Part 2. Description of the intended valorisation and knowledge transfer

In this part of the proposal the valorisation potential of OmniDrone is detailed. We start in Section 2.1 with the rationale behind the project, describe its evolution and set-up and how it fits in a much broader framework of (industrial) collaborations. Next, in Section 2.2, we detail the valorisation potential and concrete valorisation objectives, starting from 4 concrete valorisation cases, but also elaborating on the very large yet realistic broader valorisation context. Finally, in Section 2.3 our valorisation strategy and approach is detailed, explaining how we will construct a vibrant ecosystem where interested parties can interact to discuss follow-up projects, starting from the 4 concrete cases, and evolving to a creative starting place for novel concrete follow-up projects, driven by the OmniDrone results and market needs.

2.1. Rationale (including the preparatory phase and the wider valorisation framework)

In this section we will highlight the rationale behind OmniDrone, illustrate how we came through multiple contacts with industry to the current set-up, and describe the wider valorization framework.

2.1.1 OmniDrone rationale and background

Interest in UAV technology is rising since cheap and powerful platforms are becoming available with rich functionality. Since we started with the definition of this collaborative, Flemish, industry-driven research proposal in January 2014, we had numerous discussions with companies in Flanders, all agreeing that there is a huge potential for the 'Internet of Flying things', i.e., connected smart flying robots. Yet, to achieve this, several regulatory and technical bottlenecks need to be removed: (1) safety & reliability, (2) ease-of-use and (3) lifetime of the UAV. OmniDrone aims to remove those bottlenecks by proposing **a breakthrough 720 degree camera payload with reliable wireless communication, on-board processing and central learning & control for ease-of-use**. OmniDrone will propose technology, in line with regulatory trends, to help Flemish stakeholders to be the first to achieve truly 'connected and smart' UAVs, taking a pioneering role in the Internet of Flying things. After many discussions with relevant stakeholders, we will rely on the availability of frames and autopilots, and instead invest in the pioneering payload to achieve reliable 5G wireless communication, full 3D omnidirectional view, and cognitive vision. During the recent Drone Convention about the 'Internet of Flying Things', in May 2016, these three fundamental technical roadblocks were confirmed to still be the key bottlenecks in UAV technology, demanding urgent research breakthroughs towards the many stakeholders, of which a necessary and sufficient subset is represented in the OmniDrone IAC.

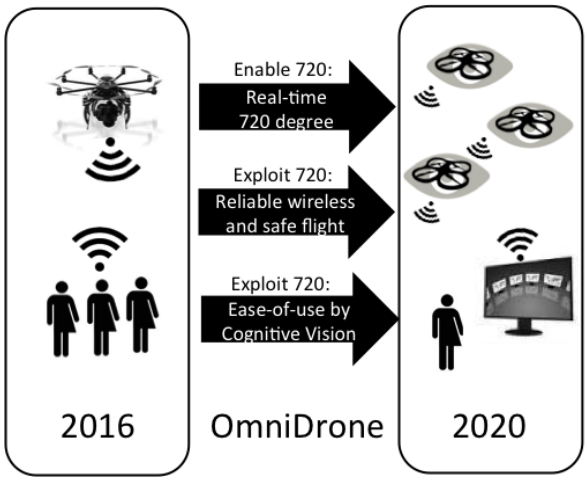


Figure 1: OmniDrone will propose breakthrough technology enabling safe, reliable and easy-to-use UAV systems and novel applications.

This OmniDrone breakthrough 720 degree payload can be used on any UAV frame, in any setting (even static), for a broad range of UAV applications. As the UAV challenges are often similar in each market, all urgently needing these reliable and easy-to-use systems, the OmniDrone technology has the potential to unlock the use of UAV systems in many parallel markets. **The versatility of the OmniDrone payload is a key strength.** After many discussions with stakeholders since January 2014, many ideas for follow-up projects, novel applications and valorization cases were created. Such broad valorization potential is attractive, yet becomes unstructured and unmanageable if not concentrated on some key priority markets and cases. On November 27, right before the very successful workshop on "ICT for UAV's", organized by the LICT coordinator with presentations by KU Leuven OmniDrone partners and some members of the IAC & VB, we discussed with the initial IAC companies how to structure the valorization potential. Companies mentioned that application-driven technology, focused IAC interactions and concrete problem statements with well-defined follow-up trajectories would be valuable for them, in addition to the OmniDrone technology itself. An application-driven focus would also enable to streamline the valorization strategy. Hence, **in order to safeguard the broad potential of our technology, while still enable companies to also sharpen their specific business models, work on well-defined applications with complementary business partners, in focused and realistic trajectories, we decided to structure the OmniDrone valorization around 4 concrete cases**, each with a small set of companies covering the entire value chain, enabling focused discussions and follow-up trajectories.

Compared to the CAMELIUS SBO proposal, submitted as a first iteration in January 2015, we hence mainly strengthened and focused the valorization approach around the 4 selected valorization cases.

In addition to this valorization focus, we also increased OmniDrone's technical focus on 720-degree technology. This is more narrow than the original CAMELIUS focus (where other camera's and even IR sensors where considered), but allowed to more tightly align with questions from industry regarding focus and 3D-awareness. Omnidirectional 3D is a logical step to enable more safety (sense&avoid) and also ease-of-use, as it allows to do camera framing as a simple post-processing step, and not during the flight itself.

We summarize the main milestones that led to the current OmniDrone proposal. More information about detailed interactions with the companies and stakeholders is available in the attached logbook in appendix.

