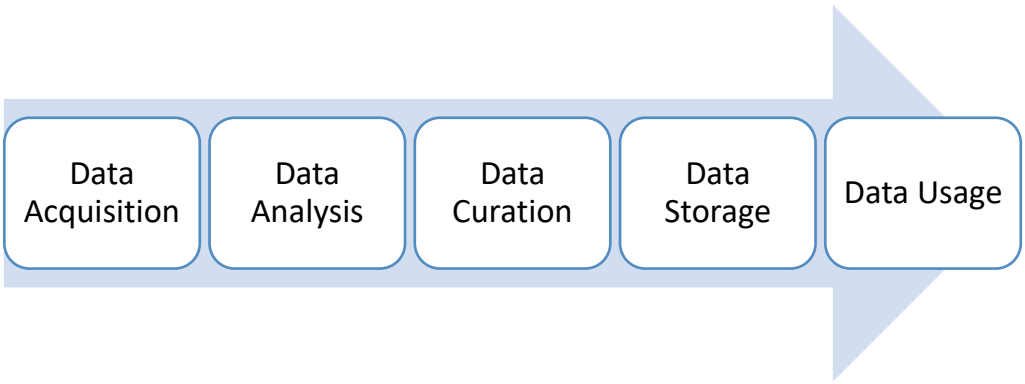


Figure 1.1

After all the process that we have followed through these pages, the data is finally ready to be used for a suited particular analysis. Thus, data need to be integrated in order to be combined in a common representation that enables them to be mapped and tracked to facilitate future analyses. Not taking into consideration the precise configuration of data,

the combination of dispersing data sources creates undiscovered information and new relationships that link different stakeholders through patterns that explore knowledge in a comprehensive modular way.

Digital Transformation

The Big Data value chain and the inclusion in a smart environment can increase the performances of companies that have successfully understood the great importance that data, as decision drivers, will have in shaping the future in terms of their valuable answers given to consumers (Mayhew et al. 2016). Big Data analytics allows in fact, to predict the course of actions, thanks to iterative learning of machines that take data from different types of sources (from people's daily actions and routines to professional installation of sensors in order to generate targeted data). Artificial intelligence is what makes everything possible, because it is able to automize processes transforming companies and developing future types of predictions; explanation of phenomena that vary from stock prices to purchasing behavior and intentions of vote. This revolution will change forever the way people and organization conceive management practices and strategy implementation, enabling them to explain what caused certain outcomes (Reed and Dongarra 2015). The knowledge generated will be used to target people under specific behavior and characteristic over time, being able to influence results. The Digital Transformation have tackled numerous sectors and industries (es. business, health, transportation, finance), but the most important interrogative that scientific community pose to themselves, is how to achieve worldwide adopters and mostly how to provide sustainable solutions that benefit all the actors within the ecosystem.

Is now interesting to try to map what are the factors that contribute to generate business value from the analysis of large volumes of unstructured multiple data sources. Companies need to effectively orchestrate data, technology and human talent in order to succeed in their strategic operations, being able to differentiate themselves from the competition (Mikalef et al., 2018). These resources, that as we said varies from tangible resources (infrastructure, data and financials) to technical and business skills, to intangible sources like data-driven culture and propensity for agile organizational structure, must be integrated and effectively connected within all companies, with the final aim to allow them to gain overall superior performances.

A useful definition of Big Data analytics given by Mikalef, Pappas, Krogstie, & Giannakos in 2017, can help us to structure our analysis: "a new generation of technologies and architectures, designed to economically ex- tract value from very large volumes of a wide variety of data, by enabling high velocity capture, discovery and/or analysis".

Supporting this quote, the MIT Sloan Management Review shows that Big Data analytics can also be a source of innovation, in fact, it has been demonstrated that a positive correlation exists between being leaders in Innovation and the likelihood to deliver new products and services that are able to stand out from rivals (Ransbotham & Kiron, 2017). Being able to reap the advantages that technology gives to firm, must be supported by a structured infrastructure of physical devices and software that enable the flow of data to stream properly. Thus, thanks to the correct orchestration and leveraging of digital capabilities, companies can infuse superior technology into daily operation, tasks and habits.

Big Data and RBV: Venn Diagram

The main premise on which we will build our discussion is that is fundamental to analyze the context of the examination, because depending on it, companies' resources may have a greater or lesser impact on value gains. This point of view is supported by the Resource-based View (RBV) framework that sees resources as key to superior firm performance. If a resource is able to reach VRIO (Valuable, Rare, Imitation, Organizational) attributes, it enables the firm to gain and sustain competitive advantage.

A very interesting study by worldwide researchers on Predictive Analysis integrates RBV with Big Data Culture and Institutional Theory. Starting from the influence of big data and predictive analysis to improve supply chain and operational performance, the paper tries to address the possible gaps and limitations in the role that RBV has in building Big Data capability. RBV emphasizes the central role of internal resources in influencing organization strategies and performance (Barney, 1991).

Previous studies on RBV have tried to explain what are the different roles that external pressures from institutions and internal resources plays in organizational decision making

as well as to deeply understand their relationships (Zhang and Dhaliwal, 2009; Zheng et al., 2013; Tatoglu et al. 2016). The majority of these studies have found that organizations that use BDPA (Big Data Predictive Analysis) to make complex decisions, reveal themselves as more competitive in the market (Chen et al., 2015; Fosso Wamba et al., 2017; Srinivasan and Swink, 2018). However, Aydiner et al. (2019) have demonstrated that organizations can't underestimate the importance of external pressures and environmental demand if they want to achieve a high level of performances. For this reason, we can say that institutional discrepancies in organizations clearly have an impact on all aspects of the company's practices (Tatoglu et al., 2016). To effectively build a BDPA capacity in the firm we must integrate these theories and we must go beyond traditional qualification of effectiveness and efficiency to reach the frontier of modern Performance Measurement Systems (PMS). It can provide important informative answers to executives to monitor performance, show progresses, potentiate motivation and communication, and discover and analyze problems (Waggoner et al. 1999; Kennerley and Neely, 2003). In this way, companies will be more efficient in developing better solution quickly and will cut on expensive actions such as delayed production, big inventory and irrecoverable sales (Srinivasan and Swink, 2018). Supporting empirically this new best practice, researchers have found a significant positive impact on organizations daily performances and have discovered positive correlation between high level of BDPA adoption and business gains made explicit by lower operating costs, high quality of product and improved product availability.

Hence if managers are not ready to effectively respond to the external pressures, the outcome shown by their analysis with inclusive big data capability, may be restricted and narrowed. Thus, managers should carefully select the resources to put into the organization, taking care of the external context in which, the operations are carried out. Moreover, leveraging big data opportunities requires not only investment and time, but also the correct human skills that can develop appropriate strategies and address the dynamic necessities of the market. A fundamental observation that this study has noted is that cognitive component of external pressure plays significant role in the broad Big Data picture and in the way, firms reach competitive advantage. This role is positive and beneficial to the selections of resources in order to build effective Big Data capability and to reap benefits from investment and from potential market opportunities.

Now that we have explained deeply what the consequences of RBV are if applied to Big Data capabilities, is time to recognize and explain what are the resources that are so important to understand the circumstances in which Big Data and analytics capabilities are inserts and what are the costs to develop them. The Venn diagram (Mikalef, Boura, Lekakos, Krogstie, 2019), as noted in Figure 1.2, illustrates the seven sets of constructs, which reflect one dependent variable (performance) and six set of casual categories to predict the outcome (independent variable).

The intersections represent factor configurations, which are higher level interactions. This diagram is a useful way to show the possibilities of how changing independent variables can lead to complex final configuration. The presence and absence of ingredients in complex solutions can indicate high score of outcomes in the performances of firms (Woodside, 2014). Firms that are able to achieve high performance score thanks to Big Data analytics, are the structured and procedural one which are active in highly heterogeneous environments. They are able to arrive to premium results because they invest in data, in strong data analytics business skills and in robust governance practices. Therefore, high levels of maturity are what allow firms to achieve performance gains under a certain set of contextual conditions.

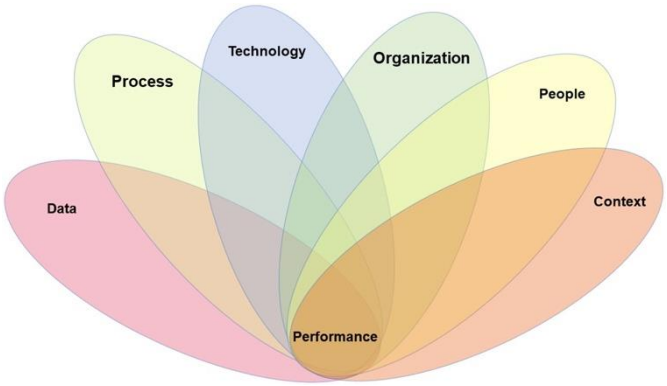


Figure 1.2

Source: Mikalef, Boura, Lekakos, Krogstie, R 2019. Big Data analytics and firm performance: Findings from a mixed-method approach. Journal of Business Research 98): 261-276

Thanks to a different set of configurations is now possible to discover multiple ways through which firms can achieve high outcomes. Thus, we can find multiple realities as Woodside (2014) notes, which, due to different combinations of factors, produce a specific outcome of interest. This theory is built upon the complexity theory, which views organizations as complex adaptive systems that self-organize and evolve to become better suited to the contingent external environments (Cabrera, Cabrera, Powers, Solin, & Kushner, 2018). Therefore, examination of variables in different configurations can bring the company to the same results depending on how elements are combined with each other. The cited configurations and their different outcome are perfect to explain the larger part of samples and their greater feedback that we find worldwide.

Complexity theory is very attractive for context-related studies that deep dive into complex casualty because it is able to analyze events simultaneously through a holistic lens (Woodside, 2013b). It seems now clear that the interest in Big Data analytics matches well into the lens of complexity theory, because in both cases the contextual elements shape the environment in which multiple actors, objects and processes interact (Wilden, Devinney, & Dowling, 2016).

Achieving Business Impact with Data

Nowadays data are becoming more and more important and they are challenging the world as we know it. They are becoming the so-called “new oil” or the “new gold” due to their high applicability and potentiality in introducing and managing new key best practices. In fact, not only the volume available of data is skyrocketing, but also their advanced analytical capability in shaping deeply the methods and approaches used to develop insights and eventually actions, is of increasing relevance.

Machine learning, which enables forefront analysis for a range of statistical methods from regressions to neural networks, has steadily improved the computational power of processing units of data and has lowered the expected cost of development for IoT nodes. As shown in McKinsey research, the unit price in USD will decrease by 50% thanks to better opportunities in the market of MCU (micro-controller unit), connectivity and sensors. Computational advances and the tremendous increase in the amount of complex data management require power infrastructures to access it through the next generation

of machine learning methods such as deep learning. The digital world is extremely connected and embodied in our physical world, having become a new corporate asset interacting to all the industrial practices, from marketing, to sales and product development. Thus, the way we can make data speak, helped by machine learning and AI (Artificial Intelligence), is connected with the capture of their full potential through the observation of how complex elements are linked to each other in an inclusive picture, without focusing too much on a single technical component. Supporting the hypothesis of Niko Mohr and Holger Hürtgen, we can arrive at the consideration that the insights value chain is multiplicative, that means that if one link in the chain is equal to zero, your total final impact will be null. "The full Ecosystem is only as good as its weakest components".

The operating model of the value chain shows us how insights in strategy and vision can be reached thanks to technical and business foundations. In the first category we find data, analytics and IT; in the second one we find people and processes. In this model:

- Data represent the entire process of collecting, connecting, cleaning and enlarging internal information without forgetting the external context. As we showed at the beginning of the chapter data need to follow a long journey of enriching (Acquisition, Analysis, Curation, Storage, Usage) before they can be useful for a strategic purpose. Moreover, security and privacy issues (es GDPR) need to be taken into account throughout the entire process;
- Analytics define the set of digital methodologies (es. software) used to bring out value and talent able to apply these advanced practices;
- IT has been studied as the technical layer allowing the storage and usage of data, (es data lakes, two-speed IT architecture). Information Technology enable computers to retrieve, transmit and manipulate information in the context of business operation and communication objectives;
- People are the figures needed to make analytics operations to give value to data. The critical step is to translate poor data into successful insights for business application. Human talent varies from the surface layer, to the front lines of sales, to deep within the business;

- Processes must be carefully understood in order to take intelligent steps to adapt the kind of task performed with the need of the analysis performed by data engineers and scientist;
- Strategy and vision are the final aim and objective of the management of Data Analytics. In fact, they are implemented thanks to the fulfilment of all the necessary steps in order to enrich data and make them useful for business purpose;
- Operating model is the layer under which the insights value chain lives due to effective governance. It communicates and describes the vision of how the organization will work in the future and the context that is targeted in order to understand how business purposes are been made explicit within the BUs and functions (es centralized, decentralized, hybrid).

From data collection to adoption

In order to contextualize Data Value chain in management practices and to study how organizations need to organize themselves in order to reap the full value of innovation, Data travel across upstream and downstream processes to generate invaluable insights through a systematic approach aimed at identifying business need and translate data collected into business value.

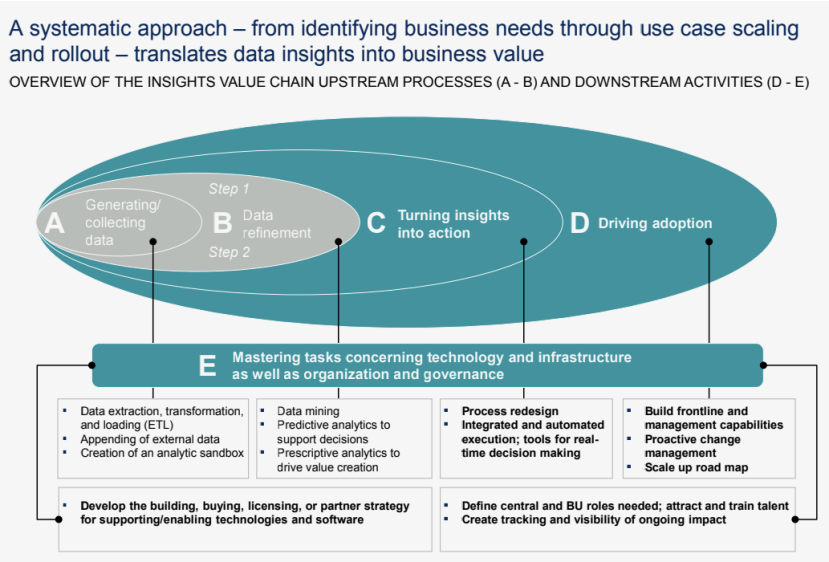


Figure 1.3

Source: Niko Mohr and Holger Hürtgen, R 2018. Achieving business impact with data. Mc Kinsey: P 9

This process shown by Figure 1.3, as reported in the Mc Kinsey report, is composed as following:

- Generating and collecting data: an upstream step in which we observe two trends, connected with the commoditizing of algorithms and the limitation of outside access as companies bet all their energy on data. The enhanced data capture ability, in fact, is not important only for B2C chain, but also for B2B one, as IoT with sensors is increasing the amount of data available being able to generate new dimensions. Given the massive increase in the amount of e-commerce and sensor-generated data, they are becoming more and more important. The increase in the quantity is increasing also the complexity in managing them; in fact, it is impossible to capture every bit of the tera/peta-bytes of data generated. Effective companies must be able to understand, relying on certain requirements, what are the series of quality data that need to be deeply studied and stored to be transformed in asset sources. The situation requires a thoughtful understanding of the way in which data can be aggregated or reanalyzed and their requirement in terms of granularity and freshness and in case of relevance, the hypothesis-driven approach, as well as the use case backwards (es. starting with customers) one, are driving the best outcomes. Instead of putting all unconnected and unstructured data into analytical tools layers all in once, is really important to carefully organize them into precise logics in order to be able to best ride the wave;
- Data refinement: upstream process composed of enrichment and extraction. The enrichment is made with additional and domain information that is discovered both by human talents and algorithms. “Man+Machine” approach has been demonstrating to be an optimal approach to further develop AI, to better explain hypothesis and to codify new information into variables creating the so-called “feature engineering”. The second step, which involves the extraction of insights using Machine Learning, is composed by the discovery of patterns that better

describe the new features of data and by the usage of various methods to identify winning combinations (descriptive, predictive and prescriptive analytics);

- Turning insight into action: downstream part of the value chain that involve nontechnical components but that include people and business understanding. This step requires two things: first, to be able to understand that downstream actions that manufacturing and service firms are very different although the mathematic of predictive model might be similar and secondly, companies need to understand that success depends not only on what actions are initiated, but also on how they are taken (es. on the process side, automation may be introduced in activities like pricing on platforms);
- Driving adoption: fundamental steps considering the crucial importance of infusing true consciousness of change in the employees of the company through the increase of their analytics quotient (AQ) and Data Analytics proficiency. The adoption, as well as in workers, is of increasing relevance for clients, that need to translate their daily routines to data science frames;
- Mastering task concerning technology, infrastructure and organization governance: the last but not least step in the journey of data enrichment through which organization take action and create impact. Companies need to implement easy-to-use tools in order to extract relevant insights in the easier and more effective way and address targeted problems. They need to design structure in order to put as close as possible new data science departments with traditional BUs and incubate innovation skills in pooled center of excellence. BUs, with the passing of time, will leverage on their improved AQs to hire more specialized data scientist for the implementation of greater data science driven analysis.

COVID Impact on Big Data

To conclude the chapter, it seems appropriate to enumerate what can be the challenges in capturing the value of data-insights driven organization. The reality of facts is that companies are mature in the technical part of the value chain, but most of them are not evolved in the structural part and they often struggle to empower a cultural shift from traditional decision-making toward the one driven by data.

Data science and business execution are two functions that have always been separated due to their differences in the structural mindset. This has led to a lack of understanding for business actors of the methodologies in which solutions are implemented from data science.

Moreover, in moving from insight to value creation there can be multiple complications that inhibit the proofs of concepts (PoCs) to be seen as included and interconnected, bringing the human mind to not properly understand the full potentiality of the insights they have just discovered.

Lastly, data analytics must be implemented consistently inside the organization at high corporate level to generate business impact. This final step requires the commitment of capable leaders to drive these digital transformations in a flexible way by virtue of guiding principles and strategic recommendations to all the part of the organization.

To properly end this chapter, COVID 19 impact must be considered concurrently with Big Data Analytics. Pandemic has generated an exponentially amount of data which can help us to improve our understanding of Big Data management and the range of analytical tools that can be utilized to respond to events and risks. Covid 19, which has led to more than 26 million cases and 800'000 deaths, has required governments and firms to learn how to effectively answer to unprecedented challenges with data-driven methodologies. For instance, Henke, Puri and Saleh (2020) indicate that "organizations are standing up analytics capabilities in a matter of weeks to inform business responses to COVID-19 challenges and prepare for the future" and in a McKinsey's report suggest that these capabilities can offer approximately 13 $ trillion in annual economic value to organizations. Companies and researchers are still not able to reap the full potentiality of this exacerbated growing amount of data and so they need to improve methodological approaches to tackle new global issues such as COVID 19. The global pandemic has stimulated organizations to use real-time analytics tools to try to understand the effect of exogenous events on their activities and to develop guidelines and directives for more well-grounded decisions. Thus, Big Data Analytics imply the review of existing methods to address uncertainties and bottlenecks to best pursue innovation in how to address future global challenges. To deep dive into our daily world, firms can utilize big Data Analytic methodologies to take effective actions regarding unclear context such as selections of a

market for expansion, predicting unexpected challenges, identification of partners and development of innovative services.
Black swan events such as COVID-19 can also determine business failures (Amankwah-Amoah, Khan and Wood, 2020), and companies can use Big Data Analytics to manage external risks and limit collapses of business through forethought and forecasting.

Another big and revolutionary application of Big Data analytical tools concern the homeworking modality. In fact, managing employees and foster social interaction represent an enormous challenge for many organizations: "People Analytics" (Isson and Harriott, 2016; Leonardi and Contractor, 2018), a descriptive and diagnostic approach, will be used to make daily operations stable through the collection and analysis of data on employees' needs, home problems and workloads stress. Predictive analysis can be used to predict behavioral changes of employees caused by COVID 19 and therefore understand how to stagger the return to work. Specific tools linked with personal information and health condition of workers can provide a clear panoramic of the current situation and an understanding of how to redesign jobs toward home-based working creating conditions for motivating employees and manage effective behavior.

Chapter 2: Ecosystems

Organization Design

The design of organizations has traditionally been linked to the status of organizations as bounded and concentrated systems and they have been distinguished from their environments (other organizations, economy and society) on the basis of:

- Rules of inclusion (Members and non-members);
- Hierarchy and authority;
- Specific practices;
- Physical spaces and installations (Investments, Plants, offices and buildings).

Organizational designs such as the functional, divisional or matrix forms are primarily ways of arranging and managing internal relationships. Yet such designs are also safeguarding the boundaries of organizations and indirectly regulate relationships to the external environment. Organizational boundaries have always been closely linked to organizational design, explaining very well what is inside and what remains outside and how relationships to other actors in the environment are governed or managed.

The diffusion of connectivity services and software allow companies to redesign their environment towards a structure that shows less strict discrepancy between what is internal and what is external, making the boundaries of the company more blur.

Instead of bounded and concentrated forms, platforms and ecosystems are diffused or distributed organizations with multiple links to their environments.

So, if we consider the production and consumption side there are many dispersed participants to the ecosystems that interface with each other in a very complex framework. The participants to the ecosystems are inserted in various layers of importance, in fact not only the direct players have interests in the products/services, but there is a broad category behind them that shows conflictual and variegates interests and that influence the process of the entire value chain.

Ecosystems are linked also to consumer experience and to the conditions under which a core product is combined with complements (ex. Computers and hardware components or operating systems and apps). To allow people to freely combine elements that exist in the market, you need to establish standards in order to combine the items. Some of the ways such conditions are managed require the emergence or building of networks of

affiliated organizations we call Ecosystems or Platform-based Ecosystems that coordinate on the production and/or distribution stage.

Player's Expectations and different levels of Ecosystem

In literature, an ecosystem is a complex network of affiliated organizations whose resources, activities and outputs are linked in multilateral ways that cannot be reduced to the sum of bilateral connections between ecosystem participants, but show dependencies running across many participants and along several dimensions. Participants are linked together by several resources or product/service dependencies (component-complement relationships) that confer to them distinct advantages that would have otherwise not emerged. In the thesis, as shown in Figure 2.1, it is clearly showed the strategic reciprocal importance of Dronus and Here. Dronus, in fact, is responsible for the generation of data, that will be transferred to Here, in order to be examined, sized and cleaned to generate a cloud of points that will constitute a highly precise picture (photogrammetry) of the territory for automotive application.

As these two big players interact together (Micro Level), other actors, that are included in a bigger layer (Marco Level) of the ecosystems, enter the fields and shows interest in this connection.