- *January 2014:* decision to start a collaborative research project between KU Leuven and U Hasselt focusing on camera equipped UAVs.
- *January – October 2014:* discussions with companies and stakeholders, attending many events, decision to focus on safety, lightweight and ease-of-use in the IWT CAMELIUS SBO proposal.
- *October 2014:* meeting with industry partners that showed interest in the proposed camera equipped UAV technology. This was a well-attended and very broad, lively discussion, resulting in a significant broadening of the CAMELIUS valorization to many markets and companies.
- *January 2015:* submission of CAMELIUS project to IWT, with broad scientific and valorization focus.
- *January-June 2015:* further iteration on the CAMELIUS valorization potential, by obtaining numbers quantifying several of the markets covered by the CAMELIUS IAC.
- *July 2015:* rejection of the CAMELIUS proposal, despite the interest of 28 stakeholders and excellent scientific reviews. Main reason was the lack of focus and structure of the valorization potential.
- *November 2015:* meeting with CAMELIUS IAC to discuss the scientific focus and clear valorization potential, and how to strengthen both. Advise to focus on application-specific cases, proving how the technology could be used to enable novel applications. Decision to also narrow the scientific focus to the innovative use of 720 degree technology on a UAV. Change of name to OmniDrone.
- *November 2015 – May 2016:* various interactions with OmniDrone IAC and novel companies, discussing the relevant valorisation cases, and creating the OmniDrone IAC with focus on 4 valorisation cases.

2.1.2 Proposal set-up

2.1.2.1 General approach

While the breadth of the OmniDrone industrial interest is a key strength, it can also be a weakness as setting up technical meetings and cooperative follow-up trajectories is very difficult when a large group of companies has to be involved. To maintain the huge market potential & industrial interest, while at the same time ensuring technical focus on relevant proof-of-concepts as a direct basis for further development and valorisation, and to keep everything manageable and discussions focused, we decided to apply a 2-stage valorisation approach.
In this respect we carefully selected, in consultation with our industrial contacts, 4 areas where the application of OmniDrone technology is expected to lead to real breakthroughs for the stakeholders involved. While each player in the IAC showed interest in many cases, and even had ideas beyond the cases, we decided to initially focus on those four cases, that drive the OmniDrone scientific benchmarks and give the contours of the first follow-up collaborative research projects that will be submitted. During the project's lifetime we will mainly be focusing on providing solutions and Proof-of-Concept demonstrations (as a basis for concrete follow-up projects) within the scope of each of these 4 so called focus-1 area's. This in close collaboration with a limited but representative group of industrial partners. In parallel, starting in the second project year, we will also keep an eye on valorisation in additional markets by inviting stakeholder representatives from complementary application area's to an extended Industrial Advisory Committee to discuss broader valorisation. The practical way of working within this 2-layer approach will be explained in more detail in section 2.3. In the rest of this section we will first go into more detail on the OmniDrone Value Chain and the 4 selected focus-1 areas, both having an important impact on defining the parties we will deal with during the project execution. Three focus areas are mobile, on a UAV. To enable very early valorisation trajectories (already after Y2), and show the potential of the technology for non-UAV use, we include one static case.

2.1.2.2 OmniDrone Value Chain

Figure 2 gives an overview of the overall OmniDrone value chain and the main parties involved. From the figure we can see that all categories are nicely covered by IAC members.

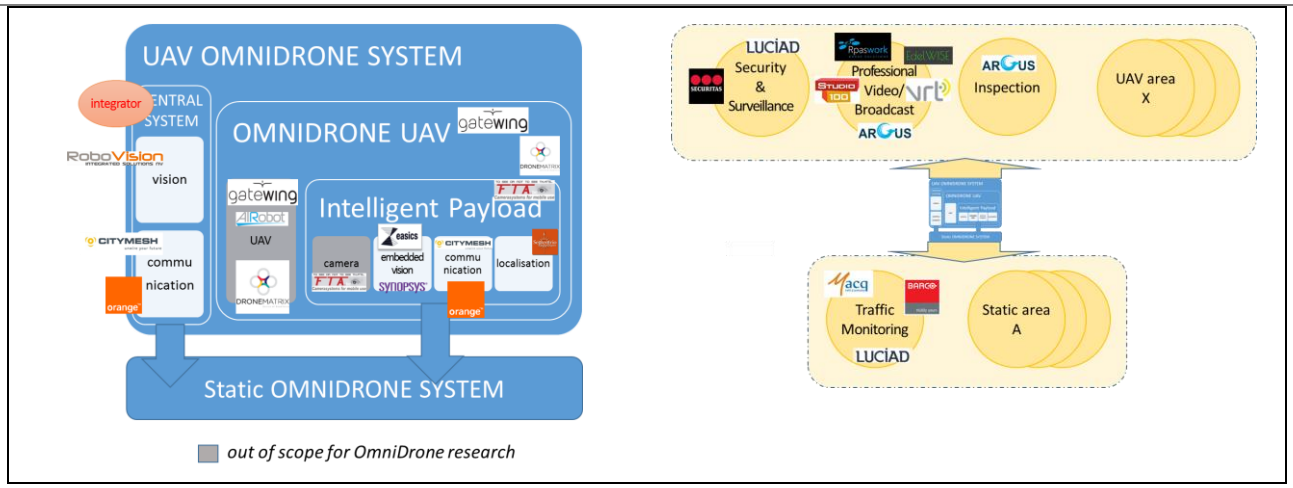


Figure 2: value chain for OmniDrone technology. Left we see the core OmniDrone technology provided by the technology providers, and right the technology users for providing new applications and services. Applications and services are defined by the 4 identified application-specific application cases (one static and 3 UAV focused ones), in addition to novel areas that will be opened during the course of the 4-year project.

The OmniDrone system, either UAV mounted or static, will be developed by "technology providers" and offered to "technology users" in multiple application domains as shown in the right part of Figure 2. These users can provide very useful input with respect to the expectations of the final technology within their specific application domain. *In this stage we call everyone a user that either offers a service to an actual end-user using OmniDrone technology or uses the technology for novel products.* We will go into more detail on specific user-roles when zooming into the 4 selected valorisation areas in section 2.2.