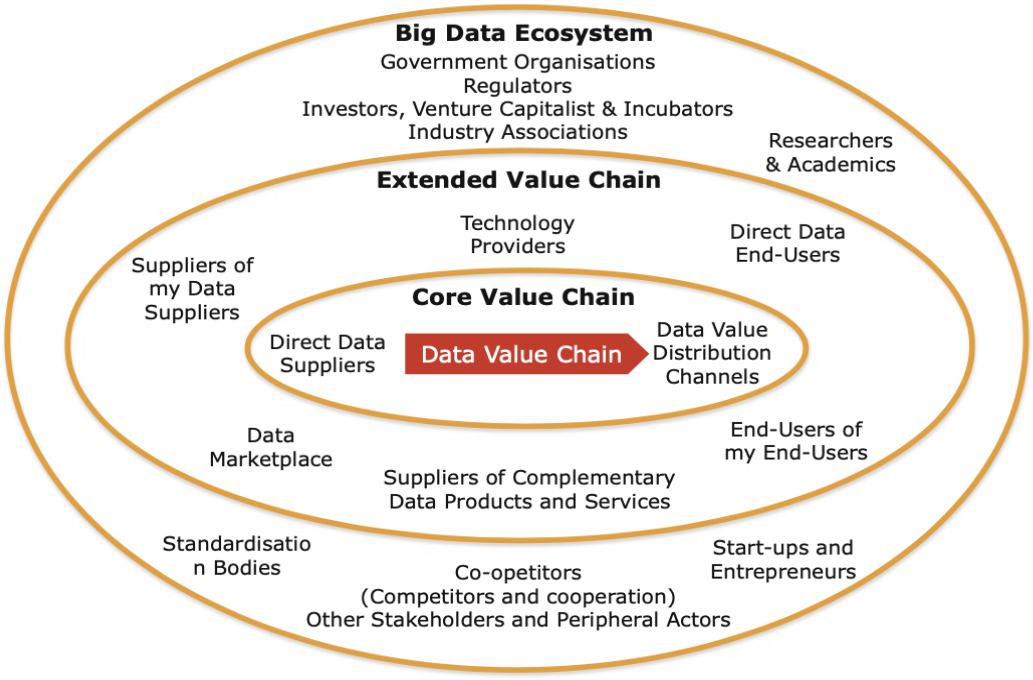


Figure 2.1

Cavanillas, Wahlster Editors, R 2016. New Horizons for a Data-Driven Economy. Springer Open: C3, P 35

Is now necessary to list what are these actors and try to understand what their expectations, responsibilities and strategies are to facilitate/challenge and support the initiatives in the ecosystems.

The biggest interest is represented at the Micro Level by the two players that generate the first and the more important interaction: the producer and the operator. The expectations of the producer/vendor are to succeed in the development and supply of data and to be able to sell them globally and make the technology be known worldwide. The interest of the operator/end-user is instead, to achieve attractive partners thanks to the innovative business model (ex. automotive brands) and to reach a broad acceptance and usage of service.

Another big category of players is represented by competitors/coopetitors. Since the business we will deep dive into is the fluid phase, where major breakthrough innovation creates a shock and this creative disruption moment is characterized by product innovation, it seems preparatory to mention dominant designs and why they are selected. Dominant design emerges after the era of ferment in which there is an initial period of turbulence in the market because all companies try to establish the standard dominant design and so they focus more on the product. After this period, we have the transition phase in which the dominant design emerges, and companies shift focus on low-cost production and process innovation. In the fluid phase there is a race through companies that are trying to obtain the dominant design to shape the technological trajectory of the future, influencing the characteristics of the standard of the product itself. Being the first mover then, shows some advantages and some disadvantages. In the first category, we can find brand loyalty, the preemption of scarce assets, the buyer switching costs and the reaping increasing return advantages. In the second category, we can find high R&D expenses, undeveloped supply and distribution channels, immature enabling technologies and complements and uncertainty of customer requirements. (Book Strategic Management of Technological Innovation)

The emergence of a dominant design is a very important moment, significantly affecting firms' strategies and performances. A dominant design also shapes future generations of

products/services in the category, resulting in “an architectural franchise” for winning firm potentially locking out competitors. That’s why it is so important that an organization is able to shape the technological trajectory succeeding over the other players. It is not necessary that the dominant design embodies superior technical performance; sometimes the technical configuration is driven by the accommodation of commercial interests between suppliers, users, and competitors. A dominant design permits the firms in the value net to shape further investments in product development efforts, to compete within the dominant design and to achieve both supply-side and demand-side efficiencies (Utterback 1994). As a result of the increase in the number of firms in the value net, we will observe greater revenue generation, providing both the financial and institutional pressure to establish a dominant design quickly (Wade 1995).

In the broader layer of the ecosystems there are Universities and Research Institutes, whose contributions is to acquire funding, create new ideas and train new potential talents, then Angel Investors, that seed investments (i.e., Seed Rounds) and provide advice for startups, Local Governments and State, who provide rules, regulations, policies and sometimes research funding and National Entities, like ENAC, that Certify the product/services or the process itself.

Complementary innovations, products, or services, who might belong to different industries and need not be bound by contractual arrangements—but have significant interdependence nonetheless, through standard, informal agreements.
It’s so important to understand that there are multiple types of complementarities, generic, unique and supermodular ones, but only the last one allows the formation of a true Ecosystem. Super-modular or Edgeworth complementarities often take the form of “more of A makes B more valuable” and possibly vice versa.
Ecosystems are groups of firms that must deal with either unique or super-modular complementarities that are non-generic, requiring the creation of a specific structure of relationships and alignment to create value.
Coordination often occurs indirectly through standards and interfaces and realized through sophisticated IT-based systems that are governed by modular architectures.
Understanding ecosystems requires a persistent pondering of how technology is involved in ecosystem formation through:

- Data management systems;
- Modular architectures;
- APIs (application programming interface) and boundary technologies through which different organizations exchange data and services;
- Data links;
- Data-based services.

All is based on the fact that they can transfer/link an enormous amount of data in the best way possible. Expand the idea of complementarity in the exchange of data on the basis on which the organizations are building their relationships and on which they interact.
In the current digital world, data are essential in the making of complementarities, they are steadily renewable, reconfigurable and expandable and they can continually be involved in the making of new services.

The impact that the ecosystem's formation and proliferation should have had is based on positive reactions and explained by the direct network effect. The value of data grows when more companies will use it for strategic and innovative purpose. The concept of network effects and positive externalities refers to the value or utility enhancement that a product or a service obtains for users or professional consumers, thanks to worldwide diffusion.

Data Ecosystem

Putting together the importance of data and the network of ecosystems, it seems appropriate to deep dive into data ecosystems. They are a collection of infrastructure/mobile sensors, analytics and applications used to capture and analyze data, that is intended to evolve over time. The first element is like the foundation of the data ecosystem. It is used to capture and store data that can be structured, unstructured or multi-structured. Analytics then serve as a front door through which teams access their data ecosystem house. They summarize data stored and tie pieces of information together, so all data is available in one place and in one format commonly understood. Lastly, applications are like walls and roof of the data ecosystem house. They are very important because they allow conversion to physical applications in various sectors and make the

data usable. A strong analytics capability is fundamental for Digital Transformation, because if organizations want to compete in the digital economy, they need to invest in multiple resources (tangible and intangible) including people, processes, technology of data and analytics (Carlsson 2017). These elements can lead to an increase in performance and thus create a competitive advantage for organizations (Grant 1991). Big data analytics capability can be recognized as the ability of a data actor to effectively use technology and talent to capture, store and analyze data, towards value creation, business change, and societal change.

A very important aspect is data governance, that is the extent to which data are managed in a structured and processed way. Companies need to establish clear data governance rules, by reporting internal guideline for how data can be captured, used and stored. Legislation (European Union's GDPR) is forcing organizations to be more transparent, but those who want to build trust within their customers should implement bigger measure to ensure safety and security.

A successful data ecosystem would "bring together data owners, data analytics companies, skilled data professionals, cloud service providers, companies from the user industries, venture capitalists, entrepreneurs, research institutes and universities" (DG Connect 2013).

What we want to demonstrate in this thesis is the importance to create a European Big Data Ecosystem thanks to the possibility to map potentially all Europe thanks to Dronus drone's highly precise photogrammetry ability. It will be feasible to define a shared vision of the European landscape so to implement new software that will be inserted in the autonomous vehicles, the new frontier of the automotive sector.

Digital Transformation and Sustainability model

In order to reach Digital Transformation two things are of massive importance:

- None of the actors involved in the ecosystem can be seen in isolation, instead we need to improve their interactions and interrelations that lead to knowledge, innovation, and value creation;

- Companies need to gain a deeper understanding of which capabilities need to be improved to exploit the potentiality of Big Data analytics.

Steps forward in Information and Communication Technology (ICT) are bringing 21st century's society into a digitalized world, where information and knowledge become readily available to more and more people every day. Digital and social media platform, digital devices and connected technologies are changing the way societies are designed and the interaction between participants. As a consequence of that, organizations are realizing that the data they are able to extract and the usage that they make is what will allow them to be ahead of the competition.

To create a business analytics ecosystem and a world of big data it is very important to implement a Digital Transformation process. The Digital Transformation and Sustainability (DTS) model is what allows this process, thanks to the conceptualization of Big Data and business analytics ecosystem through cooperation, coordination and collaboration.

In the 21st century's ecosystems, the advancement and development of business concepts have been led by the evolution of digital economy and its match with Big Data (George et al. 2014). It is critical to capture and analyze such data from multiple points of view, since all the actors of the ecosystem generate a tremendous amount of data all the time (es. while browsing the internet, using sensor networks, performing business transactions, etc.). These data are, in fact, of strategic importance in helping to shape the behavior, capabilities, and necessities of the actors involved.

To successfully implement Digital Transformation, there is a need to change the ways public and private organizations, as well as the other players, interact and collaborate in the ecosystem. Incorporating Big Data from modern technologies (es. Drones and software) with current low-grade technology services (es. Territory utilities and mapping) is a way to victoriously achieve Digital Transformation and implement sustainable societies (George et al. 2014). Based on their role, actors provide different kind of Big Data and business analytics, as resources, that can be transformed into assets that interconnect firms with users and foster cooperation and value co-creation (Xie et al. 2016). Complex technical and business challenges arise when there is the need to integrate public with private aspects and when there is the urge to address all the different

roles that each stakeholder must cover and that's why Big Data and Analytics can give support to the entire process (Chen et al. 2012). These actors share data and information with each other to successfully complete the Digital Transformation and create connected societies. The birth of such ecosystems allows them to collaborate, cooperate, and compete towards the creation of a new landscape of business for governments and entrepreneurial innovator companies that will address people's needs in a more specific and personalized way, thanks to innovative digital data-based designs.

In conclusion, as shown in Figure 2.2, an ecosystem in which Big Data is transferred openly with blur boundaries will empower lives of individuals, allowing them to choose what to share and to decide to be more proactive in the ecosystem in a sustainable way, knowing what's behind data. The proliferation of big data and business analytics ecosystems has the potential to transform theory and practice in IS, management, technology, and innovation thanks to Digital Transformation.

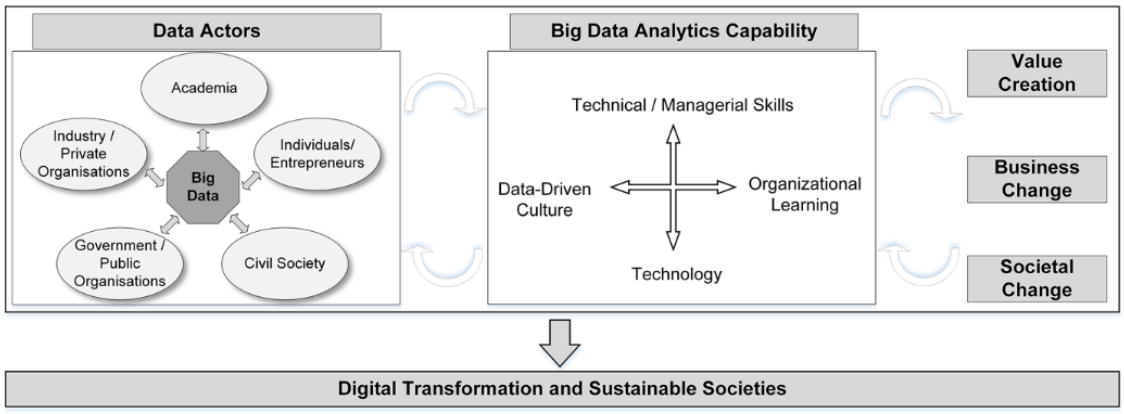


Figure 2.2

Source: Pappas, Mikalef, Giannakos, Krogstie, R 2019. Big Data and Business Analytics Ecosystems: Paving the way towards digital transformation and sustainable societies. ResearchGate

Chapter 3: Empirical context

Drones connotations

The drones' market is anticipated to grow significantly because of its growing use for commercial and professional purposes. Companies are utilizing drone-acquired data in their business operations to accelerate their service delivery and to expand the universe of possible applications. Progressions in-flight controls and technology in addition to innovations in portable video & photography technology have augmented the demand for drones including tiltrotors, multi-copters, and helicopters. The evolution of innovative technologies, such as geo-fencing and collision avoidance that make drones safer has triggered increased adoption of drones in several industries. Through all, the thesis I will follow an experimental approach in order to study and elaborate on the main application of drones, focusing on the automotive industry.

The drone's scenario is complex and variegated. There are different kind of drones, based on the weight and on the roles that the aircraft covers.
They are divided into three categories based on weight standards: less than 30 kg, in between 30 and 150 kg and more than 150 kg.
In the first category there are five primary types of drones:

- Model aircraft (radio-controlled helicopters), which are a special category of drones, because they need precise mechanical configuration to be reckoned as flying objects (they must have an autopilot and an electronic board with GPS integrated). Moreover, they don't need insurance for critical or non-critical operation;
- Consumer drones (used in creative and recreational ways), that are for consumers market and are usually used "simply" to make small shots from above (most, in fact, are drones with cameras) or as entertainment. In various events, fairs, conferences, they are also used to entertain the public, letting people try and guide these small objects, often even challenging each other in some skill competitions. They can also carry packages and objects, sometimes even of considerable size and weight, unlike non-commercial drones which, as mentioned, are used more for play and entertainment than for professional activities;

- Professional consumer drones (advanced drones utilized for professional measurements), that are usually larger in size than consumer drones, have more advanced technological features and capabilities, have longer battery life, stay in flight longer, and can take longer trips than non-commercial drones. Just as an example, here are some of the professional drones:
    - DJI Mavic 2, a drone able to withstand winds of force five particularly appreciated by photographers and video makers; is a drone that integrates cameras that use DJI's latest 3-axis gimbal technology, with 1080p transmission at a maximum distance of 8km. The battery lasts for 30-31 minutes;
    - DJI Mavic Pro is another professional drone from DJI with professional grade 4K video capture and 12MP still shots. It is equipped with "intelligent" flight modes such as ActiveTrack, TapFly and Gesture mode not only to make the flight more "fluid" but also to allow the pilot greater control;
    - MUVISTAR 1000 is a professional (high-end) drone for video and aerial photo shooting with 3-axis universal gimbal and large cameras up to 3Kg in weight (such as Canon 5D, Nikon D800, Sony Alpha, and Blackmagic). It is a 1m diameter full carbon 8-motor SAPR drone; the drone is also equipped with a black box with flight log + GPS data;
    - H2O waterproof drone, is a professional drone equipped with an IP67 body, that is, water resistant; it can therefore fly in the rain and is also able to land and take off from the water without any problem thanks to the floating structure. It has a flight range of 20 minutes and can carry up to 1kg of cargo over its own weight. The drone is equipped with a 2-axis gimbal system (also waterproof) that allows you to charge a small camera (a waterproof GoPro or with a water-resistant case);
    - X-Cam 700UV, a drone designed for precision agriculture, is an aircraft built in carbon fiber and equipped with folding arms for transport and retractable landing gear; it has a flight range of 30 minutes and a maximum payload of 4kg; this drone ensures georeferenced images at very high pixel / cm resolution thanks to the dedicated control electronics with GPS /

Glonnass and the performance of the Parrot Sequoia Multispectral camera supplied which provides very high resolution images and video footage;

- Explorer 1000 IR is a "super" professional drone designed for applications related to security, in particular for aerial video surveillance or for the search for missing persons in case of disasters, accidents, natural disasters; the drone is able to fly in the rain, with a range of up to 20km thanks to a long autonomy (up to 70 minutes). The drone has a modular carbon structure, reaches a speed of 60 Km / h and a maximum altitude of 4000mt, it can carry up to 3 kg of weight and is equipped with an HD camera with encrypted transmission of video and data;

- Tactical drones, called tactical because the firm that manufactures and distribute them needs an organizational structure similar to an Aviation organization, equipped with the ISO 9001:2015 Certification for Quality Management System (QMS) that demonstrate firm's ability to consistently provide services that meet customers and regulatory requirements and to demonstrate continuous improvement. These kinds of organizations are developed almost at Aviation level, after having controlled all technological aspects. Tactical drones are sold to the so-called "blue lights" (fire brigade, police) who take care of safety in the area, and military forces. The Wireless Sensor Network is required to have a Data Link Layer, that is a security element which guarantees a reliable communication link between neighbouring nodes by controlling the medium access and handling the errors;
- Autonomous drones, that work in a drone-in-a-box system, deploy autonomously from a box that also functions as a landing pad and charging base. After carrying out a pre-programmed list of instructions, they return to their "base" to charge and/or upload information. Traditional drones (UAVs) instead, consist of both a non-manned aircraft and some form of ground-based controller. The flight of UAVs may operate with various levels of autonomy: either under remote control by a human operator or autonomously by onboard computers (autopilot). The pilot of this kind of drones needs a specific certificate/license to fly given by ENAC for System Remote Control aircraft (SAPR). It is not possible to use a professional drone without the presence of an SAPR operator. A SAPR operator is the person

who assumes all the responsibilities and risks of using a professional drone. In order to be recognized as an operator, a person must have several certifications:

- the APR pilot certificate,
- the permit to fly,
- ENAC authorization for non-critical, critical or specialized operations.

Moreover, SAPR operator must respect both the navigation code and the ENAC Aircraft and Remote Pilot Regulation.

Remembering that an operator can also be a pilot, a SAPR Operator:

- asks for authorizations from ENAC, such as the reservation of airspace;
- communicates with entities, municipalities, individuals, companies or authorities to obtain authorizations to carry out specialized operations with drones in certain spaces;
- hires any pilots who support him in specialized or professional operations;
- answers for all risks and responsibilities associated with the use of a professional drone;
- provides services to customers.

The second vast category is defined by drones that weigh from 30 to 150 kg. They are almost airplanes, so the regulatory framework is inspired by Aviation level firms, but the normative aspects are not well disciplined.

The last category contains drones over 150 kg. These kinds of drones are disciplined by EU Regulations 2019/947 and 2019/945 from ESEA. The certifications required to fly your drone will depend on the risk level of the specific mission, which will be evaluated with a specific analysis.

Dronus

But how was Dronus born?

Dronus is an innovative startup focused on unmanned aircraft systems, that was established in 2018 from the idea of Marco Ballerini, aerospace engineer, who has always

had a passion for drones and has always believed that the high reliability of autonomous drones that carry out inspections and missions autonomously and repetitively, could have had enormous application in almost all the existing industrial sectors.

Afterwards, he realized that a conventional structure for drones and for "Return to Home" practices did not give the reliability that was expected. Conventional landing downwards could guarantee around 90% probability to return to the base. To be more specific, the drone in the landing downward phase must be centred with the base and must be able to position the battery in the correct position for charging.

Here comes the genius… Dronus has designed a base box, as shown in Figure 3.1, to which the drone hooks upwards, eliminating the instability of landing and the uncomfortable moments in which adverse weather condition force you to deploy high quantitative of energy to counter the wind and makes the drone go up and down in search of the correct position to land downwards.

Figure 3.1

Source: https://dronus.com/il-sistema-nest250/#k250 consulted 18/02/2021

As we know, a startup demands more than a great idea; it demands time, discipline, dedication and most importantly funding. Here Giulio Segurini, co-Founder and aerospace engineer, comes in. He has taken and is taking care of the "Seed Rounds", from the pre-seed funding, to the seed funding, that is divided into multiple rounds in which

venture capitals demonstrate their interest in financing the company. Dronus has demonstrated to be very attractive for investors and has already achieved a considerable amount of capitals. In fact, was transformed in SpA in April 2019 after a 1° investment with the support of a Brokerage Firm listed on the AIM market of the Italian Stock Exchange. In November 2020 Dronus SpA acquired Siralab Robotics, one of the leading Italian companies in the production of light drones.

Giulio Segurini, following his ideas, has understood a first kind of application of this new category of drones, by talking to Terna, operator of the Italian high voltage transmission network, leader in the transformation of the electricity market towards eco-compatible sources, that it was possible to use the drone to monitor and control all the high voltage Italian network. This can have a massive application because the drone can fly over infinite distances thanks to the Nests (Return to Home boxes) that can be installed in the Terna pylons, creating a network of autonomous drones that can go on mission for a long period of time.

Biella

To continue to expand the universe of possible applications of this new category of drones, Dronus has thought about something really impressive that will change the landscape of the automotive sectors, as well as other subsequent sectors. For the first time in history, thanks to the authorization of ENAC/ESEA, Dronus will fly over an urban area reconstructing the territory and all its features with high precision, getting to map all the characteristics of the city, from the ring roads, to the historical center, to the porphyry, to the conformation of the pavement, to the urban planning of roads, to roundabouts, to overpasses and to all the road signs. The choice of Biella shown in Figure 3.1) as the city in which to implement the project has been guided by the fact that this city has all the characteristic of a big city but in a collected environment, with a friendly administration that proved itself as available to give consensus to a project that will improve the safety, the legality and the mapping of the territory.

Figure 3.1

Source: Dronus Radon_Biella ConOps, company presentation, consulted 16.02.2021

BVLOS	yes
VLOS	no
NOTAM	yes
Observers	no

Urban area	yes
Automatic	yes
Manual	no
Night	no

Who is Here and what are its expectations?

This section, which continues in chapter 7, contains the story of Here, a multinational company owned by major car manufacturers and more, and its expectations from this project, and an interview format will be used. For the success of this format, I had the pleasure of interviewing Alessandro Zullo, head of the Italian market for the IT part who

joined Here reality in 2018. From here on, a series of questions will follow carried out with the subsequent responses of Doctor Zullo.

Who is Here?

"Here Technologies was born in 1985 with the name of Navteq, the first startup in the world that deals with the creation of digital cartographic maps. Navteq, from its beginnings, had acquired the image through cars that mount cameras on them. Slowly they become Lidars, a methodology for measuring distances by illuminating the target with laser light and subsequently measure the time the reflection takes to return to the sensor. This methodology had attracted multiple multinational companies, which had tried to enter the business, one of them is Google, whose cars are now famous; but we must underline that Navteq was the first to map the Northern and Southern hemisphere thanks to sensors on cars, which now are about 400 globally (of which 1 in Rome and 3 in Turin / Milan in Italy). These cars acquire the road infrastructure with a cloud of points that reaches the definition of the centimetre with cameras mounted on the roof and a laser scanner.

From 1985 onwards, Here has had great developments in history, and it was the first cartographic system put on navigation systems and we remain a leader in car navigation (4 out of 5 cars mount Here), but also on the part relating to active and passive safety solutions like brake systems and lights; these cars already mount maps in order to prepare the vehicle for certain difficult situations such as curves, roundabouts or other. Near a curve eg. a Lamborghini thanks to the GPS signal (therefore not for the navigator but thanks to the control unit itself), recognizes that it is in that position thanks to the preloaded and updated maps via OTA and the car prepares the engine and braking systems to face the curve based on the speed with which the driver wants to deal with it.

In 2012 Navteq was acquired by Nokia, the leading company in the field of mobile telephony of the time, and this company, called Nokia Maps, was created. Nokia was the first mobile to include maps for navigation so that people can reach a certain destination with their devices.

In 2013 the company became Here Maps and in 2015 it was acquired by the consortium formed by Audi, BMW, Daimler, Bosch and Continental which for the first time come

together because they look to the future of autonomous driving to fight the possibility of Google investment and try to arrive on time with a system that is useful for the implementation of autonomous driving. In this year a new CEO has been placed in charge and the DNA of the original digital cartography company has been abandoned, to become a leading Platform company in the creation of digital information in the world with the prospect that this information can be Real Time, updated every minute and On-demand. The Mission embodies the concept that if there is an obstacle in the road, the map changes at that point and the following vehicles will know that the situation has changed and will therefore be informed in real time.

So, the project with Dronus stems from the desire to combine the technological advancement of aircraft and the increasing speed of collecting data.

In 2022, Mitsubishi Corporation and AT&T also became owners of stakes."

Dronus Drone

Dronus will utilize a drone, called RADON (Figure 3.2), that obtained, after 1 year of processes, from the National Civil Aviation Authority (ENAC) the "project certification pursuant to art. 10.6 of the Sapr regulation" for the sr-sf6c system.

The certification presupposes a primary command and control system whose software complies with the aeronautical standards referred to in the Eurocae Ed-12 specification at least at the level of design reliability D. With this certification Dronus becomes a national reference point that presides over a nascent highly professionalized market that requires the highest standards and requirements of reliability and safety. Dronus qualify itself as the reference production operator for the "safety" sectors (safety of environments and workers, industrial inspections, inspections and surveys of industrial and energy production plants) and "security" (safety of citizens, in urban and suburban areas for specialized companies and law enforcement or prevention forces").

Figure 3.2

Source: Dronus Radon_Biella ConOps, company presentation, consulted 26.02.2021

Without this certification, nothing can fly over an urban area, unless it weighs less than 250 grams. This is because you need to guarantee that the software is bug free (don't forget the accident that happened to Boeing) and an adequate level of security and safety: to enter in detail you must have a system of flight termination, a parachute or a system of immediate arrest and an autopilot software with DO178 Certification (to explain it better this is the same procedure that follows an airline airplane).

So, the 10.6 Certification certifies that your drone has all the requirements to fly over urban areas. This is the result of an intrusive Risk Assessment, a procedure that is based on:

- Safety Hazard Identification: Identification of hazards and risk factors that have the potential to cause harm (hazard identification);
- Safety Risk Assessment: Analysis and evaluation of the risk associated with that hazard (risk analysis, and risk evaluation);
- Safety Risk Mitigation: Determination of appropriate ways to eliminate the hazard or control the risk when the hazard cannot be eliminated (risk control);

- Safety Documentation: Not only the results but also the whole UAS safety risk assessment process should be documented to ensure a continuous safety assurance.

The drone flight safety is the optimal state in which drone operations executed in certain circumstances can be controlled with acceptable operational risk.
The UAS safety risk assessment, based on a systematic approach from safety hazard identification to risk management, ensures the maintenance of the required safety standards for drone operations. The risk is calculated with a matrix in which we find the safety risk probability and the safety risk severity in order to create a Safety Risk Index (SRI). Then, from the SRI the assessor defines corrective and preventive actions.
When the drone flies there are multiple risks associated with the missions, so to say: High loss of altitude, Loss of control, Loss of transmission, Collision with manned, unmanned aircraft or buildings, power lines, Partial failure or loss of navigation systems, Severe weather or climatic events, Existence of corrosion, Pilot unfamiliar with the area, Rotor failures and Take-off and landing incidents as under- shooting or overrunning.

The market of drones, their characteristics and applications

In 2024, the global drone-related industry is estimated to be worth over $ 43 billion, having already generated $ 14.1 billion in 2018. This specific market will grow at a CAGR (compound annual growth rate) of 20.5 % to almost triple its value in 2024.

Drones are divided into different families according to their physical characteristics (hardware), in particular they are classified according to these three distinctions:

- With Pale Structure: These are drones equipped with motors and blades, which are intended to offer a stable flight that can be controlled by means of the appropriate remote control, which must have frequencies that are not harmful to a person's health. Drones equipped with a blade motor are called a helicopter if there is only one set of rotor blades. If the drones equipped with motor and blades have more than one set of blades, then we will have other types of drones, to be precise: tricopter if these are three, quadcopter in the case of four sets of blades,

pentacopter if these are five, hexacopter for a drone with six sets of blades and finally an octacopter if you reach the maximum number of blades present in the same drone, i.e., eight.

- With Planar Structure: There are also bladeless drones which are designed to glide: in this case the propellers are absent which are carefully replaced by two large wings;
- With Hybrid Structure: Finally, there are hybrid versions, i.e. drones equipped with both systems (engine and wings) but also drones that integrate flight with ground movement and which can therefore be used thanks to wheels (these are drones that are used for more professional purposes).

Drones are also technically known as remotely piloted aircraft systems (APR) and unmanned aircraft (VSP or UAS - unmanned aircraft systems). A technology that, by now, is experiencing a real boom on a global scale, which goes far beyond the use for playful purposes by children.

From a technical point of view, they integrate different technological components, from sensors (for example accelerometers, gyroscopes, compass and in professional drones, we also find GPS), to the components of the engines themselves (es. ESC systems to control the rotation speed), up to radio receivers, cameras, video cameras and robotic arms.

Depending on the type of drone (consumer or professional) and, of course, the price range, there are drones with different types of built-in camera/video camera. Therefore, it is good to take into account:

- the type of camera installed by checking the resolution of photos and videos that it is capable of producing (VGA, HD, Full HD, 4K, etc.);
- the type of camera stabilization (to mitigate vibrations and make the image still);

Professional drones are often equipped with an advanced stabilization system called Gimbal (it keeps the camera still on its axis, so the images are still without smudging or interference from vibration or instability of the drone in flight).

This is useful for highly precise professional applications in agriculture, video surveillance, environmental monitoring, rescue in the event of disasters, accidents, calamities etc.

Another category of very interesting drones is the Parrot professional drones that are designed for commercial/professional use and have different characteristics depending on the use to be made of them. There are on the market:

- Parrot drones for agriculture, for the inspection and analysis of crops, including large ones;
- Parrot drones for construction and for the real estate sector, used for visual and thermal inspection, inspection of buildings and homes, 3D modelling for taking the necessary measures to make any estimates but also for the 3D modelling necessary for supervision of a construction site;
- Parrot drones for public safety: search and rescue of people, investigation of crime or accident scenes, recognition of sites, location of fires or other natural disasters and so on.

Current Application of drones

Drones are an extremely serious business and are having a real impact on several economic sectors and will have even more in the near future, far beyond the possible application that we briefly are now discussing. Just think, for example, of agriculture: through the use of drones equipped with particular sensors, it is now possible to monitor farm crops in an optimal manner. Drones, suitably equipped with thermal and multi-spectral cameras, can in fact collect data capable of informing about the onset of pathogenic attacks and early detection of stressful situations. Similarly, in an extremely delicate sector such as that of the protection of natural heritage, unmanned aircraft can be extremely useful for carrying out research activities for missing and preventing forest fires, as well as for monitoring extinguishing operations when the fire is in progress. In the energy sector, drones are already used to inspect power lines and monitor photovoltaic and wind power plants, but also gas and oil pipelines. In the medical-health field, drones are often used to deliver medicines and medical material to war zones, where there have been disastrous natural disasters and, in all cases, where it is necessary to set up field hospitals.

These radio-controlled flying objects, nowadays, are exploited for various purposes, such as for professional use. In this case, we are talking about radio-controlled airplanes that are used to make videos shot from above: on certain occasions these types of articles are used to create aerial video footage to evaluate a particular terrain and to create increasingly detailed maps while, in other circumstances, the same drones are exploited to be able to carry out aerial shots such as wedding videos and others, which are carried out by professionals in the sector who have decided to exploit this kind of tool to carry out this type of work.

But also, in the military field, drones are exploited for aerial shots that are carried out on the territory where the police must intervene, and which represents the mission they must carry out.

Nowadays there is also talk of drones that allow you to drop bombs in certain war zones, which allows you to get a great advantage over enemy troops.

In addition to the war purpose, drones are used, for now in America and on eastern soil, to deliver the various packages. Amazon Prime has in fact decided to exploit one of the uses of drones that are less exploited: by using the mechanical arm, or rather the drone hook, the leading company of the web has well thought of making its deliveries more rapid, so much so that once the purchase is made, the product is delivered during the same day, using the remote control of the drone to make it reach the customer's destination.

Furthermore, drones, today, are also used to search for missing persons: thanks to the streaming of images, it will be possible to view images in high definition and understand if, in a certain area, there are people missing, due to accidents, or if they must be sought in other areas.

Obviously, it is also good to underline how the purpose of the drone is also to make the owner spend time in total fun, who can take different shots or pilot it and learn how to use it for personal purposes.

Of a completely different type, but no less important, is the use of drones in the world of cinema and television. Before their advent, filming had to be done from a plane or helicopter, making filming very expensive. Now that they are available at a more than

affordable price, many photographers and videographers can shoot overhead shots without a big budget.
Therefore, the meaning of drone assumes completely different traits depending on the type of use that is made today of the same article, which can be exploited in different areas all different from each other.

The advantages of using drones for data capture are multiple and demonstrate how these UAVs are flexible tools enabling project teams to gather and collect large volumes of highly accurate information in a safer way.
Drones:

- improve safety, they can be used to inspect and survey these environments remotely in a far safer and lowered risk capacity;
- improve accessibility, they are generally allowed to fly between 0 to 120 m above the ground, enabling them to capture information and imagery closer and with higher resolution;
- allow real-time progress monitoring project, teams can now conduct more frequent data capture and progress monitoring of construction and installations for a greater portion of the project;
- legality, flying drones legally and safely requires operators have the necessary experience, training, licenses, certifications and insurance, just as is the case with the operation of other aircraft.

As drones have multiple advantages, they face also some challenges, that are given by the restrictions enforced by regulation (operators must undergo training and hold an appropriate license, drone pilots are only allowed to fly aircraft in specific areas, which are mostly away from high traffic airspace locations), a reliance on a good flying condition (there must be an appropriate and safe condition of wind, rain or limited visibility) and data privacy (cameras capture high-resolution images and there may be instances where identifiable information that is not included within the scope of a project are captured).

Building Information modelling (BIM)

The use of drones can however go much further: they can, indeed, seamlessly integrate within BIM processes, increasing efficiency levels throughout the entire life cycle of buildings.

BIM (Building Information Modelling) is a digital tool disrupting the construction industry as a platform for central integrated design, modelling, asset planning running and cooperation. It provides all stakeholders with a digital representation of a building's characteristics in its whole life cycle and thereby holds out the promise of large efficiency gains. One particular area where standardization on BIM is needed is the exchange of information between software applications used in the construction industry. The leading organization in this domain is buildingSMART which has developed and maintains Industry Foundation Classes (IFCs) as a neutral and open specification for BIM data model. Although BIM was originally devised for buildings the benefits such as less rework, fewer errors, enhanced collaboration, and design data that can ultimately be used to support operations, maintenance, and asset management made it an attractive option also for infrastructure projects. As geographic information system (GIS) is a key element in any infrastructure project there is the need to integrate BIM and GIS. Both technologies use standard and open data formats, but they are different and presently there is no direct translation.

BIM is seen as an essential data source for built environments by GIS users. GIS is seen as a crucial data source for design and integration of new BIM models in a spatial context. Thus, drones can drive and give help through all the process. In the design phase drones are used for surveying the morphology of the land, for existing buildings (including those of historical and artistic interest), or for surveying built-up areas. The drone site survey is based on the key concepts of photogrammetry: it starts with a series of photos taken that are then processed by special software with technologies called SfM (Structure from Motion), or definition of 3D geometry starting from the movement when you take pictures. The result is a cloud of points that can be further processed to create three-dimensional mesh models. These models then form the basis for generating the BIM model.

The large amount of data collected can be used to plan construction activities, thus generating a new and interesting connection between drones, BIM and urban planning.
In the operation phase drones can be used to monitor/control the evolution and status of the construction site during operations. This is necessary to verify the real correspondence between project and construction, in fact, the photos and videos obtained from drones can be uploaded on BIM collaboration platforms, where they are automatically shared among all the actors involved, based on the degree of authority they have.
As shown in Figure 3.3, is interesting to see what is the process of creation of the Building Information Modeling, that from Conceptual Design, Analysis and Documentation, arrive at the Fabrication and effective Construction of the artifact on which the attention is posed.
Through all the life of the building Drones represent ideal tools in this phase for performing inspections of parts of the building that are difficult to reach in total safety.
In the dismantling phase instead, drones can be used to monitor disassembly, demolition and restoration phases of buildings that have reached the end of their life cycle. The in-depth knowledge of a building also enables stakeholders to identify any elements that could be recovered, or any particular material that needs to be disposed of with greater care (special waste, dangerous substances, asbestos etc.).

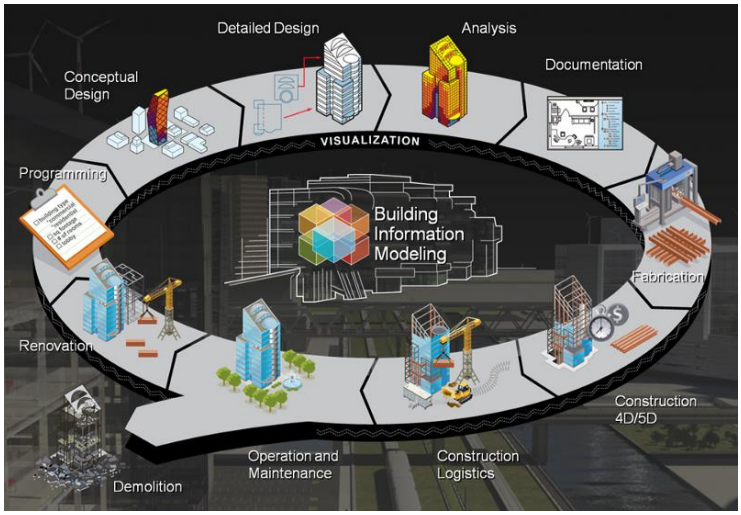


Figure 3.3

Source: https://www.h-b.it/it/societa/prestazioni/progettazione-di-strutture-portanti/bim-building-information-modelling/ consulted 12.02.2021

Geographic Information System

The Geographic Information System (GIS) (also called geographic information system or territorial information system) is a computerized information system allowing the acquisition, recording, study, design, sharing and show of information from geographic data (geo- referred). Thus, it can associate data with their geographical position on the earth's ground and process them to extract useful information.

Before, the Geographic Information System (GIS) was used after having taken photos from airplanes and satellites for professional purposes, but now drones are increasingly used to make surveys thanks to higher precision and fewer costs. It has become very important and effective to use drones for GIS and to create accurate maps. To apply this concept to our further disclosure is required to deeply understand the potentiality that these data will acquire for a multitude of players in almost all the business categories and public entities (for es. the municipality at issue will be able to extrapolate detailed maps of roof, buildings, streets, cement, eternity, so to say the state of the art of the whole city; thus, being able to have a rigid control on all the municipal oddities).

There are multiple types of applications of this new concept, so for ex. a quarry owner can know how many trucks he needs to move the material thanks to a drone that is able to understand the exact volume of the sand collected. Caspri, an American company, has been able through this certified process of analysis, to get a credit line from the bank. The innovative advances that we briefly show in this chapter will have a tremendous effect on logistics planning and information and therefore they will generate an increasing economic impact thanks to continuous process innovation in disparate sectors.

Chapter 4: Technical description

Technical definitions

To correctly understand the finding and the scope of the following chapters, it seems appropriate to try to deep dive into the main concept that will be addressed during the elaboration of technical aspects. The magnitude of the impact that the data, generated by the drone's flight, will have on the market, will depend on the ability of the company and their developing division, to correctly implement models able to shape the terrain in ways never experienced before.

But what is meant by "shape the terrain"? The answer stands in different modelling that we will now explain. Let start our analysis with the Digital Surface Model (DSM) and the Digital Terrain Model (DTM).

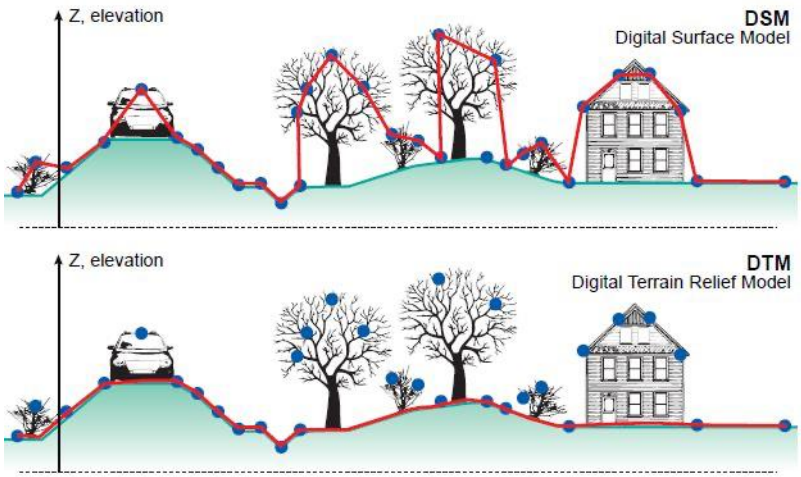


Figure 4.1

Source: https://3dmetrica.it/dtm-dsm-dem/ consulted 12.02.2021

The image shown in Figure 4.1, is used for purpose of visible representation and it is explicative of the models.

Digital Surface Model and Digital Terrain Model

For Digital Surface Model (DSM) we mean the earth's surface comprehensive of the objects (buildings, trees and other artifacts) that are on it. To generate high resolution of the representation required with inserted buildings, trees separation and urbane drainage elements, DSM is only one of the best ways to do it.
An important aspect to be understood is the "Surface characterization". LIDAR data, as we will explain better below, helps to generate a digital surface model (DSM) and to detect automatically object such as streets, parking place, grassland, bare soil etc., that are not required for the chosen representation. After the detection each of the elements will be marked with a unique surface property in terms of rainfall-runoff and surface flow. For purpose of better understanding, let's say that a stormwater falling on the trees; it will have an interception period before touching the surface, or let's say that the rain is falling on the street; it will start the runoff going inside manholes whereas rainfall on the grassland will start infiltration.

The Digital Terrain Model (DTM) represents the trend of the soil surface without anthropogenic and vegetational elements (bare earth).
It is possible to obtain a DTM with an aerial photogrammetric survey if the terrain is not very thick in vegetation, so you can filter the cloud of point in order to have only information about the terrain. DTM and DSM can be obtained from a Light Detection and Ranging (LiDAR) survey, on the condition that the tools used in the measurements can track the different pulses coming from the laser beams reflected by encountered one. The first impulse (first return) defines the DSM, the last impulse (last return) the DTM. If the laser scanner record only the first impulse, engineers are able, with practical measures during the survey, to obtain a DTM.

Photogrammetry and LiDAR

You would ask yourself what aerial photogrammetry is and what is LiDAR.
Photogrammetry is the science of making measurements from photographs. The input to photogrammetry is photographs, and the output is most of the times a map, a measurement, or a 3D model showing real object or entire aggregate of constructs. Most

of the maps we use today are a result of photogrammetry taken from aircraft and drones. Photogrammetry can be classified in two ways depending on the field based: Aerial, and Terrestrial (or Close-Range) Photogrammetry. The first category is most of the times done by drones and UAVs; they generate photos that are not processed in a stereo-plotted or thanks to automated desktop systems. In the second category, the output is not a topographic product but instead, directly a map, a point cloud or a 3D model that feature stockpiles, buildings, trees and all kind of artifacts.

Lidar is a remote sensing method used to examine the earth's surface. It uses light in the form of pulsed laser to measure variable distances on earth. These light pulses are able to generate 3D data about the shape of the surface and its characteristics.

Lidar systems enable scientists to analyze natural and artificial environments with exactitude, accuracy and agility of usage. National Oceanic and atmospheric Administration (NOAA) researchers are using LiDAR to generate more precise shoreline maps, make digital models used in Geographic Information Systems (GIS), to help during emergency transactions and in many other ways.

Thus, the base of the DTM is the topographic map, that is a tool used to transform and analyze the geographical information of a region which give in return a comprehensive image of the real world. Staying comfortable in your home, a person can view the map of a region of interest and study its natural, economic and terrain environment. In fact, thanks to the information provided by the map, analyst infer and extrapolate information not directly displayed on the map. These kinds of data have been traditionally acquired through field survey, thanks to measurement of horizontal and vertical positions. The result is typically a contour map that is able to generate a Digital Elevation Model (DEM, that is a "bare" land surface model, free of trees, buildings or other "nonground" objects) through time-consuming high-cost digitization processes.

In many GIS projects the use of DTM data to practice analytical functions and to represent geographical functions that are able to extract geomorphological parameters and features, has nowadays become common practice. If we think about the future, we can expect that the Digital Elevation Mode (DEM) will progress in reaching more rapid and cheaper acquisition of high-resolution data, in more advanced extraction methods and algorithms and faster visualization of hardware and software to allow conscious decision-making.

Ground Control Points

The Ground Control Points (GCP) are the points in the space on which we rely on to link the photogrammetric survey to the correct dimension and direction. In this way, the images taken by the drone can have importance and certainty in a geometric view and at the end, they can be measurable.

But how are they discovered?

In the operational reality, the GPCs can be viewed thanks to the chromatic contrast markers (highly recognizable objects). They can be of different materials, from synthetic fabrics to rigid panels, that are anchored to the ground, due to the necessity of maintaining the perfect position for all the survey. Thanks to a strong chromatic contrast, we are able to precisely identify points within them (the image that we have is alike the squares of a chessboard and that's why is possible to find discrepancies between black and white shapes). The task of the operator is to put them on the ground, facing upwards; he needs to be careful to place the markers in a visible area that must be visible from above.

Therefore, once the GCP grid is ready is useful to make a final check to control that no error has been performed. This check can be done with Quality Control Points (QCPs), that must be arranged in an arbitrary way to be able to go into the software and see if errors have been found. Thanks to special tools (total station, GPS rod etc.,) the markers will detect the coordinates of the GCP control point in a very accurate way.

So, you need to take all the points and geo-reference them according to GCP that is connected to GPS and thus to constellations. The revolutionary aspect of GCP is that with GIS organizations had a high error in terms of two or three meters, while with drones the precision of X and Y axes arrives under 3 centimetres and Z axe (longitude) under 5 centimetres.

Then, on the basis of the GCPs it is possible to give geometric reference to the photogrammetric survey done by the drone (in Chapter 6 we will see how Dronus Drone will be able to create the GCP) . Generally, the quantity of GCP can go from ten to twenty points depending on the availability of the area to put them in a sparse manner as far as possible. When the data are imported, the coordinates of the GCPs are given thanks to the alignment of the photos taken by the drone. Thus, thanks to the acquisition of that frames

in the software, we are able to generate a 3D Model, based on the size, the GSD and the height of the flight.

But to arrive to have a geometric measurable model we need a final link between the raster data and the vector data, so to say, between images and geometric model; this connection will be made thanks to the coordinates of GCPs that will allow the model to be translated, scaled to reality and turned. As a result of the process Here, will be able to do feature extraction, that is a process by which an initial set of raw input data is reduced to more manageable groups for processing, so is the process where the features that are most valuable for strategic purpose and desired predictions of output, are manually or automatically, thanks to Machine Learning and Artificial Intelligence, selected. To put it in practical terms, the organization will be able to perfectly understand and trace where, in the interested space, there is a sidewalk, a light pole, a crosswalk, a traffic light or a signal, thanks to an orthophoto paper that is the sum of all the photos when put one in front of the other (i.e., orthorectification). This process will be of extreme importance in order to be able to generate an integrated software containing all the information required for the circulation of the autonomous vehicle.

Without the Ground Control Points we would have only a labile model that consists of a fixed figure "swimming" in the space, but not anchored to the ground.

Technical planning for Biella flight

Dronus will comply with the creation of all the processes and photogrammetric survey thanks to two types of planning, which are the legislative, which will be briefly described in this chapter and then expanded in the authorization landscape one, and the technical one.

Technical planning is a very complex matter, which needs to take into account multiple aspects and variables that can incur suddenly or that can be planned in advance. It must deal with a correct and precise definition of the log flight data, which are the one that contains all the useful information on what will happen from when the drone's battery will be switched on, till the shutdown and they can have various format depending on the use to be made of it, so to say, they can be in .TXT (binary file), in .CSV (Litchi application that can be converted in Excel format for the individuation of interesting elements and the visualization of the coordinates of latitude and longitude of all the

survey), .DAT and more. Thanks to reverse engineering, is possible for Dronus, to make a detailed analysis of the flight log files in order to understand the functioning of the evidence collected. For example, a .DAT file starts to be registered when the battery is switched on and it will indicate the date and timing of the flight that comes from the remote control. These special files need to be supported by an external application in order to be scanned and analyzed, for example Airdata UAV which will show the mapping and the information of the flight (Total Kilometrage, Maximum Distance, Maximum Speed, Flight Airtime, Takeoff Battery, Landing Battery, Software utilized and Maximum Bat Temperature).