The actual OmniDrone system (Figure 2 left) consists of a central and a remote part. The central part will be implemented on the users'[1] IT system by a SW integrator or the own IT department. Communication modules will be offered by a communication module provider like e.g. CityMesh or Orange;.Vision SW modules are developed by a vision SW provider like Robovision.
The remote part of the OmniDrone system consists of an intelligent payload for 720 degree vision. The UAV mounting/integration can be done by a Drone Company like DroneMatrix or Gatewing, that can also provide the actual UAV[2]. An alternative is to have a Drone Integrator, like e.g. RPASWORK do this job.
The payload basically consists of a 720° camera, a vision processing module, a communication module, and a localisation module, offered by component technology providers and integrated by a (hardware) integrator. Examples of players in the different fields are respectively CityMesh/Orange (for the communication module), EASICS/Synopsys (for the processing module) and FTA (for the camera module and actual integration) or localisation module providers such as Septentrio.

2.1.2.3 OmniDrone Focus Area's

The cases we selected to focus our research on are: "Security & Surveillance", "Professional Video/Broadcast", "Inspection" and "Static 720° camera based Traffic Monitoring". The different focus areas are introduced shortly below. More information on the market potential and intentions of the case related IAC members are presented in section 2.2.

Security and Surveillance

(*SECURITAS, DroneMatrix, Robovision, Luciad, Septentrio*)
Focus is on the use of the OmniDrone System for surveillance of large areas, such as e.g. industrial sites and railroad tracks. In this scenario, a drone patrols autonomously over the designated area while looking out for intruders. The on-board algorithms detect persons in the omnidirectional video in real-time. Detected persons are also localized in 3D and their location displayed via LuciadMaps or Luciad LightSpeed.

Professional Video/Broadcast

(*VRT, Studio 100, RPASWORK, Argus Vision, DroneMatrix, EdelWISE, Orange*)
Focus is on the use of OmniDrone technology, and more specifically the automatic generation of individualized video streams for direct streaming or as a support for the production director, when making real-life and off-line productions for reporting and/or entertainment. Streams from multiple OmniDrone UAV's might be merged into a single production, offered by a content provider to the public, or by means of personalized video sharing over 4G.
It should be remarked that the 'Professional Video/Broadcast' market will not only benefit from the UAV mounted

[1] Might also be in the cloud depending on the business model adopted
[2] Remark that the physical UAV and camera are out of scope of OmniDrone research.

camera set-up, but also a fixed mounted set-up is already of added value. Within the scope of OmniDrone, however, focus will be on capturing and fulfilling the specific needs for UAV supported productions.

Inspection

(*Argus Vision, Airobot, Gatewing, Orange, CityMesh/nCentric*)
Focus is on the use of the OmniDrone System for the inspection of mostly hard to reach or dangerous locations and constructs like chimneys or (off-shore) wind turbines. The drone will autonomously perform an inspection mission and can generate one (or multiple) automatically framed/focused video stream(s) of specific pre-coded 'events/inspections'. These streams are forwarded to a central inspection officer for real-time or off-line analysis.

Static 720° camera based Traffic Monitoring

(*BARCO, MACQ, Luciad, FTA, Easics, Synopsys*)
Focus is on the use of the static 360-degree depth capturing platform that will be developed during the first 24 months of the project and will be capable of at real-time extracting omnidirectional depth maps in a traffic monitoring context. Both road monitoring as well as harbour & airport monitoring will be considered.

2.1.3 Wider valorization framework

OmniDrone is clearly not an isolated project, but nicely fits within a broader framework of (parallel) initiatives and collaborations where OmniDrone research partners collaborate with members of the Industrial Advisory Committee (IAC). In this section we will shortly touch on some of these projects that are of direct relevance to the OmniDrone project, and were key in selecting the scientific and valorisation focus.

(1) The ITEA3 project **3D Safeguard** (2015-2018), focuses on enhancing Global Situational Awareness in Rescue, Calamity and Inspection Operations. The Belgian consortium, including a.o. RiskMatrix/Fire.be[3], Citymesh, SAIT (part of Securitas) and EAVISE, focuses on the use of camera-equipped drones in this context. 3D SafeguardVL will build a first generation UAV for Security, Safety & Inspection using State-of-the-Art technology. OmniDrone will go beyond the specs of the 3D Safeguard solution and provide solutions for the 2nd & 3rd generation of the system. Also the LICT valorisation coordinator has been strongly involved in the lead to and set-up of this project.

(2) The FP7 project **ICoSOLE** (2013-2016) aims at developing a platform that enables users to experience live events which are spatially spread out in an immersive way by combining high-quality spatial video and audio and user generated content. EDM and VRT are partners in this project. The developed expertise in novel viewpoint generation between regular (panoramic) multicamera systems is used as the foundation of 3D depth extraction, depth-aware stichting and the novel smooth visual handover/transition between multiple omnidirectional systems in OmniDrone.

(3) A bilateral collaboration has been set-up between Marian Verhelst (MICAS) and Synopsys on "**Application-Specific Processor design for embedded image processing**". This collaboration actively explores good processor architecture for embedded image analysis, a.o. efficiently mapping neural networks, and optical flow tasks on the custom processors. This expertise, and the useage of the Synopsys processor designer tools will be extremely important in the OmniDrone project.

(4) A VLAIO **O&O collaboration** is currently under definition between Marian Verhelst (MICAS), Tinne Tuytelaers (VISICS) and Easics. The project proposal will be submitted in 2016, and will cover efficient FPGA mapping of (convolutional) neural networks. This work is complementary to OmniDrone, and will strengthen the links between MICAS and VISICS, and provide good insights regarding real time capabilities for vision processing on FPGA's, highly relevant to OmniDrone.

(5) The recently submitted VLAIO project **MIRADOR** (Monitoring Industrial sites with Reliable, semi-Autonomous and Online Drones) with Securitas and DroneMatrix, is directly targeted to valorize the research results from the KU Leuven CAMETRON project (see below) towards a security context. This parallel project is strengthening the links between the OmniDrone consortium, Securitas and DroneMatrix in the security focus area. The OmniDrone technology will be advancing and improving the MIRADOR vision algorithms, mainly because of the breakthrough novel 720° sensor and its embedded on-board image processing.