Technical planning must be concerned with another very important layer of this intrigued framework, that is the local meteorology and all the facets of it. Before the survey, the pilot needs to clearly:

- understand the best time to fly;
- establish the one or more flight altitudes, depending on the irregularity of the terrain;
- decide the type of sensor that will be used depending on the results Dronus wants to obtain;
- define the strategic line of flight to make sure that the drone will be always in the optical visual line of the Team to facilitate radio and video signals and to be sure that the risk of collision with civil objects will be minimized;
- calculate the number of days needed for the entire overflight of Biella, based on the number of batteries needed;
- forecast the optimal temperature to make the battery lasts for the necessary time of the flight (if the battery is at 0°, it will last 50% of the full capacity);
- address critical issues on landing, so the pilot needs to have a B Plan if the take-off site is unusable;
- establish a secure authorized connection in VHF radio with the Biella Airport in order to make sure that no aeroplane will collide with Radon.

The legislative planning, which goes hand in hand with the technical one and that define the pre-flight conditions, need to firmly understand what are all the critical issues and

hypothetical pain points that will be encountered in the airspace and adjust accordingly to request the necessary permissions to minimize the risks.
The principal permission that the pilot needs to obtain is the one from EASA to fly over the civil town and the authorization to go beyond the optical visuals line, flying in BVLOS (Beyond Visual Line of Sight) conditions.
The critical points that can be encountered when the aircraft is in the air are the risk of collision that will be analyzed further in the next chapter. For the purpose of completion of the legislative landscape, it is useful to understand the dynamic that interrelates these two aspects, so the geography coordinates with the risk of collision with Manned Aircrafts. The Biella flight will occur at 90 meters, as anticipated, and this restricted altitude permits us to notify that the collision critical risk is lowered to the minimum. Being an altitude that is very low compared to the different type of situation, in which for ex. the aeroplanes need to flight not under 1000 feet (~ 300 meters), Radon should not encounter any kind of aircraft.
Normally in general aviation, the civil town cannot be overflown, except for cases of engine failure in which the legislator permits the glide outside of it: in fact, if for ex. there is a city that is 4 km long, the pilot must fly at an altitude of minimum 1 km.
Moreover, in the Northern part of Biella there is a "Reporting Point", disciplined by an AIP compartment (Aeronautic Information Publication - legislative unique source in Italy) emitted by ENAV (the entity for flight assistance), which is a strategic point through which the air traffic coming from the Airport in the South or going to it, transits.
Another fundamental permission is the one to flight over the "correctional facility" – Papa zone (Prohibited Zones that are considered restricted for various reasons and particularly sensitive for the purposes of public safety) in which there is a jail, to the Minister of Grace and Justice, for the Prohibited Zone and for the radius of 500 meters that surrounds it in which is not permitted to flight if not under their conditions.

The only risk that cannot be eliminated and that must be mitigated is the risk that a Helicopter Rescue transit over the town at low altitude; is therefore very important to have an emergency plan: for ex. considering that Radon is a VTOL, it can be stopped in the air to lower its altitude and thus diverge from the collision course. A VTOL is an aircraft with four propellers that can hover, take off and land vertically. Once Radon

takes off, it turns on the propeller placed perpendicular to the ground along the longitudinal axis of the aircraft and the translation begins, at which point the four engines of the quadcopter switch off to permit it to become subsequently an airplane. When it has to land it makes a counter transition from helicopter to multicopter, so the four engines turn on again and the aircraft manages to land like a tiltrotor. It looks like an airplane with two very large propellers that act as rotors to make the aircraft becomes a helicopter in the landing phase, whereas in the flying phase the propellers tilt to make it becomes a turboprop airplane, thus incorporating the advantages of stopping in flight, take-off and landing very easy and on request as the quadcopter can do (take-off and landing very low) but having to go to the detriment of speed, since the plane has these four propellers that make great friction and brake turning into less efficiency.

Chapter 5: Method

In this thesis we carried out a systematic exploration of the Data Value Chain and Ecosystems in the field of technical applications, such as drone's and autonomous vehicle's market. We collected data through multiple sources, using a programmatic approach, that can be divided into semi-structured interviews with the company's representatives, direct observation and organic scientific research for literature.

The collection of literature regards:

- The Data Value Chain, its process and the importance of Artificial Intelligence to extract value;
- The Ecosystem, its participants and their interests;
- Digital Transformation model and the incorporation of Big Data from modern technologies (es. Drones and software) to victoriously implement proper societies.

Some of the information that the reader will find in this thesis has been elaborated by the semi-structured interviews that we made with the engineers of the companies that are involved in the discussion. Thus, we have been able to collect a set of direct observations and knowledge in the field.

To facilitate the discussion and to clearly highlight the principal concept, we developed a roadmap that we had strictly followed in order to establish all the steps needed to collect valuable information. A list of data collected is reported in Table 5.1.

n.	Name of the interviewee	Role	Company	Time and Day of the Interview
1	***Ing. Giulio Segurini***	Co-Founder Business Development AeroSpace Engineering	Dronus	16/02/2021 10/03/2021 15/04/2021
2	***Dott. Alessandro Zullo***	Practice Director/ Senior Account Executive	Here	15/03/2021

3	***Ing. Marco Ballerini***	Dronus CEO - Head of R&D Founder	Dronus	10/03/2021
4	***Dott. Fabrizio Murgia***	Technical Geologist / Geographic Analyst	Here	20/03/2021
5	***Ing. Michele Feroli***	CEO SiraLab Co-Founder	Dronus	01/04/2021
6	***Dott. Laura Minore***	Senior Local Data Intelligence Analyst	Here	10/04/2021
7	***Ing. Riccardo Benedetti***	Dronus Director Head of Program Co-Founder	Dronus	12/03/2021
8	***Ing. Simone Menicucci***	Certification Manager	Dronus	05/03/2021

Table 5.1. Authors Representations

We started from the collection of secondary data to structure an interview protocol that has been used for conducting personal interviews. All the collected data has been analyzed individually and then discussed with companies representative to be structured in an organic way. All the interviews have been recorded.

We started from the collection of important insights in order to structure an interview format that has been followed by all the engineers and economists, adapted to the discussion at issue. All the interviews focused on the Data Value Chain in the market of drones and automotive, on the Ecosystem and the expectation of the players involved.

Chapter 6: Authorization landscape

The authorization process is a very complex matter when it comes to Drones and it is in a continuum change due to the novelty of the market.

To now, the two entities that in Italy discipline drones and what companies and people can do with them and control the air traffics are ENAC (Ente Nazionale per l'Aviazione Civile) just for the strict Italian territory and ESEA (European Union Aviation Safety Agency) that works at European level. Till 31 December 2020, the regulation valid in Italy was the "Remotely piloted aircraft", authorized by ENAC and so, the only way to be enabled to do the Biella flight was to ask for an Experimental BVLOS authorization to ENAC, after having confirmed in front of ENAC eyes that the aircraft/drone is perfectly capable to support it without complications.

To make the reader aware of the difficulty to obtain this kind of authorization, it has been tracked that from 2017 to 2020 there have been just 15 experimentation successfully given by the legal entity.

The two regulatory entities are equally valid because we are in a transition phase that should arrive in two years to a moment in which ENAC rules will be included and harmonized in EASA regulatory body. Of course, the two documents are different in terms of how they face various topics (es. harmless drones for ENAC need to weigh under 300 grammes and for EASA they should weigh below 250 grammes) and so it will be interesting to see what the two will succeed in different articles and chapters.

Since 31 December 2020, it depends on Operation Risk if a BVLOS operation has to be authorized by ENAC or EASA.

These days Italy is in a strategic powerful position thanks to the possibility to take significant innovative steps with respect to the world of drones. Italy is, in fact, the only civil aviation to have certified drones. EASA has asked Dronus to meet them in order to write an effective and truthful rule book and to set standards reflecting the extensive knowledge of Dronus and the Italian market in general.

This will be of greater importance in shaping the technological trajectory in the future by reasons of the possibility to become a first mover and reap the full value of the young maturity of the market. The interests at stake are bigger than we can think: ENAC, in fact,

is pushing ESEA to ask Dronus to talk about the ENAC issued certifications both to become the stronger aviation in Europe and because in this way EASA will shape the European legislation on the Italian one.
The transitory phase is arriving at the new European regulations, which will overcome the law 954 and 947 of 2019. They discipline the principal three categories of operations, which will be deepened below.

Type Certificate

The immense scope of this incredibly new and unique project is made explicit by Dronus' skill in having obtained the Type Certificate on its aeronautical products. This recognition signifies that a particular category of aircraft is airworthy according to its “Type Design”, which represent the way of manufacture and it is not only very difficult to obtain, but also very costly (around US $1m).
The TC, as shown in Figure 6.1, is issued by, ESEA, the European regulatory authority and, once issued, the design can’t be changed unless the process is repeated to include the changes or if the manufacturer requests a third-party Supplemental Type Certificate (STC), that is less expensive.
It implies that the aircraft is manufactured according to the approved design and so can have an airworthiness certificate. The requirements must be approved for the aircraft and for each sub-assembly in accordance with the applicable Minimum Operating Performance Standards (MOPS), which are published by expert industry groups.

European Aviation Safety Agency

TYPE CERTIFICATE

EASA.E.210

This Type Certificate is issued by EASA, acting in accordance with Regulation (EC) No. 216/2008 on behalf of the European Community, its Member States and of the European third countries that participate in the activities of EASA under Article 66 of that Regulation and in accordance with Commission Regulation (EC) No. 748/2012 to

Dronus Spa

and certifies that the product type design listed below complies with the applicable Type Certification Basis and environmental protection requirements when operated within the conditions and limitations specified on the associated:

Type Certificate Data Sheet number: EASA.E.201

Tye Design - Model:	Date of Issue:
Radon	02.02.2021

Figure 6.1

Source: https://rotax.sorlini.com/223.html consulted 22/02/2021

The certification is done through a process which starts by the submission of the organization of the necessary documents to its local aviation regulating body. After the investigations of the regulators, the approval of these documents (after amendments and comments in order to fulfil the requirements) becomes the start of the certification. The company, in fact, need to establish a timetable with the actions needed for the test's assessments by the regulatory body. Initial design samples are built, that can refer to aircraft, engines or propellers. These prototypes are tested with various categories of subjects and once the results are disclosed, they are compared with initial calculations to establish the structural strength of the "static airframe".

Once they are successfully tested, they are ready for the flight tests, which consist of a test pilot that flies with the prototype in order to establish the ultimate flight limits that must stay within the airworthiness rules (these tests can include different environments, climates and altitude).

In parallel with these testings, the firm must also draw the maintenance program to support the design after the approval of it. This Program is constituted by the inputs from tests results and from the input of the engineering department.

After the completion of all the requirements, the firm is granted the TC for that prototype and so it can be replicated serially and more important from a strategic viewpoint, the firm might have the possibility to shape the trajectory of the industry, thanks to the first-mover advantage against competitions, with the possibility to establish lock-in features for the products and favour contracts with suppliers.

The maintenance program needs to be implemented and monitored constantly through an operation lifecycle called continuing airworthiness. Additional task associated with the program are in fact:

- Airworthiness directives (ADs) that consist in additional maintenance actions that need to be done to restore the type's airworthiness, due to encountered problems that might compromise the safety of the UAV that was not included in the testing stages;

- Service bulletins (SBs), by which the type certificate holder can improve the original design arriving at lower maintenance costs or increased performance. The SBs are suggested to the operator and thus are discretional measures that can be implemented reporting the decision to the regulatory authority.

EASA eRules definitions

EASA eRules are very exhaustive when it comes to explaining deeply the definitions involved in the drone's market. For purpose of better understanding, it seems appropriate to try to explain briefly what are the technical terms that will be used in the second part of the thesis.

So, we will deal with:

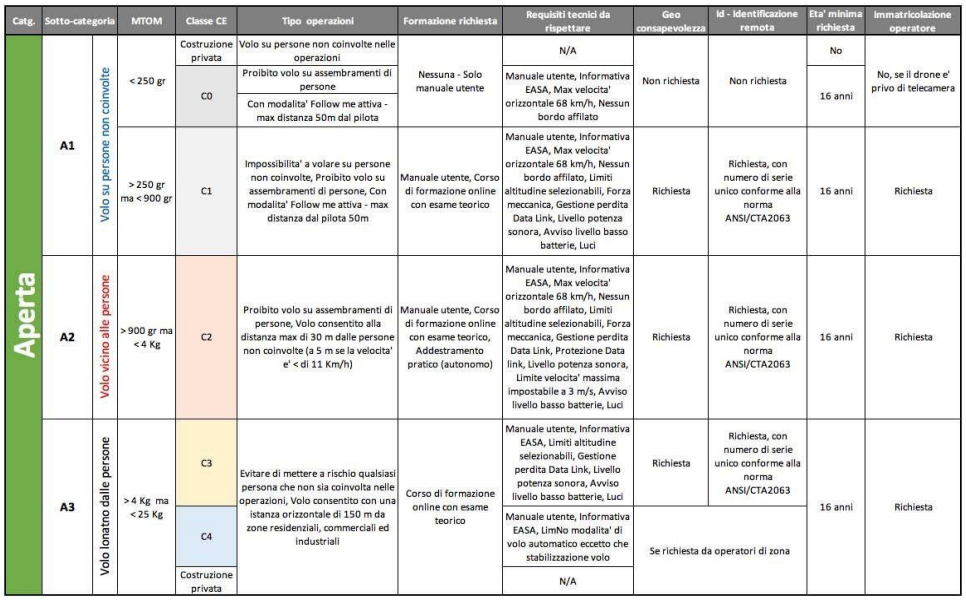
- 'unmanned aircraft system operator' ('UAS operator') that means any legal or natural person operating or intending to operate one or more UAS;
- visual line of sight operation' ('VLOS') that means a "type of UAS operation in which, the remote pilot is able to maintain continuous unaided visual contact with the unmanned aircraft, allowing the remote pilot to control the flight path of the unmanned aircraft in relation to other aircraft, people and obstacles for the purpose of avoiding collisions. In VLOS flights the pilot has a range of actions of 500 meters and a maximum height of 120 meters" (page 18 Regulation EU 2019/947 and EU 2019/945);
- 'beyond visual line of sight operation' ('BVLOS') means a type of UAS operation which is not conducted in VLOS. They are not clearly defined because in Europe schools that teach how to fly in BVLOS manner are missing. As a consequence of that, there is an absence of a normative ground by ENAC on how to enable the pilot to do these kinds of flights, in terms of technical platform and security procedure known by the pilot, that now is enabled with an experimental recognition, in case of various problematics;
- autonomous operation' that means an operation during which an unmanned aircraft operates without the remote pilot being able to intervene (page 19 Regulation EU 2019/947 and EU 2019/945);

- maximum take-off mass' ('MTOM') that means the maximum Unmanned Aircraft mass, including payload and fuel, as defined by the manufacturer or the builder, at which the Unmanned Aircraft can be operated;
- Notice To Airmen (NOTAM), which is a notice containing daily information concerning the establishment, condition or change in any component (facility, service, procedure or hazard in the National Airspace System) that are essential to personnel concerned with flight operations.

UAS Categories

The **EASA eRules** system is developed and implemented in close cooperation with the Member States and the aviation industry to ensure that all its capabilities are relevant and effective. In Article 3 of EASA eRules the legislator has identified multiple categories of UAS (unmanned aerial vehicle) operations, that are:

- Open: comprise all the UAS that belongs to one of the classes set out in Delegated Regulation EU 2019/945. Drones of this category:
    - Have a maximum take-off mass of less than 25 kg;
    - Need a remote pilot who ensures that the unmanned aircraft is kept at a safe distance from people and that it is not flown over assemblies of people and that keeps the unmanned aircraft in VLOS at all times except when flying in follow-me mode or when using an unmanned aircraft observer;
    - during flight need to be maintained within 120 meters from the closest point of the surface of the earth, except when overflying an obstacle,
    - during flight, must not carry dangerous goods and must not drop any material;
        - In Figure 6.2 are represented all the categories in a more detailed view.



Catg.	Sotto-categoria		MTOM	Classe CE	Tipo operazioni	Formazione richiesta	Requisiti tecnici da rispettare	Geo consapevolezza	Id - identificazione remota	Eta' minima richiesta	Immatricolazione operatore
Aperta	A1	Volo su persone non coinvolte	< 250 gr	Costruzione privata	Volo su persone non coinvolte nelle operazioni	Nessuna - Solo manuale utente	N/A	Non richiesta	Non richiesta	No	No, se il drone e' privo di telecamera
				C0	Proibito volo su assembramenti di persone		Manuale utente, Informativa EASA, Max velocita' orizzontale 68 km/h, Nessun bordo affilato			16 anni	
					Con modalita' Follow me attiva - max distanza 50m dal pilota						
			> 250 gr ma < 900 gr	C1	Impossibilita' a volare su persone non coinvolte, Proibito volo su assembramenti di persone, Con modalita' Follow me attiva - max distanza dal pilota 50m	Manuale utente, Corso di formazione online con esame teorico	Manuale utente, Informativa EASA, Max velocita' orizzontale 68 km/h, Nessun bordo affilato, Limiti altitudine selezionabili, Forza meccanica, Gestione perdita Data Link, Livello potenza sonora, Avviso livello basso batterie, Luci	Richiesta	Richiesta, con numero di serie unico conforme alla norma ANSI/CTA2063	16 anni	Richiesta
	A2	Volo vicino alle persone	> 900 gr ma < 4 Kg	C2	Proibito volo su assembramenti di persone, Volo consentito alla distanza max di 30 m dalle persone non coinvolte (a 5 m se la velocita' e' < di 11 Km/h)	Manuale utente, Corso di formazione online con esame teorico, Addestramento pratico (autonomo)	Manuale utente, Informativa EASA, Max velocita' orizzontale 68 km/h, Nessun bordo affilato, Limiti altitudine selezionabili, Forza meccanica, Gestione perdita Data Link, Protezione Data link, Livello potenza sonora, Limite velocita' massima impostabile a 3 m/s, Avviso livello basso batterie, Luci	Richiesta	Richiesta, con numero di serie unico conforme alla norma ANSI/CTA2063	16 anni	Richiesta
	A3	Volo lonatno dalle persone	> 4 Kg ma < 25 Kg	C3	Evitare di mettere a rischio qualsiasi persona che non sia coinvolta nelle operazioni, Volo consentito con una istanza orizzontale di 150 m da zone residenziali, commerciali ed industriali	Corso di formazione online con esame teorico	Manuale utente, Informativa EASA, Limiti altitudine selezionabili, Gestione perdita Data Link, Livello potenza sonora, Avviso livello basso batterie, Luci	Richiesta	Richiesta, con numero di serie unico conforme alla norma ANSI/CTA2063	16 anni	Richiesta
				C4			Manuale utente, Informativa EASA, LimNo modalita' di volo automatico eccetto che stabilizzazione volo	Se richiesta da operatori di zona			
				Costruzione privata			N/A				

Figure 6.2

Source: https://4mydrone.com/it/droni-principiante/easa-regolamento-droni-ctg-aperta/ consulted 12.02.2021

- Specific: the less framed category due to high specialization of components. This category allows to perform critical operations by certified pilots respecting precise standard operating limits and after a specific risk assessment;
- Certified: comprise UAS which meet the following requirements:
    - the UAS is certified with Paragraph 1 of Article 40 of Delegated Regulation EU 2019/945;
    - the operation is conducted over assemblies of people, it involves the transport of people; it involves the carriage of dangerous goods, that may result in high risk for third parties in case of an accident.

In addition, UAS operations are in the 'certified' category where the competent authority, based on the risk assessment, considers that the risk of the operation cannot be adequately mitigated without the certification of the UAS operator and without the licensing of the remote pilot.

Specific Operation Risk Assessment (SORA)

The Dronus flight over Biella is a BVLOS one and it has been approved by a ENAC commission thanks to positive results on the risk assessment analysis. To be approved by ENAC is a very complex task, because after having specified the category of the drone, the characteristics of the company and the flight and maintenance manual, you need to pass the risk analysis with SORA (Specific Operation Risk Assessment), of which Simone Menicucci, Dronus engineer, is one of the Italian top experts and this chapter is elaborated thanks to it contribute.

SORA, as anticipated in the previous chapters, is a multi-stage process of Risk Assessment aiming at analyzing the risk of certain drones' operations and the definition of necessary mitigations and robustness levels. It has been endorsed by the European Aviation Safety Agency (EASA) for being an Acceptable Means of Compliance (AMC) to fulfil the requirements of the EU Regulations, made explicit by Basic Regulation, Implementing Act, Delegated Act and Annexes.

In BVLOS operations the legal entity assigns to the operation a Risk Level of 6, and the company must lower it to 2. The company need to find mitigatory actions to reduce it to an acceptable level. The risk is, in fact, divided into two main categories:

- Ground Risk Class (GRC), for ex. Risk of impact to the ground, that as you can see in Figure 6.3, vary based on operational scenarios, typical kinetic energy expected and max UAS characteristics dimensions;
- Air Risk Class (ARC), for ex the risk of mid-air collision (MAC) with an aeroplane (not with a drone). The process by which is determined the level of risk for this class is analyzed in Figure 6.4, that shows the complex frame that needs to be studied in order to define which ARC (a,b,c,d) is associated with the current operation.

The GRC and ARC constitute the base level to form the so-called Specific Assurance and Integrity Levels (SAIL). It represents how much the UAS operation will stay within the boundaries of the intended operation confidence. The SORA permits operators to make use of precise threat barriers and mitigating measures to reduce the SAIL. Collision avoidance with manned aviation, has been recognized as a fundamental layered approach

to address when mixing drones with common airspace and it can be done thanks to airspace structure, ATC services, right-of-way-procedures.

Intrinsic UAS ground risk class				
Max UAS characteristics dimension	1 m / approx. 3 ft	3 m / approx. 10 ft	8 m / approx. 25 ft	>8 m / approx. 25 ft
Typical kinetic energy expected	< 700 J (approx. 529 ft lb)	< 34 kJ (approx. 25 000 ft lb)	< 1 084 kJ (approx. 800 000 ft lb)	> 1 084 kJ (approx. 800 000 ft lb)
Operational scenarios				
VLOS/BVLOS over a controlled ground area[3]	1	2	3	4
VLOS over a sparsely populated area	2	3	4	5
BVLOS over a sparsely populated area	3	4	5	6
VLOS over a populated area	4	5	6	8
BVLOS over a populated area	5	6	8	10
VLOS over an assembly of people	7			
BVLOS over an assembly of people	8			

Figure 6.3

Source: Dronus SpA SORA analysis, consulted 16.02.2021

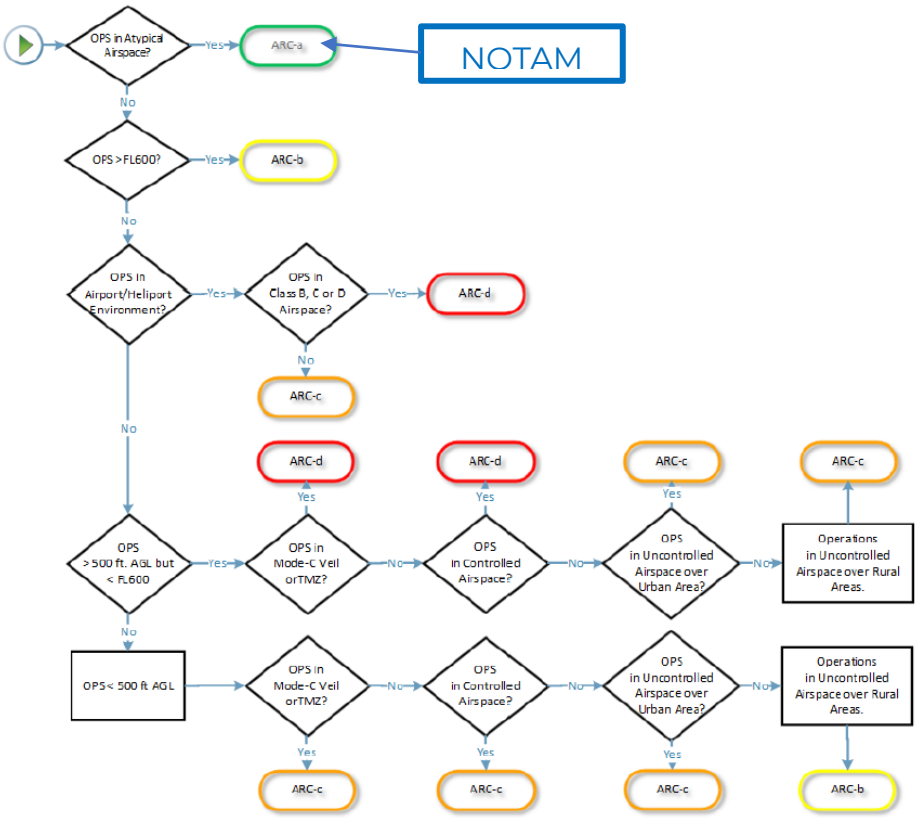


Figure 6.4

Source: Dronus SpA SORA analysis, consulted 16.02.2021

How to effectively mitigate the risk? Thanks to three principal measures, as reported in Figure 6.5:

- M1: the company ensures that below the flight zone there will be no people;
- M2: the company ensures that the drone will have a parachute;
- M3: the company ensures that it will insert an Emergency Response Plane (ERP) in order to circumscribe the damage in the defined area and not propagate it.

		Robustness		
Mitigation Sequence	Mitigations for ground risk	Low/None	Medium	High
1	M1 — Strategic mitigations for ground risk[1]	0: None -1: Low	-2	-4
2	M2 — Effects of ground impact are reduced[2]	0	-1	-2
3	M3 — An emergency response plan (ERP) is in place, the UAS operator is validated and effective	1	0	-1

Figure 6.5

Source: Dronus SpA SORA analysis, consulted 16.02.2021

Thanks to these mitigation measures, the assessment level can be lowered to 4. Another very important task to be performed after the authorization and after the control of air traffic (D-Flight by ENAV for flying objects weights more than 250 grammes) but before the start of the fly, is to communicate with ENAC to ask about NOTAM in force in the air over Biella the chosen day. If there are none, the pilot can successfully request proprietary NOTAM, indicating that for a predetermined amount of time the above air will be forbidden to traffic by other aircrafts. Aeronautic procedures need to be carefully implemented following all the necessary steps in order to arrive at level 2, due to high liability in a multitude of different sectors and contexts.

The final GRC is established by adding all the correction factors (-1-1-0=-2) and adapting the GRC by the resulting number (6-2=4).

Thanks to MAC and GRC integrated together, the authorization authority can arrive to declare a Safety Assurance and Integrity Level, that contains 24 requirements for the

drone to be able to carry out the operation and at what level. These requirements (OSO#1 to OSO#24) are divided in technical issue with the UAS, deterioration of external systems supporting UAS operations, human error and adverse operating condition. The SAIL that is taken into account for Dronus Radon, as shown in Figure 6.6, is the III category, which presents High Risk on OSO#8, OSO#11, OSO#14 and OSO#21.

OSO number (in line with Annex E)		SAIL					
		I	II	III	IV	V	VI
	Technical issue with the UAS						
OSO#01	Ensure the UAS operator is competent and/or proven	O	L	M	H	H	H
OSO#02	UAS manufactured by competent and/or proven entity	O	O	L	M	H	H
OSO#03	UAS maintained by competent and/or proven entity	L	L	M	M	H	H
OSO#04	UAS developed to authority recognised design standards[1]	O	O	L	L	M	H
OSO#05	UAS is designed considering system safety and reliability	O	O	L	M	H	H
OSO#06	C3 link performance is appropriate for the operation	O	L	L	M	H	H
OSO#07	Inspection of the UAS (product inspection) to ensure consistency with the ConOps	L	L	M	M	H	H
OSO#08	Operational procedures are defined, validated and adhered to	L	M	H	H	H	H
OSO#09	Remote crew trained and current and able to control the abnormal situation	L	L	M	M	H	H
OSO#10	Safe recovery from a technical issue	L	L	M	M	H	H
	Deterioration of external systems supporting UAS operations						
OSO#11	Procedures are in-place to handle the deterioration of external systems supporting UAS operations	L	M	H	H	H	H
OSO#12	The UAS is designed to manage the deterioration of external systems supporting UAS operations	L	L	M	M	H	H

OSO number (in line with Annex E)		SAIL					
		I	II	III	IV	V	VI
OSO#13	External services supporting UAS operations are adequate for the operation	L	L	M	H	H	H
	Human error						
OSO#14	Operational procedures are defined, validated and adhered to	L	M	H	H	H	H
OSO#15	Remote crew trained and current and able to control the abnormal situation	L	L	M	M	H	H
OSO#16	Multi-crew coordination	L	L	M	M	H	H
OSO#17	Remote crew is fit to operate	L	L	M	M	H	H
OSO#18	Automatic protection of the flight envelope from human error	O	O	L	M	H	H
OSO#19	Safe recovery from human error	O	O	L	M	M	H
OSO#20	A human factors evaluation has been performed and the human machine interface (HMI) found appropriate for the mission	O	L	L	M	M	H
	Adverse operating conditions						
OSO#21	Operational procedures are defined, validated and adhered to	L	M	H	H	H	H
OSO#22	The remote crew is trained to identify critical environmental conditions and to avoid them	L	L	M	M	M	H
OSO#23	Environmental conditions for safe operations are defined, measurable and adhered to	L	L	M	M	H	H
OSO#24	UAS is designed and qualified for adverse environmental conditions	O	O	M	H	H	H

Figure 6.6

Source: Dronus SpA SORA analysis, consulted 16.02.2021

After having done all the steps, the company can successfully send to ENAC the documentations and from that moment on, the back-and-forth phase starts in order to be officially approved (more or less five months).
The SORA is a way to successfully integrate, with a sufficient level of safety, UAS operations with commercial manned aviation, not considering the weight and the altitude. To facilitate the SORA process, Standard Scenarios (STS) can be generated for specific types of surveys, with clear hazards and adequate risk-mitigations. The STS can subsequently be utilized by operators and regulating authorities to automize certain operations that have the necessary requirements to use them.

The ECA (European Cockpit Association), is worried that some principles of SORA (ex. Joint Authorities for the Rulemaking of Unmanned Systems-Guidelines) might not be fully embraced by all the stakeholders involved. As a result, it is trying to put emphasis on the following points from the JARU guidelines:

- SORA document must not be used as a 'checklist' or capable to give all the answers to the challenges encountered;
- SORA is a tailoring assessment that allows to reduce the risk to an acceptable level that best describes a perfect fit for the mitigation scope. In fact, it does not include prescriptive clauses, but targets to be met for robustness levels;
- SORA measurement is a model structured on the principle of a holistic safety risk assessment.

The complexity of the procedure is included in the JARUS WG6: "It is important that both the competent authority and operator take great care to understand the Operational Volume and under what circumstances the definition of the ARC assignment process could be invalidated". For this reason, SORA should not be regarded as a purely quantitative process like a computer-algorithm, but more as a qualitative process, that is a key perspective for the assessment: the operator and the competent authority must show

adequate levels of detailed knowledge and expertise, but it is not always the case. As a consequence, it is good practice to consult third parties' independent experts (e.g. manned aviation stakeholders, manufacturers, ANSPs (ATM/UTM), academia, associations).

Chapter 7: Process of Data through the Value Chain

In this Chapter, the process of Data will be analyzed, following a clear and defined path, with multiple perspectives, which focused on the main players of the project and the actors that gravitate in this Micro-Ecosystem. It seems appropriate to enumerate the main successful points of using drones in industrial use in order to get the complete sense of the imminent and huge revolution that is about to begin, which are the following:

- Unique ability to acquire aerial data;
- Ability to provide fast and uninterrupted data collection;
- Ability to act in dispersed and dissimilar areas;
- Easy access to difficult areas such as power grids, power plant chimneys, etc;
- Autonomous navigation, without the need for human interaction with regards to continuous management of their trajectories;
- Simple integration with other systems, such as privacy software, clouds and warehouse, using the modularity principle of Industry 4.0.

To fully understand the capability of Drones and the revolution that they have the possibility to bring in all sectors in which Data play a crucial role, it is important to try to map as clear as possible the path of Data from the raw beginning to the enriched end.
In the data flow, there are multiple factors that need to be taken into consideration, as well as actors and pressure entities which have the power to shape the context and the subsequent target setting.
The principal players, as anticipated in the previous Chapters, are Dronus and Here. They are the ones involved face-to-face in the exchange of Data which will be manipulated and supervised by other actors in order to acquire legal and precise valence.
The process, which can be traced in its totality in Figure 8.1, is divided into two big branches, the first one is managed by Dronus and its Team and the second one is controlled by Here and its engineers.
The initial phase will be called the “Collection phase”, which goes from the requirements analysis to the image filtering, meanwhile the second one will be called the “Enrichment phase”, which goes from the geotagged gateway to the data annotation and final enrichment to the end client of Here, which are the car manufacturers.

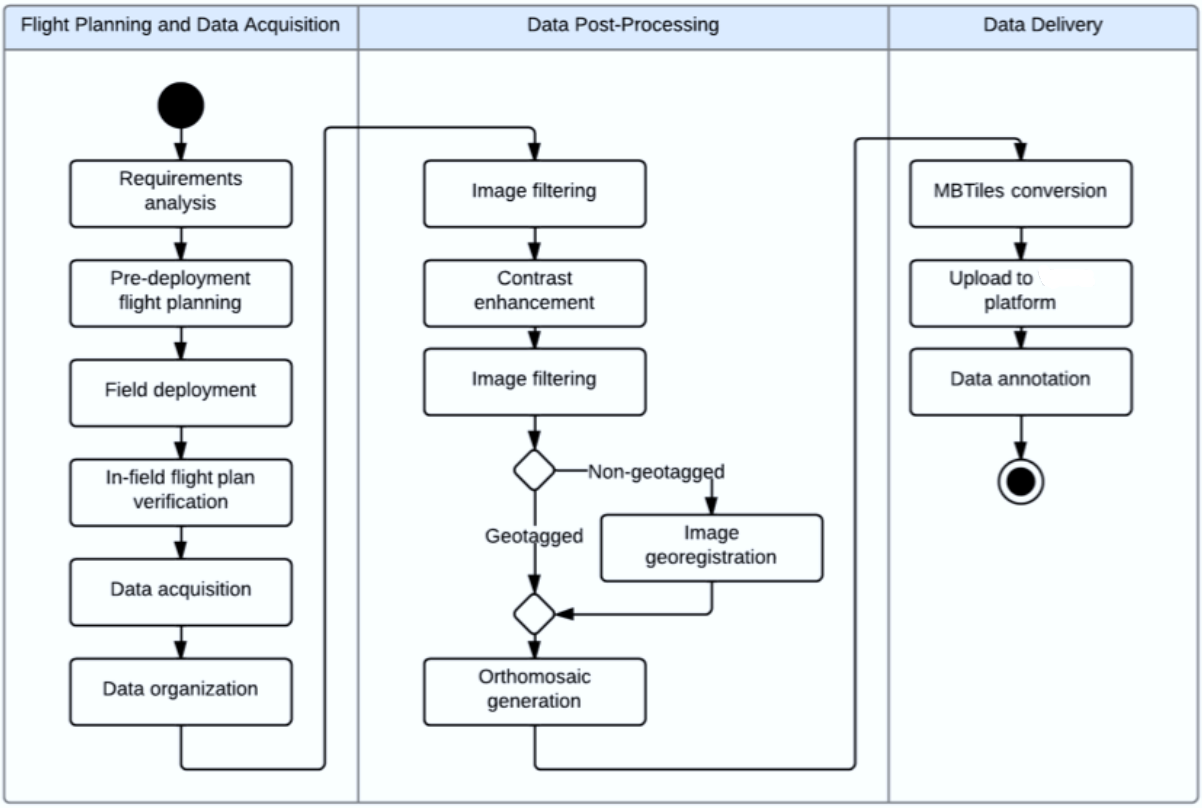


Figure 8.1

The Collection phase is composed of four big steps, as noted in Figure 8.2, which are:

- Taking pictures with Dronus drone in the interested area. As mentioned above and fully explained in the previous chapters, the overflight has been done after a multitude of condition checks, risk measurements, fixed requirements compliance analysis, pre-deployment flight planning and in-field flight plan validation;
- Upload these pictures into a personalized Dronus Cloud which is capable to retain information thanks to various layers of security, which can vary depending on the type of clients requesting the Data. In the case of interaction with Here, Dronus had implemented the maximum layer of security, which is composed by a VPN that encrypts the information and shield online activity from cybercriminals and Internet Service Provider (ISP). In this way, none a part Here, can access or even see the messages, files and activities employees are exchanging and doing, thanks to a mechanism which allow Data traffic to be routed through an encrypted virtual tunnel that makes Dronus IP address location invisible to everyone, except for Here which have the two-factor authentication key;

- Process picture in the cloud thanks to ad-hoc software and high-tech privacy systems. Dronus have implemented the Cisco SecureWorkload (Tetration) which guarantee micro-segmentation policies of the network through comprehensive analysis of application communication patterns and dependencies. It also ensures high protection of the workloads with consistent policy enforcement at scale through distributed control of native host firewalls and infrastructure, including Application Delivery Controllers (ADCs) and firewalls. The peak power for CSW-M (8 RU) are about 22.5 kW, the maximum cooling requirements is 50,000 BTUs per hour and the number of flow events that can be processed per second is up to 2 million per second;
- Check result in web browser and specific platforms, as Agisoft Methashape, which discover intelligent photogrammetry, process digital images and generate 3D spatial data to be used in GIS application and for indirect measurements of objects of various scale. Dronus uses the Agisoft platform for cloud processing service to send the project for processing in the cloud and to save on investment in hardware infrastructure for a photogrammetric pipeline. With this software, Dronus can share processing result options, embed code generation tool to integrate models in its website and in the Here one.

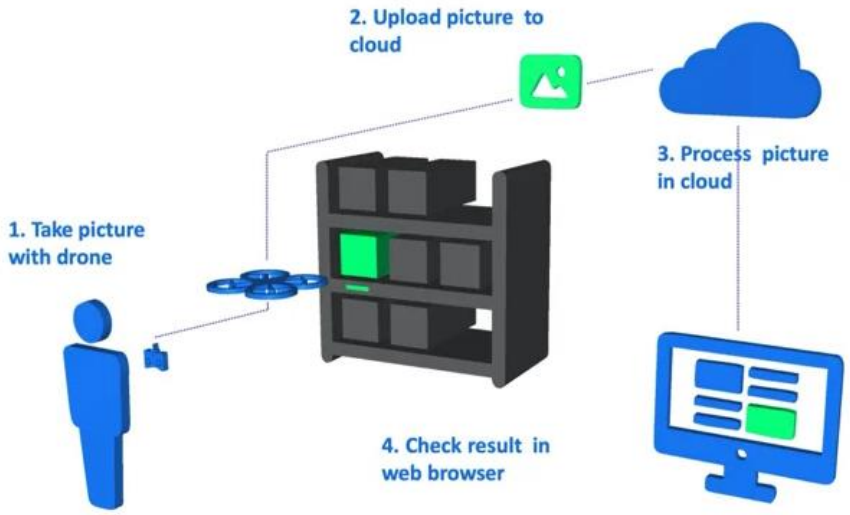
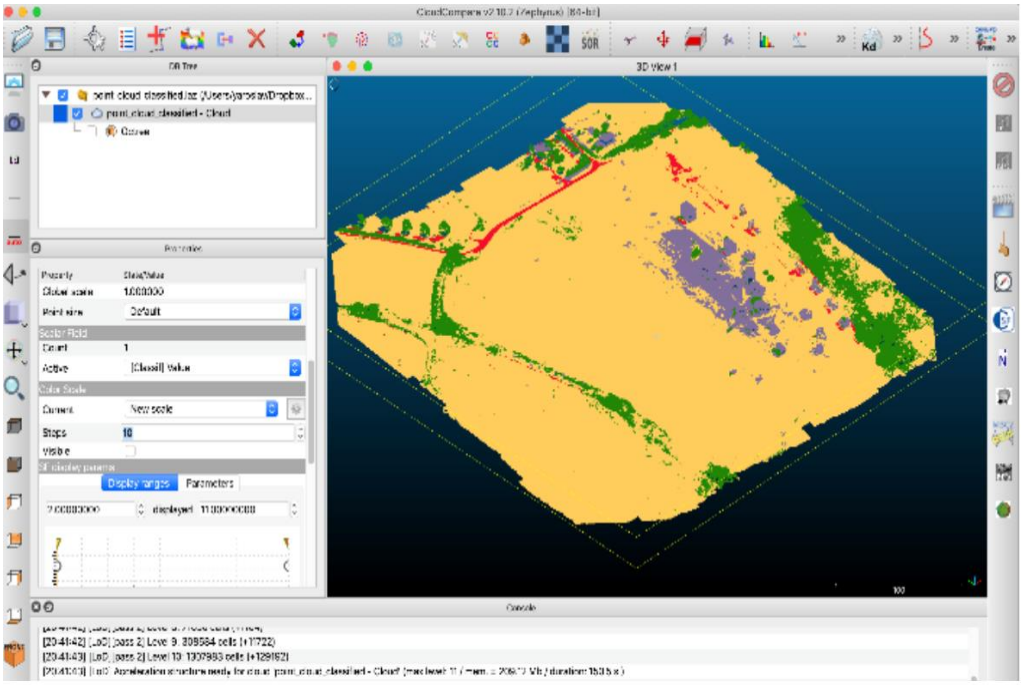


Figure 8.2

After having organized the Data in a structured way, in the data post-processing phase, Here acquired via securitized way the codes for the authentifications needed for decrypting the information included in Dronus Cloud and its software applications. The process that gives strategic validation is run by Here thanks to the possibility to create multiple outputs from a single entity of Data.

The variety of Data that can be extrapolated by photogrammetric imagery is way much higher than a normal flow. In fact, the owner of these kinds of Data can decide what kind of analysis and examination to pursue depending on the expectations of the client. Here clients need multiple format of Data due to the fact that its Team is going to discipline the market of autonomous driving at 360 degree. Here Team needs a complete arrangement of the target terrain which will allow the software that will process the information, to range in all the steps and constructs needed for a successful implementation of a highly precise, on-demand and real-time application software.



Tab 1

Source: Dronus Radon_Biella ConOps, company presentation, consulted 27.05.2021

So, Here has organized the second part of the flow as noted in Tab 1, which we called the "Enrichment phase", in four steps:

- Image georegistration, which permits to match UAV Dronus images to georeferenced image Data by relating an internal coordinate system of data to a ground system of geographic coordinates;
- Orthomosaic generation which can be in five other stages, which are:
    - Creation of a mask used to specify the most important areas on the photos which can otherwise be confusing to the program or lead to incorrect reconstructions results;
    - Align the photo, setting recommended values for the decided parameters after having chosen the interesting part that you want to build in the software;
    - Build dense point cloud, which permits to generate and visualize a model based on the estimated camera positions. The program calculates depth information for each camera to be combined into a single dense point cloud;
    - Build mesh, which is a polygonal model showing the raw characteristics of the interested zone, that is created automatically by the software;
    - Build orthomosaics, which are high-resolution imageries based on the source photos and reconstructed model. The most common application is aerial photographic survey data processing which can be saved in .PSX format for chunks with the existing mesh or Digital Elevation Model (DEM).
- Upload to Here Platform, which is a distributed network with the highest level of protection imaginable. Using combinations of distributed channels, encrypted communication channels, token files and smart contracts, it guarantees the integrity and immutability of information. Here Maps uses an accurate snapshot of the interested zone with location technology that provides context and relevance to data. Thanks to Dronus Photogrammetry, Here is able to build Road Geometry, Point of Interests (POIs), 3D landmark advanced city models and real-time traffic predictive analysis. Digital map technology is efficient, safe,

accessible and accurate. Land level intelligence and visual guidance combined with advance driving assistance systems is what is made possible thanks to the elaboration of geospatial insights and data. Here maps are curated to perfection via robotics, Artificial Intelligence (AI), Machine Learning (ML) and high-quality sensor data. The highest standard of validated data is given by the ISO certified quality management process improved with ETAs, timely deliveries and managed unforeseen delays.

- Data annotation is the process of labelling the data available in various formats like video or images. For supervised Machine Learning labelled data sets are required, so that machine can easily and clearly understand input patterns as seen in Figure 8.8. Data need to be precisely annotated to create data sets by which computer vision-based Machine can learn, so, for example, the software to be inserted in the vehicles need to clearly understand where the vehicle is in the spatial coordinates and what is around it, including people, traffic lights, cars, busses, traffic lines and so on. In image annotation, there are different types as polygon annotation, landmark annotation and 3D point cloud annotation. This technique is directly benefiting the Machine Learning algorithm to get trained with supervised learning process accurately for right prediction. Artificial Intelligence and Machine learning are one the fastest growing technology and for Here to create such automated machines thanks to intelligent software, a huge amount of training data sets is required.

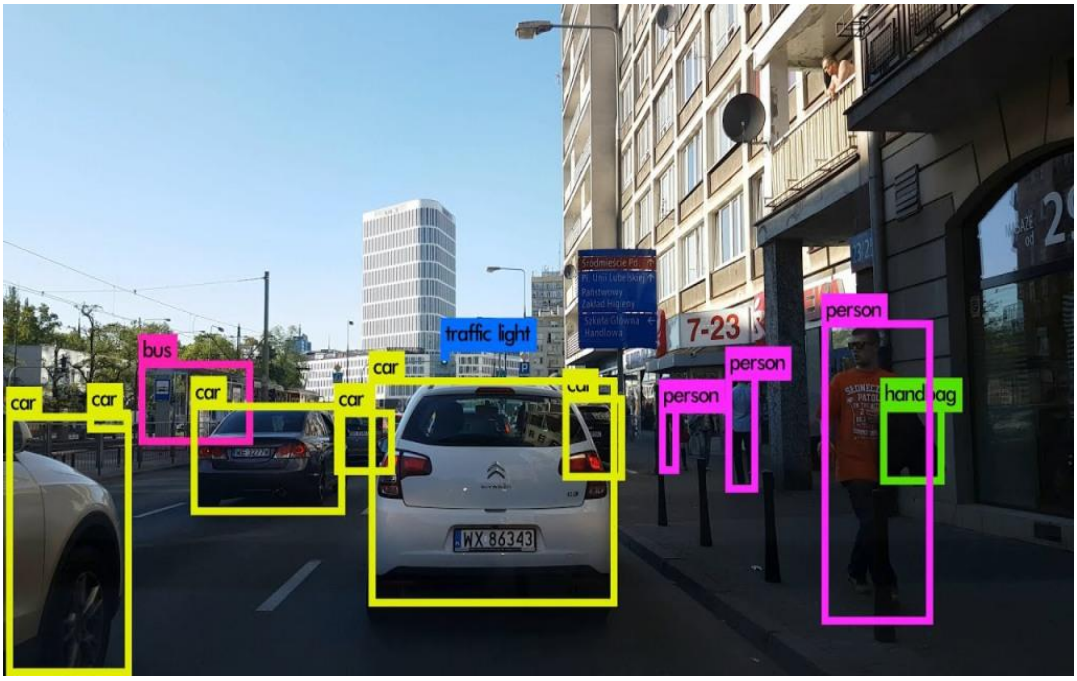


Figure 8.8

Data annotation can be helped and made simpler thanks to Python SDK or API. Here can stream data into training data platform and push labelled data into training environments like PyTorch or TensorFlow. Labelbox helped Here to develop an infrastructure to scale up and connect Machine Learning models to accelerate labelling productivity and orchestrate active learning as reported in Figure 8.9.

```
pip install labelbox
os.environ["LABELBOX_API_KEY"] = 'your_api_key'
lb = labelbox.Client()

dataset = lb.create_dataset(name="Tesla dataset upload example")
task = dataset.create_data_rows(local_file_paths)
task.wait_till_done()
print('Upload complete.')
```

Figure 8.9

Here currently use HERE Live Sense SDK to transform a device with a front-facing camera into a second pair of eyes for the driver. This technology, which has been embodied till now in the phone, will be inserted in Here proprietary software in autonomous cars in order to have the intelligence needed to make conscious decisions on the road. SDK has been used to scan the driver's environment and then AI detects and classifies road conditions and objects on it. This task will be implemented by the drone which will guarantee real-time and on-demand data which are more accurate and that resolve a series of issues like speed limits, road signs, potholes, construction zones and other safety risks, improving driver awareness. The implemented software will be aware of the alerts which can encounter the car, making it sudden change roads, speeds and driving conditions.