(6) The SBO project **SINS** (2014-2017) has as a target to drastically improve both lifetime and performance of the state-of-the-art of sensing swarms, with a focus on acoustic sensing. MICAS & TELEMIC are partners in the project and the LICT valorisation coordinator is the valorisation manager for SINS; Easics & DSP Valley are members of the IAC & VB respectively . Although both projects are complementary with SINS focusing on audio technology and "fixed" sensors, and OmniDrone on vision technology mounted on flying objects, OmniDrone will certainly learn from the findings within SINS on low-power, energy-proportional, (swarm) processing and communications.

(7) The SBO project **SAMURAI** (2015-2018) will focus on a driver architecture that allows to easily optimize the

[3] Shortly after submission of the 3D Safeguard project, RiskMatrix has bundled its Drone activity in a spin-out "DroneMatrix"

performance of off-the-shelf radios and chipsets for a range of contexts. This software will be an important starting point for the OmniDrone communication payload, where off-the-shelf chips are optimized for the aerial communication context. TELEMIC is partner in the project; Septentrio and Easics are members of the IAC; DSP Valley of the VB.

(8) The TETRA project **VIPER (Visual Person Detection made Reliable)** (2015-2017), focuses on translating existing state-of-the-art technologies for image processing and AI to allow for automatic incident detection and alarm generation in security applications. One of the cases within the project focuses on implementing this technology on a security UAV. EAVISE is the executor; DroneMatrix and DSP Valley are members of the User Committee.

(9) In the **AR4GUS** project, a self-funded cooperation between Orange, FTA and Gatewing, TELEMIC already carried out an initial measurement of the Mobistar 4G network.

(10) EAVISE offered vision consultancy to Airobot on "**Development of an image-based UAV-control for industrial inspection**", where they developed optic-flow based visual stabilisation of drones. Quite complex vision algoritms were implemented on an on-board embedded processing platform

(11) Via the KMO-portefeuille program EAVISE offered vision consultancy to DroneMatrix, on "**Technology exploration for the development of a vision system for the precision landing of a drone** " and "**Technology exploration for the development of a PID for the precision landing of a drone on a docking station**".

(12) The recently submitted VLAIO SME project proposal **EagleEye** between EAVISE and RoboVision targets to introduce state-of-the-art person detection, tracking and re-identification and rule-based reasoning into RoboVision's fixed camera surveillance solutions. In OmniDrone, this application will be extended to drone based surveillance with superior 360° 3D cameras.

In order to complete the list, although not in direct collaboration with current IAC members, following drone-related projects with OmniDrone partners involved are considered very relevant for OmniDrone as well.

(1) The ITEA3 project **HI-RISE (High Integrity RPAS by Innovative Software Engineering)** with Belgian partners (UN)MANNED, T-REGS & EAVISE, focuses on the development of innovative methods & processes to reduce DO-178C certification costs. EAVISE focuses on the detection, classification and estimation of the motion vector of other aircrafts from a visual sensor mounted on a UAV, on the ground or on a ground vehicle.

(2) The KU Leuven GOA project **CAMETRON (Technology for a virtual camera crew)** of EAVISE/VISICS aims to build a system that can produce high quality AV productions with minimal human intervention and is as such very relevant for the Professional Video/Broadcast case

(3) The KU Leuven OT project **CAPACITIES (Context-aware trade-off between local processing and communication for UAV)** of TELEMIC and MICAS focuses on the communication and processing trade-off for dynamic, context-aware aerial networks.

(4) The iMinds project **SafeDroneWare**, with partner CiTiP, focuses on the development of safety-securing software for UAV's with respect for the relevant legal framework.

2.2. Valorisation potential and valorisation objectives of the project

The OmniDrone valorisation potential is large but at the same time broad, wide, and a moving target. The UAV market, technology and regulation is very dynamic, illustrated by a large number of small companies in the IAC. At the same time, we see a very realistic and increasing interest from large players. To embrace the wide potential, yet ensure realistic outcomes, we have constructed very specific valorisation cases and objectives, along the four defined focus areas. Each focus area is represented by a necessary and sufficient set of small and large companies, proving the potenial and enabling the definition of a clear set of valorisation objectives, mapped to the scientific objectives. We first detail the potential, and then zoom in on the objectives.

2.2.1 Valorisation potential

In this section we will present the valorisation potential for OmniDrone Technology. After touching the overall potential for UAV technology we will go into more detail on the valorisation perspective within each of the selected focus-1 area's. For each focus-1 area, we will illustrate the market potential, list some problems mentioned by the IAC members, for which a **technical solution is really a must have**, and describe the involved IAC companies. To end, we will shortly list some other application domains where OmniDrone technology could be of added value to illustrate once more the huge potential beyond the 4 selected cases.

Not all relevant company information and intentions could be integrated in the following section. More details (and quantified information) can be found in the more detailed company-profile descriptions and Letters-of-Intent in

Appendix B, of which an update, potentially containing updates on business expectations, will be sent before June 24[4].

2.2.2.1 Overall market potential camera equipped UAVs

Several market studies[5] are predicting a real boost for UAV technology in the years to come as can e.g. be seen in Figure 3. While UAVs have initially been introduced in a military context where their utility has yet been demonstrated, civil and commercial usage is becoming ever more prominent and is expected to outperform the military use in the years to come[6]. Between 2015 & 2020, the commercial/civilian market is expected to grow with a CAGR of 19%, compared to a 5% growth for the military market. Many of the vendors in this domain are small private companies and start-ups.

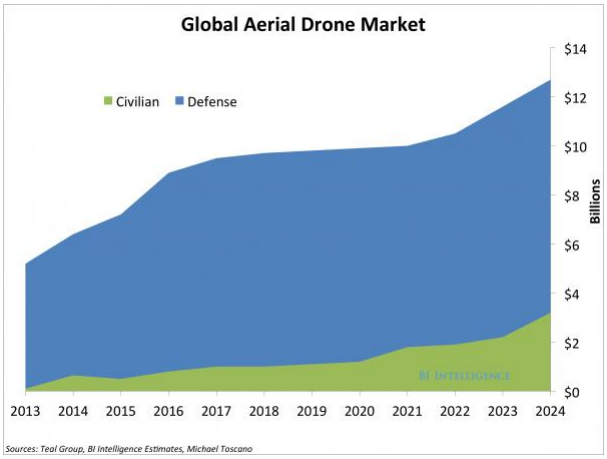


Figure 3: Global Aerial Drone Market
source: Teal Group, BI Intelligence Estimates[7]

2.2.2.2 Focus Area: Security & Surveillance

Market potential

The importance and potential of UAV technology for the Private Guarding sector was studied in detail in the Ansecur roadmapping project [8]. Carrying along very low margins, the sector is forced to evolve from "people based services" to "solution & technology based services" and from "Physical or Close Proximity" to "Remote Proximity". By providing security drones with an unlimited depth-view on their environment, powerful and real-time (person) detection algorithms and increased autonomy, OmniDrone will be an enabler to this evolution.

To get an idea of the overall potential in this sector we can look into the results of the Ansecur study as well as the information available in the business case of the MIRADOR project.
The worldwide private security services market is estimated at 179 billion euro in 2016 with a CAGR of 6,9%. The full UAV security Services case has been estimated for the market in the EU and in the MESA to a potential of 2,5 billion euro (5 year period, starting 2016). For Europe the Ansecur study sees, as of today, a potential for about 27.500 security drones replacing mobile agents. With a lifetime of about three years, this would represent a potential yearly sales of about 9.200 security UAV's. Looking at the Belgian market this would come down to about 400 UAV's/year, when considering the three major national firms (G4S, Securitas & Seris). This all without taking into account the expected yearly growth of the Security market of 6,9 %. Another way to look into the potential is by looking into the number of big surveillance sites in Belgium, being 20% out of 7500 or 1500, that are in theoretically, all candidates for UAV based security service introduction

Market related problems

- **MP_SS1**: The private guarding market in which companies such as Securitas manifest themselves as major players are inherently unhealthy markets. Such a company mostly provides interchangeable people at locations to be guarded and as a result can deliver low relative value versus competitors. This led to pressure on the tariffs, resulting in very **low operational margins** (often going down to only 2%). (Securitas, DroneMatrix)

[4] An update to these Letters of Intent will be sent to FWO before June 24 as for the moment some companies were not able yet to provide a **signed** LoI with **quantitative** projections on their future business. The latter is also the reason why the following sections to not include business information for all IAC members but only a few ones
[5] THE DRONES REPORT: Market forecasts, regulatory barriers, top vendors, and leading commercial applications; Teal group BI Intelligence
[6] The speed of civil/commercial usage uptake will strongly depend on the regulatory framework on national, European and Global level.
[7] http://uk.businessinsider.com/uav-or-commercial-drone-market-forecast-2015-2
[8] The UAV Security Services Roadmap project (Ansecur) studied the potential of UAV technology being deployed and accepted by users in private guarding processes in corporate sites, industrial areas and compounds or gated communities

- **MP_SS2**: Non-supervised surveillance patrols are only possible if the UAV systems are highly **autonomous (MP_SS2.1)** and **safe (MP_SS2.2)** (Securitas, DroneMatrix)
- **MP_SS3**: The bottlenecks in current surveillance camera systems to allow for fully autonomous, highly reliable operations with a minimum of human interventions are **precision and reliability**. Pain-points are on:
  - **MP_SS3.1:** limited **field of view** and **blind spots** (Luciad, DroneMatrix)
  - **MP_SS3.2:** (indoor) **localisation** accuracy (Septentrio, DroneMatrix)
  - **MP_SS3.2**: accuracy and performance of person & object **detection** (including localisation) (RoboVision, DroneMatrix)

Valorisation stakeholders

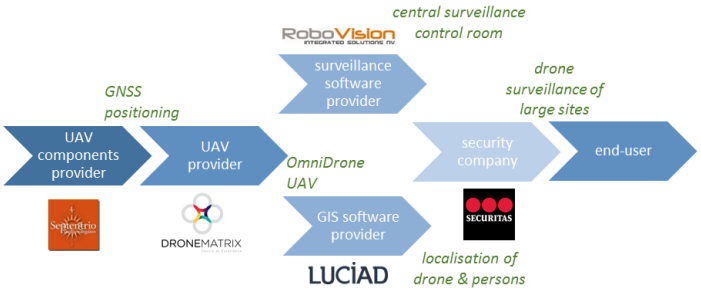


Figure 4: Surveillance value chain

Figure 4 shows a typical value chain for Surveillance. Towards an end user, a security company (e.g. Securitas) wants to use UAVs for surveilling large sites. They do not develop SW and HW themselves, but rent a drone surveillance kit from HW & SW suppliers (e.g. RoboVision for SW & DroneMatrix). If a connection with GIS information is of interest, for e.g. adding the ability to show all detected anomalies directly on an interactive map, the products of relevant SW vendors such as Luciad can be bought additionally. The UAV builders themselves of course also rely on subpart suppliers, e.g. Septentrio for their accurate GNSS localisation modules.

Within the OmniDrone IAC, following players are sufficient and necessary to cover the Surveillance value chain:

As Belgium's 2nd largest security services provider with worldwide activities **Securitas** wants to apply autonomous UAVs as a cheaper alternative to human patrolling to lower operational costs and increase its results. Securitas already collaborates with DroneMatrix and EAVISE towards a first generation security UAV solution in the MIRADOR project. OmniDrone technology would become part of future generations of the solution. UAV introduction in the security portfolio must lead to increased revenues adding up to a cumulated value of 26,7 Meuro by 2023.

DroneMatrix is a high-tech startup company in UAV-systems and -solutions. DroneMatrix plans to integrate the OmniDrone omnidirectional sensing technology in its UAVs and accompanying SW solutions, starting within a security market oriented solution. This should allow the company to stay ahead of competition and realize the projected growth scenario from 4 FTE now to 38 FTE in 2023.