Below there are represented the three most important photogrammetrical classifications that are useful for mapping purpose, which are respctively the Dense Point Cloud in Figure 8.10, the Digital Elevation Model - DSM/DTM in Figure 8.11 which is a model georeferenced based on EXIF metadata, flight log and GCPs data and the Georeferenced orthomosaic generation in Figure 8.12, which is a type of photo exchanged in GeoTIFF format or KML format which is based on HML standard and is normally used to display geographic data in Earth browser like Google Earth.

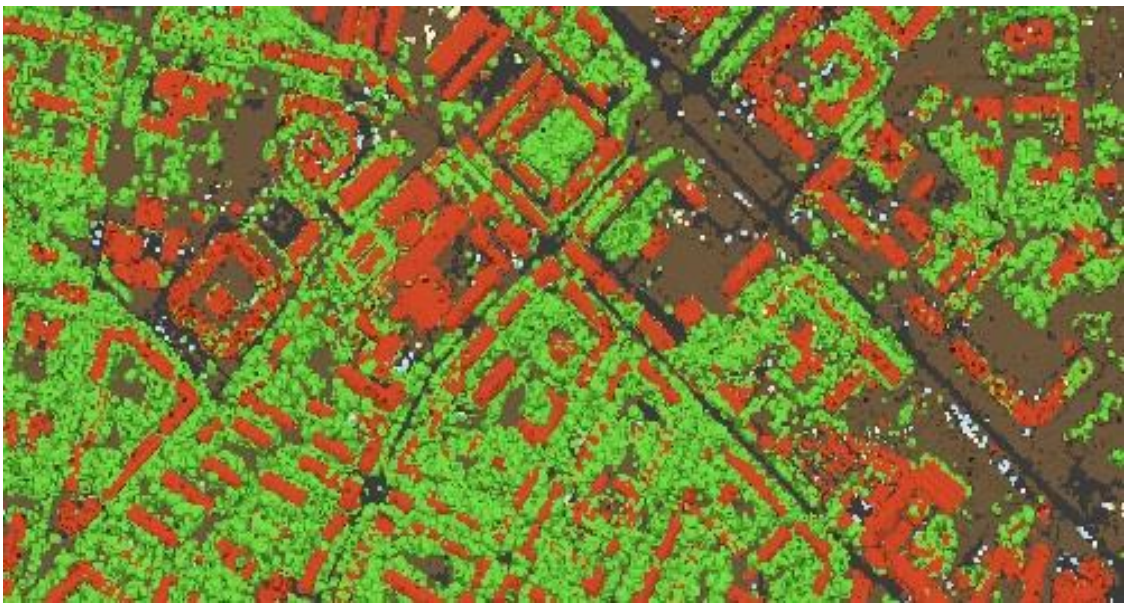


Figure 8.10

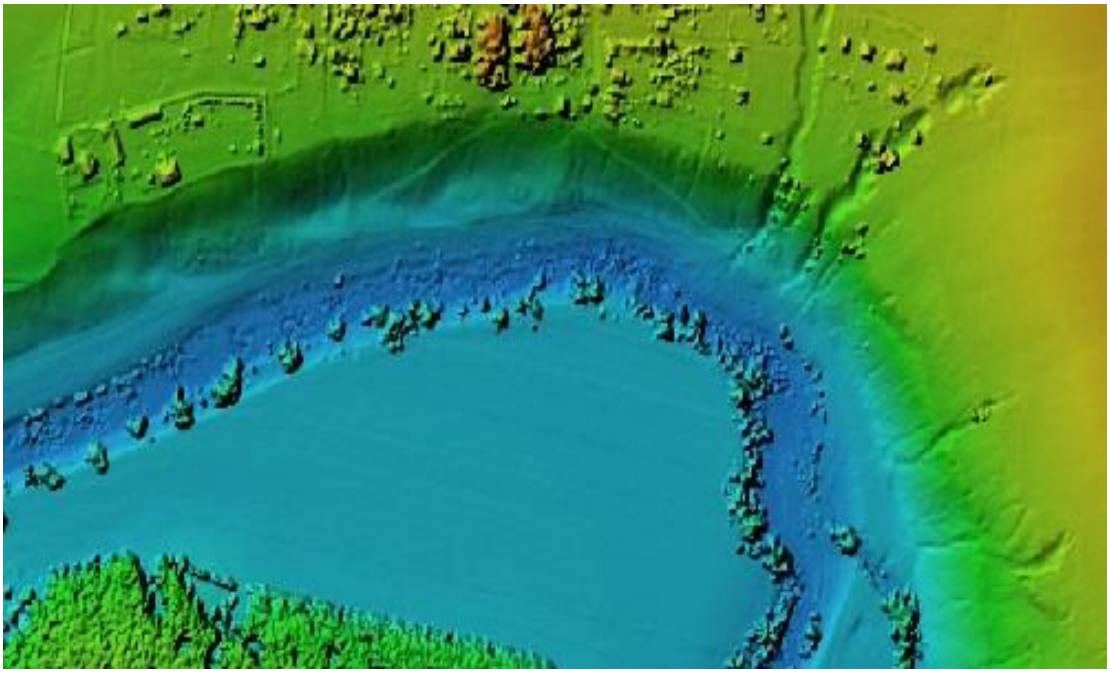


Figure 8.11

Figure 8.12

At this point of the process, Data have arrived at Here Warehouse and they have been analyzed to discover the potentiality of their aggregation and interconnection. Here supports its structured data extrapolation and usage thanks to a highly precise

manipulation in order to make them easier to read. Indeed, Here can achieve higher value thanks to the interconnection of Data, capability and knowhow which come from multiple sources (es. past projects, employees skills, organization flexibility) as it will be understood in the next chapter thanks to direct evidence.

Moreover, thanks to ETL (Extract, Transform and Load) tools, which feed a single source of Data ensuring that it is detailed, comprehensive and of high quality, Here has been able to extract Data from heterogeneous data sources, transform it (by merging fields, eliminating incorrect data, georeferencing points) and upload it to a data warehouse.
Only then various Business Intelligence (BI) tools can be used to generate meaningful multidimensional reports, visualizations using these data, photogrammetrical artefacts and more important the generation of Data that can be inserted in specific software for autonomous driving implementation.

As mentioned at the beginning of this chapter, not only Dronus and Here play a role in this process, but also some external stakeholders which gravitate in their ecosystem and exercise socio-economical pressure having the ability to shape the structural set-up around them. They are represented by Universities, Governments, Public entity such as ENAC and EASA, Private Companies which are in the industry, Aviation companies and banks.

The methodologies and flow that we have analyzed in this chapter had the purpose to make the reader discover what are the incredible tools and software that are around the world of drones, photogrammetry and machine learning.
Being the first mover toward completely new applications, is not easy at all, and more importantly it requires a long phase of process innovation from the beginning of the discovery to the full implementation of the successful flow which will entail the exchange of data to be efficient and effective.
The process of exchange and integration of data on the behalf of these two big players represent a new possibility for the future and a frontier which has the potentiality to be the door for a new reality and a new life.

Chapter 8: Here Elaboration of Data

Interview with an Insider

This chapter, which is the continuum of the interview with Doctor Zullo, contains six questions about the modality of acquisition of Data nowadays, its expectations on the new landscape of acquisition via drone, its elaboration of Data and finally how Here thinks this project will change the future of autonomous vehicles and not only. From here on, a series of questions will follow carried out with the subsequent responses of Doctor Zullo.

1) *How do you carry out the data acquisition to date to carry out the mappings? Do you use aeroplanes or satellite information?*

"We use satellite maps as we are in the field to acquire the information; our maps use 900 attributes for every single segment. There are cars but generally we do not rely on those, as the problem is that they do not have global coverage, they are not highly accurate, and the cost is very high.
In fact, it is all a matter of recognition through Artificial Intelligence, we start from a base of object observation through a 3D methodology given by the scanner of the vehicles that run on the street, then with the satellite information we can inspect and see things like if a straight road has been replaced by a roundabout and then on the basis of the mixture with other information systems that we have, we redraw the cartography to add the roundabout.
With satellite maps, we are not able to have such a high freshness of the data because accuracy plus fast updates mean very high costs. We hope with the Dronus and Here project to be able to reduce these costs thanks to the possibility of a lower-altitude flight, on-demand, which can fly over urban areas and therefore certified, which has higher definition cameras than GPS with fixed points geo-localized. To reduce costs and have highly precise images thanks to our recognition systems and Artificial Intelligence, we will make two advances:

- Modify and improve our content;
- Recognize some details that neither from the satellite nor with our machines we are able to obtain (e.g., we can improve the presence of pedestrian crossings or

identify holes on the roads) since with the drone it is possible to obtain a weekly or monthly update, so on-demand and in real-time."

2) *What are your expectations and your goals from this partnership?*

"It is not just a matter of autonomous driving, our goal is broader and more important. Despite COVID 19, which has slowed down our action plan, it is an initiative that continues because technology is evolving. With Dronus drone we want to implement a mapping, more detailed cartography, a reconstruction of the digital world of a higher level with such high detail that we can perfectly shape some critical objects like the canopy of trees and the billboards or stacks. These objects will allow the Telco world to better analyze what are the radio frequency emissions. The possible applications do not stop there, there is the issue of urban safety and the creation of landing areas for safe drones to avoid various cases of danger and many others more. Autonomous driving certainly brings with it all the safety systems, that make, as they increase, you will arrive at autonomous driving step by step. Some cars have a level 3 but by law the authorization is stopped at level 2."

3) *When you talk about levels, what do you mean?*

"In the process for full autonomy there are 5 levels of autonomous driving, as shown in Figure 8.1, which are:

- Level 0: No Automation: the driver is responsible for driving at all times with the possibility of having Active Cruise Control (which maintains a safe distance from the car). Level 0 vehicles can have safety features like backup cameras, blind-spot warnings and collision warnings and even automatic emergency braking in the event of an imminent collision;
- Level 1: Driver Assistance: a step in which the automated systems start to take control of the vehicle in specific situations, but do not fully take over. An example of this level is the implementation of Line Keeping (the car remains there when you are inside the lane);

- Level 2: Partial Automation: the vehicle can perform more complex functions which pair steering (lateral control) with acceleration and braking (longitudinal control), thanks to a greater awareness of its surroundings. So, for e.g., during highway cruises the driver may leave the steering wheel and follow the road but still keep his attention;
- Level 3: Conditional Automation: more advanced, which requires the car to slow down and accelerate and you can leave the steering wheel while remaining alert (to date only the Audi A8 carries level 3 but is not active in Italy);
- Level 4: High Automation: the "driver" can also sit in the back seat and is taken by the car to its destination autonomously. the vehicle's autonomous driving system is fully capable of monitoring the driving environment and handling all driving functions for routine routes and conditions. However, depending on the operational design domain (ODD) of the vehicle, the system may on rare occasions need a driver to step in. In those cases, the vehicle can alert the driver that there is, say, an environmental condition that requires a human in control, such as heavy snow;
- Level 5: Full Automation: step so advanced that the car becomes like a smart cabin, like a room, without a steering wheel. No driver is required behind the wheel and they might not even have gas/brake pedals, so the passengers can issue voice commands to choose destinations, media or the temperature.

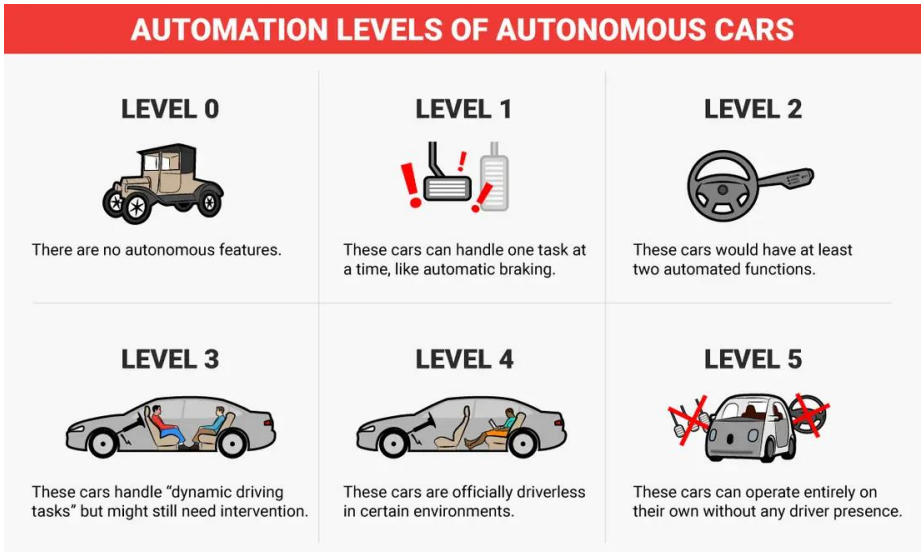


Figure 8.1

Source: https://www.businessinsider.com/what-are-the-different-levels-of-driverless-cars-2016-10?IR=T . Consulted 05.03.2021

To date, we hope to store such detailed information with Dronus that will allow us to reach Level 4, even if only Level 2 and 3 vehicles are authorized on the world market."

4) What is your role in the Data Value Chain?

"Dronus at this time, as agreed, will give us a single image or a series of angled or vertical images, depending on the type of terrain, connected with a GPS position and with reference points (GCP) such as e.g., the antenna or the church tower.
Then, there will be two processes, of which:

- First Process: automatic or semi-automatic in which the Artificial Intelligence will recognize all that is the positioning of specific infrastructures (e.g., trees, tram wires, light poles, traffic lights, signs, buildings, etc.);
- Second Process: manual made by Team India to confirm situations of doubt in the face of the comparison with our database (DB) and so the differences will be manually validated.

This means that Here will significantly increase the accuracy of the acquired data for the part relating to the height (since with the scanner on the road it is possible to reach a maximum of 15 meters), the part of the study of the roofs of the houses and the categorization of a series of infrastructures that will be able to be studied better than satellite images.
All this will then be an Artificial Intelligence and Machine Learning process with a manual check by our team.
This data will be used to create a digitalization of the world that is compared with the implemented database and then, what is incremental will be automatically accepted, while the critical points will be analyzed. Once the process is completed, these data will be inserted into a software that will be mounted in the new generation cars that will experience autonomous driving thanks to this new frontier of extremely precise data. "

5) *Will this data be paid for by car manufacturers to be usable?*

"Yes, we are a business company and obviously this data acquisition has a cost and therefore, on the other hand, all the OEM infrastructure has to pay a fee for this new generation cartography."

6) *What is the impact that this revolution will have on the automotive industry and how will it change the way cars are produced?*

"One of the important aspects is to feel and see how customers will change their habits and how they will be satisfied thanks to the improvement of their experience in the car. The building structure on board and on the side of the road is supported thanks to the increasing interactivity of navigators, representing the world in a digital way (e.g., the Audi GLE represents the navigator with virtual reality via camera that correct directions directly on the road creating a superimposed information between what reality sees with the cameras and the cartography behind it).
In addition to better defining the structure on the road, a whole series of objects will also be better defined such as the crowns of trees, signals, traffic lights or some critical issues such as the horizontal part, then stop signs, pedestrian crossings and potholes on the road. This ability to fly over quickly and acquire data with a certain quality allows us to replicate it over time and therefore being able to have more and more updated data. The level of precision is never enough, and we never stop acquiring new data that are increasingly updated in real time; this is the real challenge of autonomous driving that we hope to meet with the drone. "

Here Automotive Navigation On-demand

Here is the world's first Saas Solution for navigation and connected services. HERE Navigation On-Demand lets you deliver freshness beyond the map, including new functionality and UX elements to cars in the field, anytime. Extendable via its software development kit, it differentiates from mobile-brought-in solutions with vehicle-

integrated experiences, including hardware controls, multiple screens, mobile companions and map enablement of ADAS systems.

Figure 8.2

Source: https://www.here.com/platform/automotive-services/navigation-ondemand consulted 05.03.2021

Here is interested in growing its revenues stream through a portfolio of connected services, while reducing investment and risk through HERE Navigation On-Demand's service delivery framework. They offer functionality embedded off the lot or via subscription, and let customers personalize their in-vehicle navigation experience as they go, as shown in Figure 8.3.

HERE Navigation On-Demand reduces the development lifecycle investment for a connected services solution. It's a one-stop-shop for tailoring navigation experiences in any vehicle segment, trim level or platform embedded, mirrored or mobile-only. HERE Navigation On-Demand is based on the HERE Open Location Platform.

When used in tandem, they reduce the development complexity and time-to-market of your location-based services, from data ingestion to delivering the ready-to-use functionality OTA.

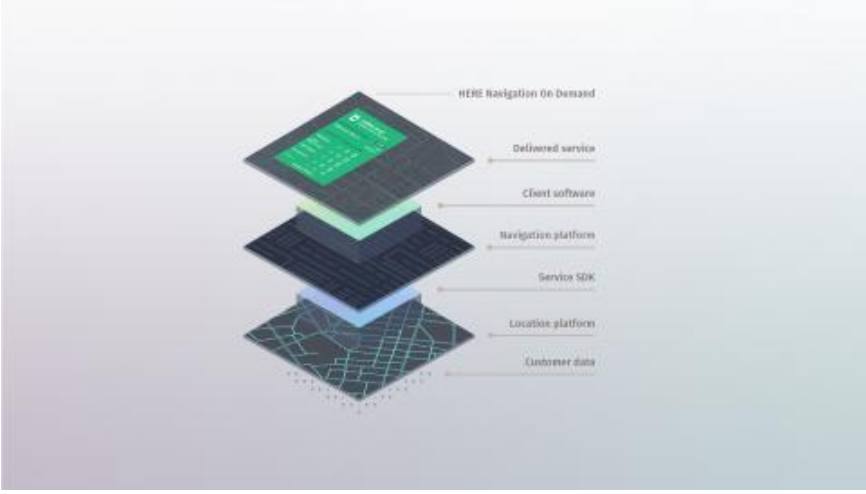


Figure 8.3

Source: https://www.here.com/platform/automotive-services/navigation-ondemand consulted 05.03.2021

The core elements of the service provided by Here are:

- Services Packages which include the assets needed to deliver specific functionality like map data, software and UX elements, as well as APIs and they can be licensed flexibly and combined with each other;
- Client Software: deployed on embedded or mobile platforms, it cached the SP from the Cloud to enable offline availability and integrates with the target platforms like other navigation software;
- OEM Configuration Portal which lets clients create differentiated user experiences for trim levels and vehicle segments and access a marketplace for third-party services and analytics tools.

Here HD Live Map

The Live Map is created thanks to intelligent sensor data for autonomous driving solutions.

As we move into the era of autonomous driving and vehicles, safety, trust in driving with intelligent HD maps and comfort are the key challenges to address. The aim of

Here is to replicate the human driving experience and build trust as a driver, passenger and pedestrian.

There are many critical pieces to the autonomous driving puzzle. The autonomous vehicle needs to understand, as shown in Figure 8.4, it is precise positioning, plan beyond sensor visibility, possess contextual awareness of its environment and have local knowledge of the road rules.

Figure 8.4

Source: http://here.heresf.acsitefactory.com/platform/mapping/map-data consulted 05.03.2021

The purpose of the map is to:

- Be scalable, open and flexible: HERE Connected Vehicle Services and Open Location Platform offers a wide range of products and services that, with HERE HD Live Map, provide the most flexible solutions, as shown in Figure 8.5;

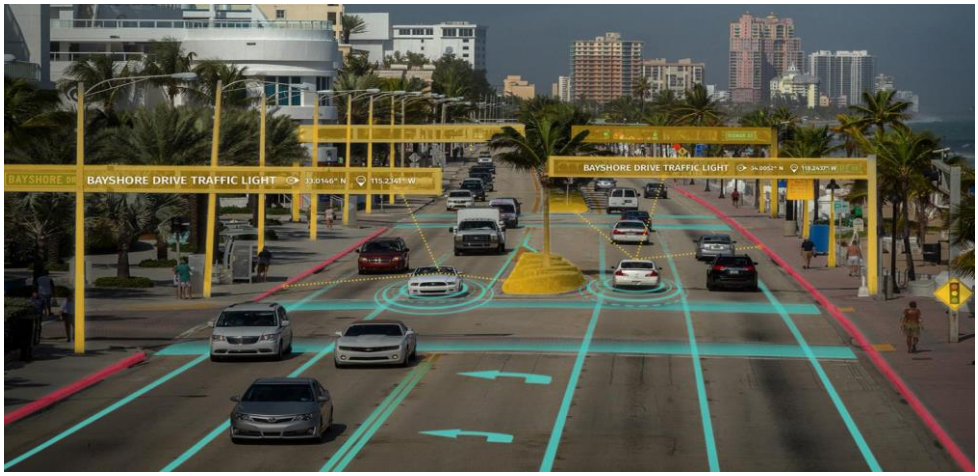


Figure 8.5

Source: http://here.heresf.acsitefactory.com/platform/mapping/map-data consulted 05.03.2021

- Enhance safety and driver trust: Safety comes first on the road. To help a self-driving vehicle make more informed decisions about its driving strategy, the Quality Index-unique to HERE HD Live Map uses Machine Learning (ML) to validate map data against the real world in real time;
- Expand into new markets: as a global solution that can sustain global product roll-outs, HERE is a partner to grow with. Their global map data lets customers build reliable and scalable solutions for the current and future needs with an extensive location-based database;
- Experience reliability: Vehicles rely on the most recent data to inform their driving decisions. Their self-healing map analyzes data from multiple sources, such as satellite imagery, sensors from OEM fleets in real-time and in the near future from drones data, allowing maps to always stay fresh and reliable.

Chapter 9: Expectation for the future

Algorithms and programming advances provide exciting possibilities for the drone industry in the next decade. These unmanned aerial marvels are stimulating the imagination of people all over the world and to be true, at the moment, the industry has only scratched the surface of its potential.

In fact, although drones have been around for a few years, it is only recently that the experts have started to catch up with drones' capabilities of being merged with algorithms and programming.

Drones by design are able to take to the skies and capture visual information of extremely precise measure thanks to the possibility to fly at a reduced distance from the ground compared to whatever flying artifact. Thus, with the right computing power and programming, this possibility translates any landscape into a data point that can be used in various ways. Drone technologies make it easier to capture visual information, mine, analyze and reshape them in order to utilize data extracted making them reach strategic value.

It is amazing to try to understand what the future for drones in all their applications will be and in particular in the automotive industry. What is expected for the future is that thanks to the implementation and innovation in the software industry, cars will be able to arrive to a maximum level of automation thanks to Artificial Intelligence and Machine Learning. Cars will be equipped with software capable to be uploaded real-time and on-demand by the service provider thanks to close partnership between car manufacturer, drones' organizations and software implementers.

The strategic triangle will allow the flow of data which will be composed of three steps, in which first of all drones carry out overflies all the time is required thanks to disciplined law which government are implementing in these years, then the software providers to receive information and data in a photogrammetrical format and to elaborate them in order to insert the maps created in the software, and lastly the car manufacturer enter the "game" acquiring these data embedded in the programming interface and putting them into the car systems allowing them to become smart.