RoboVision is active in the camera surveillance market, introducing automatic processing and real-time reaction to events captured by surveillance cameras. They plan to integrate the OmniDrone person detection algorithms as a routine in their rule-based reasoning engine for analysing filmed situations. A first generation of person detection SW is already under development with EAVISE in the EagleEye project. Future generations would be based on OmniDrone technology. As such OmniDrone will contribute to the projected growth from 9 FTE today to 33 FTE by 2021.

Luciad is a product software company that builds components to connect, visualize, and analyze geospatial data sources. Luciad's main product "LuciadLightspeed" allows visualizing regular perspective static or UAV camera feeds in real-time by re-projecting the video frames on a 2D or 3D map. Luciad wants to upgrade their system towards a larger situational awareness by integration OmniDrone camera feeds offering a complete field of view, and target novel markets in inspection and use of their technology towards AR/VR.

Septentrio designs, manufactures and sells highly accurate GPS/GNSS receivers, for demanding applications requiring accuracies in the decimeter or centimeter range. Vision-based localization is seen as complementary to GPS/GNSS localization where satellite signals are not received well. To obtain a sufficient visual-sensor based accuracy, the novel omnidirectional technology of OmniDrone is indispensable. Septentrio plans to integrate both GPS/GNSS and vision-based localization in a single receiver module.

2.2.2.3 Focus Area: Professional Video/Broadcast

Market potential

UAVs have a high potential in professional video in general and broadcast in specific, since they can have a drastic impact on these sectors in multiple ways, cost saving and novel creative opportunities being the leading ones. Cost savings e.g. result from replacing helicopters by smaller and (a factor 5) cheaper UAVs and/or multiple camera's by a

single one. The advanced vision technology will also allow a single operator to steer (multiple) UAVs and at the same time make impressive video productions with spectacular viewpoints. Regarding novel "creative" opportunities the technology offers the possibility to bring cameras to difficult reachable locations, to easily select specific views (either in real-time or during post-processing) for personalized projections and experiences or to make more spectacular recordings, and to exploit real and high quality 3D video.
In Flanders there are about 85[9] production houses and 46 TV channels, most of which also have an internal production department. Depending on the type of productions they make, all of these might benefit to a lesser of larger extend from OmniDrone. Typical production numbers for VRT & Studio 100 can be found below and in their LoI's. Besides of the classical TV production houses and broadcasters, also advertisement companies might be in favour of OmniDrone technology to promote products or 'organisations' in an appealing way. As well as operators of events that would like to offer their public special experiences, like second screens with specific views on the show.

Market related prolems

- **MP_PV1**: Due to competition, major concern for production houses and broadcasters is to be able to provide their clients with ever more **appealing productions at a "competitive" price.** (VRT, Studio 100)
- **MP_PV2:** Increasing demand for **personalised** event experiences (EdelWISE, VRT, Studio 100)
- **MP_PV3:** Live reporting requires delay-free and reliable **communications** (**MP_PV3.1)** as well as **efficient video processing** (**MPV_PV3.2) (**VRT, Studio 100, EdelWISE)
- **MP_PV4:** When making productions in presence of a live audience, **safety** (**MP_PV4.1)** is of utmost importance and the operators/organisators need to be backed up by a **legal context** (**MP_PV4.2)** to avoid liability charges. (VRT, Studio 100, RPASWORK)
- **MP_PV5:** When streams from multiple camera's are used in a production it is not easy to smoothly combine them into a single stream.

Valorisation stakeholders

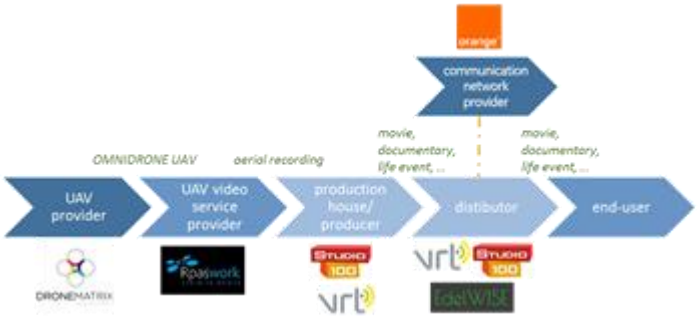


Figure 5: Professional Video/Broadcast value chain

Figure 5 zooms in on a typical value chain for the selected "Professional Video/Broadcasting" case. The final product (movie, series, life event, promotion film, …) is offered to the end-user via some kind of distributor. This might be a classical broadcaster (like VRT, Studio 100 TV), an alternative second screen service provider (like EdelWISE) etc. They receive the production from a production house (VRT, Studio 100, …) (or have it made in-house). For doing recordings using UAV technology they rely on an external (or internal) party that is allowed to and has expertise in flying UAV's for making recordings[10] (e.g. RPASWORK). This party finally gets a UAV from a UAV provider (e.g. Gatewing, DroneMatrix). A communications provider (e.g. Orange) needs to provide sufficient bandwidth for real-time transmission. And eventually (not reflected explicitely in the picture) the integration of the post-processing vision algorithms on the production systems of the production house could be done by their own IT department or an independent integrator.Within the Professional Video/Broadcasting WG the value chain is covered by the following players:

VRT is a classical public broadcaster that also makes some own productions. They see (OmniDrone) UAV's as a means for cost-efficient media-production mainly within the context of live reporting (on e.g. sports events) and news reports on disasters or other events. Every year VRT covers about 70 live sports events, with in total 110 hours of live transmission. Cheaper production costs would allow them to cover smaller events as well. Additionally, OmniDrone will also contribute to their strategic objective of offering more personalized media experience to its audience

Studio 100 is a production house, making TV fiction & non-fiction series, movies and recordings of live-shows. They also own the PLOPSA thematic parks. They intend to use OmniDrone video technology to improve their productions and production processes. In 2016 they plan to record amongst others about 85 hrs of TV content, 10 hrs captation of shows and 1 movie. OmniDrone technology could also be used to create a flying character in the shows or to create new experiences in their thematic parks.

[9] Source: De Vlaamse Televisie Academie (http://www.vlaamsetelevisieacademie.be/tvmakers/productiehuizen)
[10] Remark that when UAV's are getting more autonomy, potentially more parties will be allowed to use them in productions. Actually a license is needed.