This process, which is the maximum innovation and integration of very different industry, will guarantee several advantages to people in their daily life which go from the

implementation of security standard, to the limitation of traffic congestion, to the foster of efficiency and effectiveness for workers and businessman/woman.

The automotive industry will experience a complete change of direction toward a more intelligent and conscious world.

Drones applications go far beyond the autonomous driving that we explored and analyzed in this thesis and it seems appropriate to mention all the possible applications that are at stake along with the self-driving cars.

One of the incredible applications that experts have developed is the monitoring of vegetative health. In Canada in fact, several industry leaders completed a 4G proof-of-concept mission to demonstrate a real-world application called “Digital Vineyard of the Future”. As a result, the project has been able to report diagnostic map used by entrepreneurs for crop uniformity optimization, irrigation management, harvesting planning and plant health information.

Mapping and surveying represent another high-growth opportunity in drone applications yet for its car-free use of drone technology yet for the higher accuracy projects that researchers can do with drones. Implementing mapping projects means also shifting from Lidar-only point cloud to photogrammetry which is preferred for advanced feature recognition. However, it has inherent limitation with vegetation penetration and linear objects. So, it has become necessary to find the perfect match for innovation in a commutative way; experts define the technological advances of RGB (red, green, blue) colourized Lidar point cloud, which gives the best of both words being very easy to identify terrain features and to be able to create 3D perspective.

Unmanned aircraft revolutionize Agriculture, Conservation and Delivery. In fact, the Environmental Protection Agency has started to utilize drone technology to manage livestock, survey crops and irrigate the fields, as shown in Figure 9.1. It will be interesting to see how farmers will succeed in integrating this innovative technology into their daily life.

Figure 9.1

Source: https://www.edx.org/course/drones-for-agriculture-prepare-and-design-your-dro consulted 20.04.2021

Unmanned aircraft are starting to be used also to monitor endangered species and map all the changes in the ecosystem around the globe, as we can see in Figure 9.2. “Drones are going to change the way data is collected”, says Leanne Hanson, U.S. Geological Survey biologist who has used them to count migrating Sandhill Cranes. Unlike UAV has been classically used for military purpose, biologists are carrying cameras and sensors to be able to look in an unprecedented way to hard-to-reach places, like orangutan nest in the jungles and for stopping illegal logging. Vision-based navigation, in fact, allows the drone to automatically circumvent obstacles being able to grab an object in midairs like an eagle and all while guaranteeing more precision than GPS-based systems.

Figure 9.2

Source: https://kryptomoney.com/a-poacher-tracking-drone-will-be-introduced-by-blockchain-project/ consulted 20.04.2021

Another revolutionary application is the delivery possibility as shown in Figure 9.3. Thus, anything the postman can carry can be also delivered by drone, let this be food, prescriptions, or the last-minute birthday gift for a parent. In several places around the world, drones are used for time-sensitive delivery like medicine and for delivery in places that would be difficult to reach using traditional vehicles. The introduction of drones offers several benefits to the crowd, which go from the reduction of roadway congestion, to the improvement of safety, to the reduction of greenhouse gas emission, to the reduction of streets and bridges maintenance costs. Along with the pros, there are also some cons, like the limited package weights, the requirement of collision avoidance systems, the constrained flight times and the possibility of unpredictable events such as weather or wildlife.

Figure 9.3

Source: https://www.unmannedairspace.info/latest-news-and-information/drone-delivery-operations-underway-in-26-countries/ *consulted 20.04.2021*

Drones are also able to arrive at places that humans can't access, so they can mitigate and relieve disaster as well as deliver emergency supplies to remote location and disaster areas. Indeed, in situation of risk, drones can successfully fly over the interested zone and they can do even more, they can arrive in hidden crevices and support people or animal that have been injured or that require any form of help as noted in Figure 9.4.

Figure 9.4

Source: https://www.pharmaceutical-technology.com/news/zipline-ghana-medical-supplies-drones/ *consulted 20.04.2021*

Another big category of applications which encloses myriads of possibility is law enforcement. In Seattle and Miami, for example, police have already applied the use of a drone to help them in large public events. The appeal comes from the small size, lack of crew and lower cost compared to police helicopters. Looking at Figure 9.5, drones can be used for search and rescue operations, for surveillance thanks to camera systems capable of license plate scanning and thermal imaging as well as radio equipment and other sensors.

Figure 9.5

Source: https://www.dailynews.com/2019/01/25/more-police-departments-are-getting-drones-heres-how-theyre-using-them/ consulted 20.04.2021

Drones can also be used by big tech companies like Facebook and Google using solar power energy to beam Internet to remote locals and this has the power to transform the connectivity as we know it. Indeed, Internet Service Providers (ISPs) can design an Internet of Drones (IoD), which is a "layered network control architecture designed mainly for coordinating the access of UAV to controlled airspace and provide navigation services between locations referred as nodes" (Gharibi et al, 2016). This layer can provide various applications that we have mentioned above such as package delivery, traffic surveillance, search and rescue and more. But of course, all these applications need a robust airspace allocation architecture, given the thousands of daily flights and the risk of intersecting routes. The creation of a network in which all the flight can be done on-demand and in a safe manner, takes with it a series of benefits such as openness, modularity, interoperability, scalability and the important concept of collision free network.

The last application, that complete our deep analysis of drones, is for Real Estate purpose as noted in Figure 9.6. UAVs are completely changing the high-definition videos capture that can be done through neighbourhoods and into rooms. They will provide a unique perspective for featuring property, being able to capture images, video and multiple overhead map images with 360 degrees panoramas. Using drones for aerial photography can show the buyer a much more accurate and cooler description of the property. According to some calculations done by RISMedia, listing agents who use drones for real estate could increase deals closing as high as 68%.

Figure 9.6

Source: https://staaker.com/best-drones-for-real-estate/ consulted 20.04.2021

The COVID-19 pandemics has thrust technology innovations ahead at a rapid pace. Indeed, other cases have been developed that have come to light solely due to coronavirus. The potentiality of drones during this difficult period will be exploited using them to enforce social distancing and monitor crowds. For example, Morocco has launched a fleet of drones to combat coronavirus. However, with all this monitoring of movements, the theme of privacy and civil liberties is emerging due to the fact that governments would be able to monitor civilians all the time.

Large-scale drone integration and autonomation is the solution and this will be able for sure to make advances in the industry with more availability of data and cross-referencing.

Using AI to automatically identify the characteristic of imagery and physical features like measurements and spectrum analysis will improve rapidly the possibility to process an increasing amount of data, reaching the moment when software will drive the heart of drone technology and all the potential applications.

To accomplish this mission, experts will need a combination of ground-based images, manned aerial vehicle images and previously mapped data information in order to be able to reference the processes and to geo-reference the cloud of points.

The perception that people have about drones need to be shifted gradually from the idea that they are simply a manner to take photo of something to the idea that drone technology has the ability to map out any data points being able to collect and connect information to quickly present a full picture of the area interested. This will guarantee to a multitude of industries the possibility to efficiently gather and analyze information that will be crucial for beating the competitions and being at the edge of innovation.

Conclusion

Drones are becoming enormously important having evolved with exceptional growth over the past 10 years. They have been used in agriculture, surveying, monitoring of vegetative health, conservation of endangered species, delivery & logistics, real estates, law enforcement and energy and the next frontier is to use them in the automotive industry. The drones' market will grow significantly because of its increasing use for commercial and professional purposes. Firms are increasingly utilizing drone-acquired data in their business operations to accelerate their service delivery and to expand the universe of possible applications (Giordan et al., 2020).

Through this thesis we have analyzed multiple aspects of the wide industry of drones and the universe of Big Data and Ecosystem underneath. The examination has been carried out following a reasoned path, which sees the start in Chapter 1 with the importance that data have in our lives showing Big Data characteristic, the process of Data Value Chain and the upcoming Digital Transformation. Having understood that, we depart from data as a single entity and we built a complex analysis about Ecosystems creation and its inner interconnections in Chapter 2. We examine player's expectation at the different levels and the sustainability model that is behind the ecosystem. After a deep analysis of the literature on the topic, an empirical context has been developed in Chapter 3 in order to discover the drone's connotations, the company's profiles that have been taken as an experimental case study and the market of drones with its characteristic and applications. It has been studied that to reap the full advantage of the enormous quantity of data produced, firms are taking into consideration the opportunities offered by the technological field of Big Data. However, Big Data need to be processed to gain strategic validation; to do so, they are often included in a Data Value Chain (DVC) system. With DVC we refer to the information flow within a Big Data System as a series of steps needed to generate value and useful insights from data. The value chain permits the analysis of big data for all the steps of the chain.

Such technological advances have been discussed in Chapter 4 arriving at the point that they require that current firms and startups which want to adopt the innovation wave need to reorganize their relations and collaborative forms, in order to be able to meet the new technological and organizational requirements. In fact, in an increasingly interconnected world, economic value is less and less created by one firm alone but rather is created by

correct and strategic combination and enrichment of data by various actors in their data ecosystems, which we deeply discussed in this thesis. Through Chapter 6, 7 and 8 we extensively discuss all the flow of information from the authorization landscape and the data creation by Dronus in Biella flight, examining the type certificate and the Specific Operation Risk Assessment (SORA), to the mining, to the analysis thanks to Here Automotive Navigation On-demand, to the implementation of software embedded technologies by Here. We arrive at the conclusion that a successful Big Data ecosystem shows interactions between all the stakeholders within a digital single market, leading to business opportunities, easier access to knowledge and capital, with the underline of a clear benefit for all. The main challenge that experts need to face is about on how they can give purpose to the data and extract actionable insight from them, going beyond technical innovations and security issues. The expectations for the future, discussed in Chapter 9, are very high and the debate on how to bridge business transformation with Big Data analytics for value creation and to accelerate the autonomous drive development of the society as a lifestyle is still open.

The premise we made referring to performance enhancement, long-term reduction of costs and market profitability and efficiency, seems to indicate an imminent disruption of the market despite the challenges regarding technology development, scepticism and regulations.

Bearing in mind all these topics that have been analyzed through the thesis, the future of drones looks bright.

Acknowledgements

It's so weird that my university cycle is coming to an end…how much effort, space and time I dedicated to it and how many rewards and moments of pride I encountered…
This last year, in which a worldwide pandemic has devasted our habits and lifestyle, has been really difficult for me as a student and as a human being, because of the impossibility to "unplug" from my daily duties and because of the negativity that we breathe constantly interfacing with the awful news.
To proper end this beautiful although tough period of my life, I would like to dedicate this ending space of my thesis to all the people who have contributed, with their tireless support, to its realization and to my entire path.
First of all, I would like to thank endlessly my Supervisor Professor Federica Ceci, who, from the beginning of the row idea, to the definition of all the milestones needed to clearly show the experimental view of the project, has always supported me with passion and with an open mind, that is difficult to find nowadays; for her immense patience, for her indispensable advice and for the knowledge transmitted throughout the drafting process.
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things don’t go as planned and that despite my moment of absence due to my intense study and work, have always found the way to make me feel comfortable and loved. Thanks to her I was able to experience new professional and personal ideas, way of life and to get involved to savour the beauty of simplicity through her extreme sunshine e truthfulness.

Lastly, I would like to thank all my friends and colleagues, for always showing great respect for me and for always giving me that extra hug when I needed it and for encouraging me to do more and more.

In such a difficult moment for world health due to last year happenings regarding COVID-19, my last wish is for mankind, hoping that a real cure will be found and that we will be able soon to carry out a normal and healthy life and that we will be able to hug us again.

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Department of Business and Management

Chair of Management of Innovation

TITLE

Data flying on the future: Integrating Unmanned Aerial Vehicles (UAV) and Artificial Intelligence (AI) for Autonomous driving implementation (Summary)

SUPERVISOR

Prof.ssa Federica Ceci

CANDIDATE

Cristina De Simone

CO-SUPERVISOR

Prof. Tommaso Federici

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Introduction

Drones are growing tremendously in their importance in nowadays lives and applications. They are currently used in agriculture, industries, oil & gas, real estates, public safety, energy, delivery, and the next frontier is to use them in the automotive industry.
What we will demonstrate in this thesis, using an experimental approach, is that Dronus, a company specialized in the production of highly precise drones used in professional applications, will succeed in flying over Biella, our target city, with the Radon Drone to collect strategic data of massive importance, that will be used by Here, a multinational leader company in the navigation sector, to build a highly precise map that will be used for the implementation of the autonomous vehicle software insert in car's system. This flight will change the landscape of the automotive sector that we currently know, allowing Here to collect enough data needed to build an integrated map at high definition (42 Megapixel) of almost all the cities in the world, for the new frontier of the automotive world: the autonomous driving. These surveys will be executed by Dronus, that will become a strategic partner in the collection of data for the implementation of this innovative, potentially worldwide, project. Dronus has the potentiality to shape the technological trajectory of the future in multiple sectors being the first mover on this type of experimentation and having even reached strategic agreements with the National and International legislation entities.

Chapter 1: The importance of data

The volume of data available is growing exponentially, arriving at more than 44 Zettabytes (44 Trillion GB) of useful data in 2020. We live in a time where every device is connected, where sensors are ubiquitous in our world generating streams of data continuously, where data available and consumed on Internet will increase by orders of magnitude, where the Internet of Things will shape inevitably the world as we know it. Innovative new ways of extracting value have been made possible thanks to the technological field of Big Data, which highlights the tsunami of new information available. The current frontier on which competitors are fighting to establish the best performer and to gain competitive advantage is the ability to effectively manage

information and extract powerful knowledge from them. Big Data adoption in fact, is not something that you can transcend, but is an imperative that must be inserted in organizations' core business in order to survive and enhance the establishment. The massive impacts of Big Data go far beyond the commercial world; the proliferation of disposable data is creating the so-called Data Science (Hey et al. 2009) in scientific literature. This new world is a comprehensive approach that shows data as an innovative factor of production, in the same way as physical assets and human capital. The Internet of Things, Sensor Networks, Open Data on the Web, data from mobile applications, social network data is creating a new layer of data environments that requests innovative management strategies which can comply with the birth of this incredible amount of disposable data (Manyika et al. 2011).

Data Value Chain

Big data need to be processed to gain strategic validation and so to be inserted in a Data Value Chain system. A value chain is composed of a series of subsystems each with inputs, processes of transformation and outputs. Rayport and Sviokla (1995) were one of the first in the literature to apply the value chain metaphor to information systems on Virtual Value Chains. This tool can be used to understand the creation of value given by data's information flow, made explicit by a series of subsequent steps useful to the creation of effective advantage.

The European Commission has acknowledged the Data Value Chain as the "center of the future knowledge economy, bringing the opportunities of the digital developments to the more traditional sectors (es. transport, financial services, health, manufacturing, retail)" (DG Connect 2013).

Big Data value chain is used to manage, integrate and coordinate data through the service continuum from data generators to end users that seek to make decisions. They are fundamental to create collaborative partnership and to effectively manage the multitude of data from different stakeholders thanks to the optimization of service delivery and prime decisions. To allow positive results for all strategic actors, data are wisely streamed to establish a portfolio-management approach that allows companies to invest in people,

processes, and technology that will maximize the value of joined data and informed decisions.

It is possible to identify 5 phases in the Data Value Chain, briefly described as follows:

- *Data Acquisition*: a process by which the data are gathered, filtered and cleaned to generate an element that can be inserted in the Data Warehouse to carry out the necessary analysis;
- *Data Analysis*: a process that involves the exploration, transformation and modelling of data with the aim of making data useful for strategic purpose;
- *Data Curation*: a process by which involved data management is obtained by ensuring that the required quality of data has been met over the entire life cycle;
- *Data Storage*: a process by which the data are correctly clustered and stored in a scalable way in order to be quickly and efficiently accessed by companies and actors that need them;
- *Data Usage*: activity of proactive integration of the data analysis in the business processes through tools that are aimed at supporting the analysis and the access to storage data.

Achieving Business Impact with Data

Nowadays data are becoming more and more important and they are challenging the world as we know it. They are becoming the so-called “new oil” or the “new gold” due to their high applicability and potentiality in introducing and managing new key best practices. In fact, not only the volume available of data is skyrocketing, but also their advanced analytical capability in shaping deeply the methods and approaches used to develop insights and eventually actions, is of increasing relevance.

Machine learning, which enables forefront analysis for a range of statistical methods from regressions to neural networks, has steadily improved the computational power of processing units of data and has lowered the expected cost of development for IoT nodes. As shown in McKinsey research, the unit price in USD will decrease by 50% thanks to better opportunities in the market of MCU (micro-controller unit), connectivity and sensors. Computational advances and the tremendous increase in the amount of complex data management require power infrastructures to access it through the next generation

of machine learning methods such as deep learning. Digital world is extremely connected and embodied in our physical world, having become a new corporate asset interacting to all the industrial practices, from marketing, to sales and product development. Thus, the way we can make data speak, helped by machine learning and AI (Artificial Intelligence), is connected with the capture of their full potential through the observation of how complex elements are linked to each other in an inclusive picture, without focusing too much on a single technical component. Supporting the hypothesis of Niko Mohr and Holger Hürtgen, we can arrive at the consideration that the insights value chain is multiplicative, that means that if one link in the chain is equal to zero, your total final impact will be null. “The full Ecosystem is only as good as its weakest components”.

Chapter 2: Ecosystems

Organizational designs such as the functional, divisional or matrix forms are primarily ways of arranging and managing internal relationships. Yet such designs are also safeguarding the boundaries of organizations and indirectly regulate relationships to the external environment. Organizational boundaries have always been closely linked to organizational design, explaining very well what is inside and what remains outside and how relationships to other actors in the environment are governed or managed.

The diffusion of connectivity services and software allow companies to redesign their environment towards a structure that shows less strict discrepancy between what is internal and what is external, making the boundaries of company more blur.

Instead of bounded and concentrated forms, platforms and ecosystems are diffused or distributed organizations with multiple links to their environments.

So, if we consider the production and consumption side there are many dispersed participants to the ecosystems that interface with each other in a very complex framework. The participants to the ecosystems are inserted in various layers of importance, in fact not only the direct players have interests in the products/services, but there is a broad category behind them that shows conflictual and variegates interests and that influence the process of the entire value chain.

Ecosystems are linked also to consumer experience and to the conditions under which a core product is combined with complements (ex. Computers and hardware components or operating systems and apps). To allow people to freely combine elements that exist in

the market, you need to establish standards in order to combine the items. Some of the ways such conditions are managed require the emergence or building of networks of affiliated organizations we call Ecosystems or Platform-based Ecosystems that coordinate on the production and/or distribution stage.

Player's Expectations and different levels of Ecosystem

In literature, an ecosystem is a complex network of affiliated organizations whose resources, activities and outputs are linked in multilateral ways that cannot be reduced to the sum of bilateral connections between ecosystem participants, but show dependencies running across many participants and along several dimensions. Participants are linked together by several resources or product/service dependencies (component-complement relationships) that confer to them distinct advantages that would have otherwise not emerged. In our case, as shown in Figure 2.1, it is clearly showed the strategic reciprocal importance of Dronus and Here. Dronus, in fact, is responsible for the generation of data, that will be transferred to Here, in order to be examined, sized and cleaned to generate a cloud of points that will constitute a highly precise picture (photogrammetry) of the territory for automotive application.

As these two big players interact together (Micro Level), other actors, that are included in a bigger layer (Marco Level) of the ecosystems, enter the fields and shows interest in this connection.

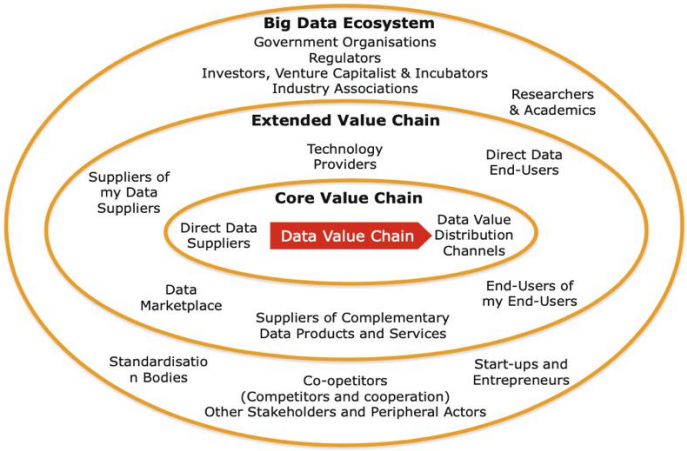

Figure 2.1

Cavanillas, Wahlster Editors, R 2016. New Horizons for a Data-Driven Economy. Springer Open: C3, P 35

Is now necessary to list what are these actors and try to understand what their expectations, responsibilities and strategies are to facilitate/challenge and support the initiatives in the ecosystems.

The biggest interest is represented at the Micro Level by the two players that generate the first and the more important interaction: the producer and the operator. The expectations of the producer/vendor are to succeed in the development and supply of data and to be able to sell them globally and make the technology be known worldwide. The interest of the operator/end-user is instead, to achieve attractive partners thanks to the innovative business model (ex. automotive brands) and to reach a broad acceptance and usage of service.

Another big category of players is represented by competitors/coopetitors. Since the business we will deep dive into is the fluid phase, where major breakthrough innovation creates a shock and this creative disruption moment is characterized by product innovation, it seems preparatory to mention dominant designs and why they are selected. Dominant design emerges after the era of ferment in which there is an initial period of turbulence in the market because all companies try to establish the standard dominant design and so they focus more on the product. After this period, we have the transition phase in which the dominant design emerges, and companies shift focus on low-cost production and process innovation. In the fluid phase there is a race through companies that are trying to obtain the dominant design to shape the technological trajectory of the future, influencing the characteristics of the standard of the product itself.

The emergence of a dominant design is a very important moment, significantly affecting firms' strategies and performances. A dominant design also shapes future generations of products/services in the category, resulting in "an architectural franchise" for winning firm potentially locking out competitors.

In the broader layer of the ecosystems there are Universities and Research Institutes, whose contributions is to acquire funding, create new ideas and train new potential talents, then Angel Investors, that seed investments (i.e., Seed Rounds) and provide advice for startups, Local Governments and State, who provide rules, regulations, policies and

sometimes research funding and National Entities, like ENAC, that Certify the product/services or the process itself.

Coordination between ecosystem participants often occurs indirectly through standards and interfaces and realized through sophisticated IT-based systems that are governed by modular architectures.
Understanding ecosystems requires a persistent pondering of how technology is involved in ecosystem formation through:

- Data management systems;
- Modular architectures;
- APIs (application programming interface) and boundary technologies through which different organizations exchange data and services;
- Data links;
- Data-based services.

All is based on the fact that they can transfer/link an enormous amount of data in the best way possible. Expand the idea of complementarity in the exchange of data on the basis on which the organizations are building their relationships and on which they interact.
In the current digital world, data are essential in the making of complementarities, they are steadily renewable, reconfigurable and expandable and they can continually be involved in the making of new services.

Chapter 3: Empirical context

Drones connotations

The drones' market is anticipated to grow significantly because of its growing use for commercial and professional purposes. Companies are utilizing drone-acquired data in their business operations to accelerate their service delivery and to expand the universe of possible applications. Progressions in-flight controls and technology in addition to innovations in portable video & photography technology have augmented the demand for drones including tiltrotors, multi-copters, and helicopters. The evolution of innovative technologies, such as geo-fencing and collision avoidance that make drones safer has triggered increased adoption of drones in several industries. Through all, the thesis I will

follow an experimental approach in order to study and elaborate on the main application of drones, focusing on the automotive industry. The drone's scenario is complex and variegated. There are different kind of drones, based on the weight and on the roles that the aircraft covers.

Dronus

Dronus is an innovative startup focused on unmanned aircraft systems, that was established in 2018 from the idea of Marco Ballerini, aerospace engineer, who has always had a passion for drones and has always believed that the high reliability of autonomous drones that carry out inspections and missions autonomously and repetitively, could have had enormous application in almost all the existing industrial sectors.
Dronus will utilize a drone, called RADON that obtained, after 1 year of processes, from the National Civil Aviation Authority (ENAC) the "project certification pursuant to art. 10.6 of the Sapr regulation" for the sr-sf6c system.

Who is Here and what are its expectations?

Here Technologies was born in 1985 with the name of Navteq, the first startup in the world that deals with the creation of digital cartographic maps. In 2013 the company became Here Maps and in 2015 it was acquired by the consortium formed by Audi, BMW, Daimler, Bosch and Continental which for the first time come together because they look to the future of autonomous driving to fight the possibility of Google investment and try to arrive on time with a system that is useful for the implementation of autonomous driving.

The market of drones, their characteristics and applications

In 2024, the global drone-related industry is estimated to be worth over $ 43 billion, having already generated $ 14.1 billion in 2018. This specific market will grow at a CAGR (compound annual growth rate) of 20.5 % to almost triple its value in 2024.
Drones are divided into different families according to their physical characteristics (hardware), in particular they are classified according to these three distinctions:

- With Pale Structure: These are drones equipped with motors and blades, which are intended to offer a stable flight that can be controlled by means of the appropriate remote control, which must have frequencies that are not harmful to a person's health
- With Planar Structure: There are also bladeless drones which are designed to glide: in this case the propellers are absent which are carefully replaced by two large wings;
- With Hybrid Structure: Finally, there are hybrid versions, i.e. drones equipped with both systems (engine and wings) but also drones that integrate flight with ground movement and which can therefore be used thanks to wheels (these are drones that are used for more professional purposes).

Building Information modeling (BIM)

The use of drones can however go much further: they can, indeed, seamlessly integrate within BIM processes, increasing efficiency levels throughout the entire life cycle of buildings.

BIM (Building Information Modelling) is a digital tool disrupting the construction industry as a platform for central integrated design, modelling, asset planning running and cooperation. It provides all stakeholders with a digital representation of a building's characteristics in its whole life cycle and thereby holds out the promise of large efficiency gains. Through all the life of the building Drones represent ideal tools for performing inspections of parts of the building that are difficult to reach in total safety. In the dismantling phase instead, drones can be used to monitor disassembly, demolition and restoration phases of buildings that have reached the end of their life cycle. The in-depth knowledge of a building also enables stakeholders to identify any elements that could be recovered, or any particular material that needs to be disposed of with greater care (special waste, dangerous substances, asbestos etc.).

Geographic Information System

The Geographic Information System (GIS) (also called geographic information system or territorial information system) is a computerized information system allowing the acquisition, recording, study, design, sharing and show of information from geographic data (geo- referred). Thus, it can associate data with their geographical position on the earth's ground and process them to extract useful information.

Chapter 4: Technical description

Digital Surface Model and Digital Terrain Model

For Digital Surface Model (DSM) we mean the earth's surface comprehensive of the objects (buildings, trees and other artifacts) that are on it. To generate high resolution of the representation required with inserted buildings, trees separation and urbane drainage elements, DSM is only one of the best ways to do it.
An important aspect to be understood is the "Surface characterization". LIDAR data, as we will explain better below, helps to generate a digital surface model (DSM) and to detect automatically object such as streets, parking place, grassland, bare soil etc., that are not required for the chosen representation. After the detection each of the elements will be marked with a unique surface property in terms of rainfall-runoff and surface flow. For purpose of better understanding, let's say that a stormwater falling on the trees; it will have an interception period before touching the surface, or let's say that the rain is falling on the street; it will start the runoff going inside manholes whereas rainfall on the grassland will start infiltration.

The Digital Terrain Model (DTM) represents the trend of the soil surface without anthropogenic and vegetational elements (bare earth).
It is possible to obtain a DTM with an aerial photogrammetric survey if the terrain is not very thick in vegetation, so you can filter the cloud of point in order to have only information about the terrain. DTM and DSM can be obtained from a Light Detection and Ranging (LiDAR) survey, on the condition that the tools used in the measurements can track the different pulses coming from the laser beams reflected by encountered one. The first impulse (first return) defines the DSM, the last impulse (last return) the DTM. If the

laser scanner record only the first impulse, engineers are able, with practical measures during the survey, to obtain a DTM.

Photogrammetry and LiDAR

Photogrammetry is the science of making measurements from photographs. The input to photogrammetry is photographs, and the output is most of the times a map, a measurement, or a 3D model showing real object or entire aggregate of constructs. Most of the maps we use today are a result of photogrammetry taken from aircraft and drones. Photogrammetry can be classified in two ways depending on the field based: Aerial, and Terrestrial (or Close-Range) Photogrammetry. The first category is most of the times done by drones and UAVs; they generate photos that are not processed in a stereo-plotted or thanks to automated desktop systems. In the second category, the output is not a topographic product but instead, directly a map, a point cloud or a 3D model that feature stockpiles, buildings, trees and all kind of artifacts.
Lidar is a remote sensing method used to examine the earth's surface. It uses light in the form of pulsed laser to measure variable distances on earth. These light pulses are able to generate 3D data about the shape of the surface and its characteristics.

Technical planning for Biella flight

Dronus will comply with the creation of all the processes and photogrammetric survey thanks to two types of planning, which are the legislative, which will be analyzed in the "authorization landscape" section and technical.
Technical planning is a very complex matter, which needs to take into account multiple aspects and variables that can incur suddenly or that can be planned in advance. It must deal with a correct and precise definition of the log flight data, which are the one that contains all the useful information on what will happen from when the drone's battery will be switched on, till the shutdown and they can have various format depending on the use to be made of it, so to say, they can be in .TXT (binary file), in .CSV (Litchi application that can be converted in Excel format for the individuation of interesting elements and the visualization of the coordinates of latitude and longitude of all the survey), .DAT and more. Thanks to reverse engineering, is possible for Dronus, to make

a detailed analysis of the flight log files in order to understand the functioning of the evidence collected. For example, a .DAT file starts to be registered when the battery is switched on and it will indicate the date and timing of the flight that comes from the remote control.

Chapter 5: Authorization landscape

The authorization process is a very complex matter when it comes to Drones and it is in a continuum change due to the novelty of the market.

To now, the two entities that in Italy discipline drones and what companies and people can do with them and control the air traffics are ENAC (Ente Nazionale per l'Aviazione Civile) just for the strict Italian territory and ESEA (European Union Aviation Safety Agency) that works at European level. Till 31 December 2020, the regulation valid in Italy was the "Remotely piloted aircraft", authorized by ENAC and so, the only way to be enabled to do the Biella flight was to ask for an Experimental BVLOS authorization to ENAC, after having confirmed in front of ENAC eyes that the aircraft/drone is perfectly capable to support it without complications.

To make the reader aware of the difficulty to obtain this kind of authorization, it has been tracked that from 2017 to 2020 there have been just 15 experimentation successfully given by the legal entity.

The two regulatory entities are equally valid because we are in a transition phase that should be arrived in two years to a moment in which ENAC rules will be included and harmonized in EASA regulatory body. Of course, the two documents are different in terms of how they face various topics (es. harmless drones for ENAC need to weigh under 300 grammes and for EASA they should weigh below 250 grammes) and so it will be interesting to see what of the two will succeed in different articles and chapters.

Since 31 December 2020, it depends on Operation Risk if a BVLOS operation has to be authorized by ENAC or EASA.

Specific Operation Risk Assessment (SORA)

Dronus need to pass through multiple complications and problems, which are given by the immaturity of the law in the drones industry, by the certification of the drones by ENAC, by the articulated authorization landscape and subsequently by all the physical complications that can incur in the moment of collection of data, from the meteorological phenomena to the architecture of the ecosystem.

The Dronus flight over Biella is a BVLOS (Beyond Visual Line of Sight) one and it has been approved by a ENAC commission thanks to positive results on the risk assessment analysis. To be approved by ENAC is a very complex tasks, because after having specified the category of the drone, the characteristics of the company and the flight and maintenance manual and you need to pass the risk analysis with SORA (Specific Operation Risk Assessment). SORA is a multi-stage process of Risk Assessment aiming at analyzing the risk of certain drones' operations, which are of two types: Ground Risk Class (GRC) and Air Risk Class (ARC). The pilot needs to effectively understand the mitigation measures in order to lower this risk to an acceptable number.

How to effectively mitigate the risk? Thanks to three principal measures, as reported in Figure 3:

- M1: the company ensures that below the flight zone there will be no people;
- M2: the company ensures that the drone will have a parachute;
- M3: the company ensures that it will insert an Emergency Response Plane (ERP) in order to circumscribe the damage in the defined area and not propagate it.

		Robustness		
Mitigation Sequence	Mitigations for ground risk	Low/None	Medium	High
1	M1 — Strategic mitigations for ground risk[1]	0: None -1: Low	-2	-4
2	M2 — Effects of ground impact are reduced[2]	0	-1	-2
3	M3 — An emergency response plan (ERP) is in place, the UAS operator is validated and effective	1	0	-1

Fig. 1. Source: Dronus SpA SORA analysis, consulted 16.02.2021

Thanks to these mitigation measures, the assessment level can be lowered to 4. Aeronautic procedures need to be carefully implemented following all the necessary steps in order to arrive at level 2, due to high liability in a multitude of different sectors and contexts.
The final GRC is established by adding all the correction factors (-1-1-0=-2) and adapting the GRC by the resulting number (6-2=4).

The analysis on the SORA is very important for the implementation of the flight, and by the collection and analysis of data through photogrammetry, Digital Surface Model (DSM), Digital Terrain Model (DTM) and Building Information Model (BIM), that will show the process of data through the entire Data Value Chain and that will make the reader understand the magnitude of these new process discovery for the automotive industry and more.

Chapter 6: Process of Data through the Value Chain

In this Chapter, the process of Data will be analyzed, following a clear and defined path, with multiple perspective, which focused on the main players of the project and the actors which gravitate in this Micro-Ecosystem.
To fully understand the capability of Drones and the revolution that they have the possibility to bring in all sectors in which Data play a crucial role, it is important to try to map as clear as possible the path of Data from the raw beginning to the enriched end.
In the data flow, there are multiple factors that need to be taken into consideration, as well as actors and pressure entities which have the power to shape the context and the subsequent target setting.
The principal players, as anticipated in the previous Chapters, are Dronus and Here. They are the ones involved face-to-face in the exchange of Data which will be manipulated and supervised by other actors in order to acquire legal and precise valence.
The process, which can be traced in its totality in Figure 8.1, is divided inwo two big branches, the first one is managed by Dronus and its Team and the second one is controlled by Here and its engineers.

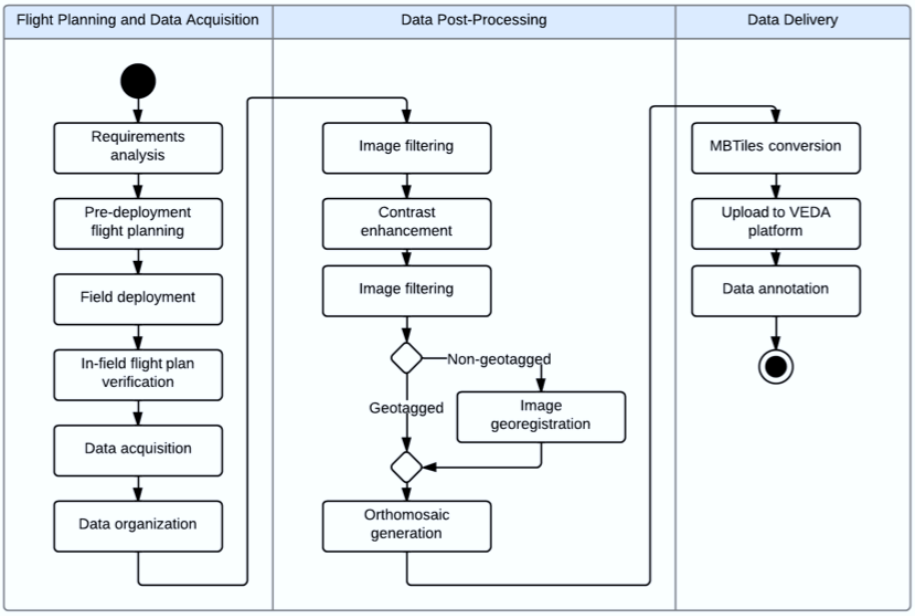

Figure 8.1

The Collection phase is composed of four big steps, as noted in Figure 8.2, which are:

- Taking pictures with Dronus drone in the interested area. As mentioned above and fully explained in the previous chapters, the overflight has been done after a multitude of condition checks, risk measurements, fixed requirements compliance analysis, pre-deployment flight planning and in-field flight plan validation;
- Upload of these pictures into a personalized Dronus Cloud which is capable to retain information thanks to various layers of security, which can vary depending on the type of clients requesting the Data. In the case of interaction with Here, Dronus had implemented the maximum layer of security, which is composed by a VPN that encrypts the information and shield online activity from cybercriminals and Internet Service Provider (ISP);
- Process picture in cloud thanks to ad-hoc softwares and high-tech privacy systems. Dronus have implemented the Cisco SecureWorkload (Tetration) which guarantee a micro-segmentation policies of the network through comprehensive analysis of application communication patterns and dependencies. It also ensures high protection of the workloads with consistent policy enforcement at scale throuh distributed control of native host firewalls and infrastructure, including Application Delivery Controllers (ADCs) and firewalls;

- Check result in web browser and specific platforms, as Agisoft Methashape, which discover intelligent photogrammetry, process digital images and generate 3D spatial data to be used in GIS application and for indirect measurements of objects of various scale.

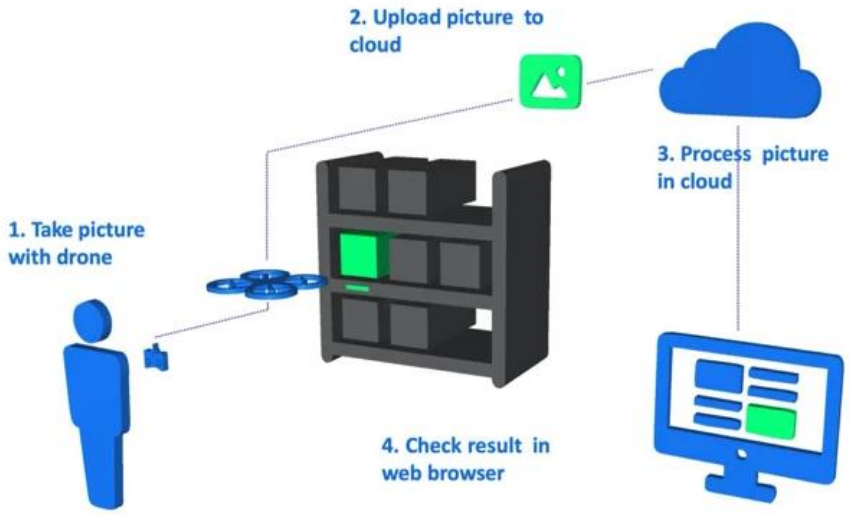

Figure 8.2

After having organized the Data in a structured way, in the data post-processing phase, Here acquired via securitized way the codes for the authentifications needed for decrypting the information included in Dronus Cloud and its software applications. The process that gives strategic validation is run by Here thanks to the possibility to create multiple outputs from a single entity of Data.

So, Here has organized the second part of the flow, which we called the "enrichment phase", in four steps:

- Image georegistration, which permits to match UAV Dronus images to georeferenced image Data by relating an internal coordinate system of data to a ground system of geographic coordinates;
    - Orthomosaic generation which is a high resolution imagery based on the source photos and reconstructed model. The most common application is aerial photographic survey data processing which can be saved in .PSX

format for chunks with the existing mesh or Digital Elevation Model (DEM).

- Upload to Here Platform, which is a distributed network with the highest level of protection imaginable. Using combinations of distributed channels, encrypted communication channels, token files and smart contracts, it guarantees the integrity and immutability of information. Here Maps uses an accurate snapshot of the interested zone with location technology that provides context and relevance to data. Thanks to Dronus Photogrammetry Here is able to build Road Geometry, Point of Interests (POIs), 3D landmark advanced city models and real-time traffic predictive analysis. Digital map technology is efficient, safe, accessible and accurate. Land level intelligence and visual guidance combined with advanced driving assistance systems is what is made possible thanks to the elaboration of geospatial insights and data;
- Data annotation is the process of labelling the data available in various formats like video or images. For supervised Machine Learning labelled data sets are required, so that machine can easily and clearly understand input patterns. This technique is directly benefiting the Machine Learning algorithm to get trained with supervised learning process accurately for right prediction. Artificial Intelligence and Machine learning are one the fastest growing technology and for Here to create such automated machines thanks to intelligent software, a huge amount of training data sets is required.

At this point of the process, Data have arrived at Here Warehouse and they have been analyzed to discover the potentiality of their aggregation and interconnection. Here supports its structured data extrapolation and usage thanks to a highly precise manipulation in order to make them easier to read. Indeed, Here can achieve higher value thanks to the interconnection of Data, capability and knowhow which come from multiple sources (es. past projects, employees skills, organization flexibility) as it will be understood in the next chapter thanks to direct evidence.

The process of exchange and integration of data on the behalf of these two big players represent a new possibility for the future and a frontier which has the potentiality to be the door for a new reality and a new life.

Chapter 7: Here Elaboration of Data

Interview with an Insider

In this Chapter is has been adopted an interview procedure in order to understand how Here will elaborate data and what are its expectation from the partnership with Dronus.

1) *What are your expectations and your goals from this partnership?*

“It is not just a matter of autonomous driving, our goal is broader and more important. Despite COVID 19, which has slowed down our action plan, it is an initiative that continues because technology is evolving. With Dronus drone we want to implement a mapping, more detailed cartography, a reconstruction of the digital world of a higher level with such high detail that we can perfectly shape some critical objects like the canopy of trees and the billboards or stacks. These objects will allow the Telco world to better analyze what are the radio frequency emissions. The possible applications do not stop there, there is the issue of urban safety and the creation of landing areas for safe drones to avoid various cases of danger and many others more. Autonomous driving certainly brings with it all the safety systems, that make, as they increase, you will arrive at autonomous driving step by step. Some cars have a level 3 but by law the authorization is stopped at level 2.”

2) *What is your role in the Data Value Chain?*

"Dronus at this time, as agreed, will give us a single image or a series of angled or vertical images, in .JPEG or other formats, depending on the type of terrain, connected with a GPS position and with reference points (GCP) such as e.g., the antenna or the church tower.
Then, there will be two processes, of which:

- First Process: automatic or semi-automatic in which the Artificial Intelligence will recognize all that is the positioning of specific infrastructures (e.g., trees, tram wires, light poles, traffic lights, signs, buildings, etc.);

- Second Process: manual made by Team India to confirm situations of doubt in the face of the comparison with our database (DB) and so the differences will be manually validated.

This means that Here will significantly increase the accuracy of the acquired data for the part relating to the height (since with the scanner on the road it is possible to reach a maximum of 15 meters), the part of the study of the roofs of the houses and the categorization of a series of infrastructures that will be able to be studied better than satellite images.

All this will then be an Artificial Intelligence and Machine Learning process with a manual check by our team.

This data will be used to create a digitalization of the world that is compared with the implemented database and then, what is incremental will be automatically accepted, while the critical points will be analyzed. Once the process is completed, these data will be inserted into a software that will be mounted in the new generation cars that will experience autonomous driving thanks to this new frontier of extremely precise data. "

3) *Will this data be paid for by car manufacturers to be usable?*

"Yes, we are a business company and obviously this data acquisition has a cost and therefore, on the other hand, all the OEM infrastructure has to pay a fee for this new generation cartography."

4) *What is the impact that this revolution will have on the automotive industry and how will it change the way cars are produced?*

"One of the important aspects is to feel and see how customers will change their habits and how they will be satisfied thanks to the improvement of their experience in the car. The building structure on board and on the side of the road is supported thanks to the increasing interactivity of navigators, representing the world in a digital way (e.g., the Audi GLE represents the navigator with virtual reality via camera that correct directions directly on the road creating a superimposed information between what reality sees with the cameras and the cartography behind it).

In addition to better defining the structure on the road, a whole series of objects will also be better defined such as the crowns of trees, signals, traffic lights or some critical issues such as the horizontal part, then stop signs, pedestrian crossings and potholes on the road. This ability to fly over quickly and acquire data with a certain quality allows us to replicate it over time and therefore being able to have more and more updated data. The level of precision is never enough, and we never stop acquiring new data that are increasingly updated in real-time; this is the real challenge of autonomous driving that we hope to meet with the drone. "

Chapter 8: Expectation for the future

Algorithms and programming advances provide exciting possibilities for the drone industry in the next decade. These unmanned aerial marvels are stimulating the imagination of people all over the world and to be true, at the moment, the industry has only scratched the surface of its potential.

In fact, although drones have been around for a few years, it is only recently that the experts have started to catch up with drones' capabilities of being merged with algorithms and programming.

Drones by design are able to take to the skies and capture visual information of extremely precise measure thanks to the possibility to fly at a reduced distance from the ground compared to whatever flying artifact. Thus, with the right computing power and programming, this possibility translates any landscape into a data point that can be used in various ways. Drone technologies make it easier to capture visual information, mine, analyze and reshape them in order to utilize data extracted making them reach strategic value.

The COVID-19 pandemics has thrust technology innovations ahead at a rapid pace. Indeed, other cases have been developed that have come to light solely due to coronavirus. The potentiality of drones during this difficult period will be exploited using them to enforce social distancing and monitor crowds. For example, Morocco has launched a fleet of drones to combat coronavirus. However, with all this monitoring of movements, the theme of privacy and civil liberties is emerging due to the fact that governments would be able to monitor civilians all the time.

Large-scale drone integration and autonomation is the solution and this will be able for sure to make advances in the industry with more availability of data and cross-referencing.

Using AI to automatically identify the characteristic of imagery and physical features like measurements and spectrum analysis will improve rapidly the possibility to process an increasing amount of data, reaching the moment when the software will drive the heart of drone technology and all the potential applications.

To accomplish this mission, experts will need a combination of ground-based images, manned aerial vehicle images and previously mapped data information in order to be able to reference the processes and to geo-reference the cloud of points.

The perception that people have about drones need to be shifted gradually from the idea that they are simply a manner to take a photo of something to the idea that drone technology has the ability to map out any data points being able to collect and connect information to quickly present a full picture of the area interested. This will guarantee to a multitude of industry the possibility to efficiently gather and analyze information that will be crucial for beating the competition and being at the edge of innovation.

Conclusion

Drones are becoming enormously important evolving with exceptional growth over the past 10 years. They have been used in agriculture, surveying, monitoring of vegetative health, conservation of endangered species, delivery & logistics, real estates, law enforcement and energy and the next frontier is to use them in the automotive industry. The drones' market will grow significantly because of its increasing use for commercial and professional purposes. Firms are increasingly utilizing drone-acquired data in their business operations to accelerate their service delivery and to expand the universe of possible applications (Giordan et al., 2020).

The volume of data available is growing exponentially, arriving at more than 44 zettabytes (44 Trillion GB) of useful data in 2020 (Sivarajah, Kamal, Irani, & Weerakkody, 2017). It has been studied that to reap the full advantage of the enormous quantity of data produced, firms are taking into consideration the opportunities offered by the technological field of Big Data. However, Big Data need to be processed to gain

strategic validation; to do so, they are often included in a Data Value Chain (DVC) system (Chiang, Grover, Liang, & Guest, 2018). With DVC we refer to the information flow within a Big Data System as a series of steps needed to generate value and useful insights from data. The value chain permits the analysis of big data for all the steps of the chain.

We arrive at the conclusion that a successful Big Data ecosystem shows interactions between all the stakeholders within a digital single market, leading to business opportunities, easier access to knowledge and capital, with the underline of a clear benefit for all

The premise we made referring to performance enhancement, long-term reduction of costs and market profitability and efficiency, seems to indicate an imminent disruption of the market despite the challenges regarding technology development, scepticism and regulations.

Bearing in mind all these topics that have been analyzed through the thesis, the future of drones looks bright.

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