RPASWORK is an RPAS service provider focusing on aerial filming and photography. They create their own recording technology by integrating standard UAV's and cameras. They see OmniDrone technology as a competitive edge against their competitors.

Like RPASWORK, the Media Business unit of **Argus Vision** provides aerial video and photo captures for television, documentaries, commercials and film productions to its customers. In OmniDrone, Argus Vision is interested in a semi-autonomous system providing the UAV pilot with flight-path planning and supporting the camera-operator with real-time object tracking

DRONEMATRIX sees a direct opportunity to introduce OmniDrone stereo 360° technology on TYTHUS, a tethered drone with 360° video capturing and real-time communications. The stereo feed and viewpoint selection are an asset for the future media and event capturing market. Offering a non-thetered Media OmniDrone UAV, is another objective. **(**see also security & surveillance case).

EdelWISE is a small company that recently started to commercialise the SpiGlass service being an on-line LIVE broadcast for public of live events, allowing spectators to watch secondary video streams on their smartphone as if they were looking through binoculars. EdelWISE sees 2 opportunities for SpiGlass to evolve in accordance to OmniDrone results: (1) offering 360 or 720 camera streams to improve the public's experience, possibly even making them their own director and (2) offering the SpiGlass cloud environment and websocket http streaming for low latency (video) applications. If feasible this could mean a real added value and potential breakthrough for SpiGLASS. EdelWISE has already been in contact with EDM and VRT to look into the further evolutions of the product

As real-time and reliable communications are an absolute requirement for e.g. life event capturing, also a network provider like **Orange** plays an important role in the process of ensuring real-time high capacity video delivery from aerial systems. Orange has a clear interest in providing aerial 4G coverage (as first operator in Flanders) and is hence actively engaged in obtaining measurements from their 4G network and proposing improvements to the system (e.g., put aerial antennas).

2.2.2.4 Inspection

Market potential

For a broad range of inspections, accurate 3D reconstruction and/or omnidirectional video with sufficient geospatial and site localization, allows real-time and a posteriori inspections by a (remote) expert that does not necessarily need to operate the UAV itself. Although inspections can take place in all kinds of domains, a very important sector eager to the introduction of UAV's is that of the so called high risk inspections (flare tips, industrial installations, off-shore wind turbines, high chimneys, high voltage cables, radio masts, internal tank inspections, sewers, …).

A first idea of the potential for UAV technology within this High Risk Inspection market can be derived from the business case presented in the 3D Safeguard proposal. This business case sees a potential for the sales of 560 Inspection UAV's for the national and 966 for the international market in 5 years after the start of the project. This would reflect a potential total revenue of about 41 Meuro as well as a potential for about 104 FTE's for production and support of these FTE's.

Market related problems

- **MP_IN1: Safety and human risk mitigation**: Industrial site inspections are quite often high risk and require specific measures to guarantee safety of an on-site inspection officer. Such measures are often quite expensive, e.g. when needed to completely turn down the installation.
- **MP_IN2: Timing and cost efficiency*:*** Inspection sites are often very difficult to reach (chimney, off-shore locations, …), making the inspection officer loose a lot of time getting there
- **MP_IN3: Accuracy and installation risk mitigation*:*** Very large inspection sites and related lengthy tiresome inspections risk on missing certain details or other human errors, even if the inspection officer is especially trained for this.
- **MP_IN4: Remote communications**: When inspection officers are not on-site, a reliable communication infrastructure is needed to transfer inspection data from the often remote location, like off-shore wind turbines, to a central location.

Valorisation Stakeholders

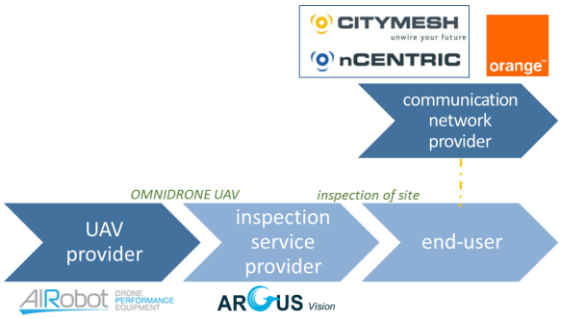


Figure 6: Inspection value chain

Figure 6 represents the vale chain for the inspection case. Typically an inspection service provider (e.g. ArgusVision) will offer to an end-user, either a site owner or an official inpection agency, an inspection of a site/terrain, … For this he will make use of an inspection OmniDrone UAV, provided by a UAV provider (e.g. AIRobot) as well as some central SW (not represented on this picture) for a posteriori analysis. Communication to the remote off-shore site is provided by a communication network provider like CityMesh/nCentric or Orange.

Argus Vision is specialized in operating UAVs in specific domains like inspections and media. OmniDrone technology should enable them to deliver a service for safety inspections – using a company owned patrimony of autonomous inspection UAVs – with virtually no manpower, except for maintainance. They forecast a total benefit of €288.000 in the first year of complete autonomous UAV deployment

Airobot develops drone performance equipment for easy, precise and professional operations. After three years of intensive research and development, Airobot released the RANGER, the first UAV radar system. The Airobot RANGER is currently commercialized all around the world among numerous happy users. Airobot is developing a safety component for e.g. inspection drone. The outcome of the OmniDrone project would be ideal in this case, because of the ability to detect obstacles in every direction from the drone and the precise visual localisation possibilities. If these can be integrated in an embedded payload package, it can be realidy employed on Airobot's products.

Gatewing launched its first product in October 2010 – the Gatewing X100 – which was the first turnkey unmanned aircraft system (UAS) for terrain mapping and surveying. In April 2012 Gatewing was acquired by Trimble Navigation. In June 2013, combined efforts of Trimble UAS and other sites within Trimble resulted in the Trimble UX5 Aerial Imaging System. This all-Trimble solution includes both a successor for the Gatewing X100 and an industry leading office software solution for image processing. The legal entity of this Trimble subsidiary is still known as Gatewing NV. Gatewing sees incorporating OmniDrone technology as a form of generalization of their (now more niche and specialized) drone systems

CityMesh/nCentric is a communication technology and network provider for both (ad-hoc) city as well as off-shore environments They want to learn how to set up reliable communications between UAV's or a UAV and existing networks. Integrating OmniDrone communication technology in their products and solutions should lead to a company growth in both city & off-shore divisions.

Orange, being large mobile communications network operator, has a clear interest in providing aerial 4G coverage (as first operator in Flanders) and is hence actively engaged in obtaining measurements from their 4G network and proposing improvements to the system (e.g., put aerial antennas).

2.2.2.5 720° perception static camera (traffic monitoring)

Market potential

Also without the UAV mounting, a static 720° (360° depth information) camera system is of high industrial relevance in many markets, in particular for traffic monitoring on both road & commercial (airport, rail, harbour) traffic.
Regarding road traffic monitoring, it allows to replace current expensive systems of multiple distributed camera's. The 720° system give omnidirectional awareness without complex installations, can be placed at a strategically chosen central location avoiding occlusions, and can accurately track cars, bicyclists, and pedestrians. The traffic management market, consisting of smart traffic monitoring systems and traffic signal control systems is steadily growing, with a predicted CAGR of 11.57% between 2015 and 2020 running up to 17.64 Billion US$ by 2020 (RnR Market Research[11]). Also in Belgium there is a growing market for traffic cameras, with. a lot of the medium sized

[11] http://www.rnrmarketresearch.com/intelligent-transportation-system-market-by-component-interface-board-sensor-surveillance-camera-and-others-system-atms-atis-its-enable-transportation-pricing-system-apts-and-cvo-application-and-geography-analysis-forecast-to-market-report.html

cities now investing, as well as a recently announced additional investment of 260 cameras to be placed on Belgian high ways[12]. Macq, an industrial leader in traffic monitoring solutions, estimates the market for 720° cameras in traffic situations to be ¼ of the total traffic camera market.
Alternatively, the technology can also be used in virtual traffic towers for e.g. airports and harbors. The valorization potential is here driven by the increasing amount of air traffic, with a predicted annual growth close to 5% [1], or hence a doubling in the next fifteen years. To ensure a sustainable and cost-effective growth, increased autonomy and remote monitoring will be of crucial importance, with interest from IAC partners active on airports (Barco) and in harbors (Luciad).

Market related problems

- **MP_TM1: Situational awareness** with current single video camera systems for traffic monitoring is limited due to a **small field of view .** (Luciad, Macq) A better situational awareness is e.g. needed to be able to detect bicycles and pedestrians and their interaction with the traffic (Macq).
- **MP_TM2: Ease-of-installation and cost:** Current solutions for this small field of view require costly distributed multi-camera systems to overlook an area (e.g. a crossroad, or fly zone). As a result, current traffic management solutions require expensive installation, wiring & synchronization. (MACQ)
- **MP_TM3: Lack of accurate depth information** within the video stream requires 2nd source detailed terrain/elevation information, e.g. from a digital elevation map, to accurately integrate the video in a 2D or 3D map. (Luciad)
- **MP_TM4:** Existing smart cameras lack sufficient **processing efficiency** to extract, in real-time, in an embedded form factor, depth information from 3 or more camera streams (FTA, Easics). In order to enable autonomous, long lived static systems in the field for e.g. traffic monitoring, a system consuming <10Watt is required.

Valorisation stakeholders

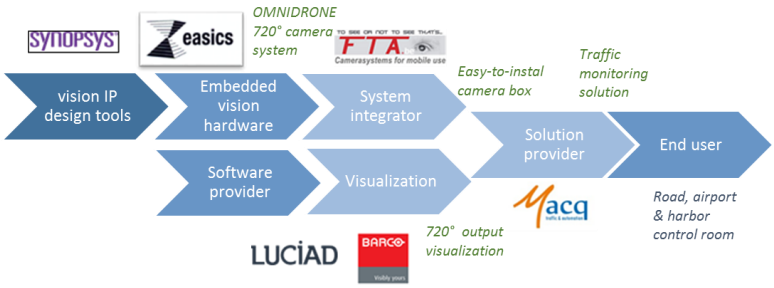


Figure 7: traffic monitoring value chain

Figure 7 represents the vale chain for the traffic monitoring case. Typically a solution provider in traffic monitoring (e.g. Macq) will offer complete traffic control and monitoring solutions. To enable him to offer OmniDrone's 720° solution, processing hardware has to be customized by digital design experts (e.g. Easics using Synopsys tools), and integrated in a robust camera system by a camera system integrator (e.g. FTA). Moreover, a software suite for results mapping and visualization has to be developed (e.g. by Luciad), and tightly integrated with market-specific remote visualization solutions, such as large screens, AR camera's, etc. (Barco's expertise). Within the OmniDrone IAC we hence have a representative of every players in the value chain of such smart 720 ° cameras:

Macq is an active player in the field of intelligent roads, both w.r.t. infrastructure automation, as well as w.r.t. smart camera based recognition of number plates, incidents, etc 720° cameras are complementary to current traffic monitoring cameras. Macq sees great potential in integrating the two technologies, having the advantage to cover the complete scene and inherently see 3D. Macq predicts that theoretically the total market for 720° cameras in traffic situations will be ¼ of the traffic camera market

Barco designs and develops networked visualization products for the Entertainment, Enterprise and Healthcare markets. Several groups within Barco are interested in the OmniDrone project, in particular the group working on virtual airport traffic monitoring towers and remote control rooms. Barco sees many interesting paths towards the visualization of such 720-degree content, such as on handhelds, videowalls , operator desks and VR glasses. Besides using this system standalone, it would also form the perfect complement to integrate with other existing camera systems for increased information

Luciad is a product SW company building components to connect, visualize & analyze geospatial data sources. Luciad's main product "LuciadLightspeed" allows visualizing regular perspective static or UAV camera feeds in real-time by re-projecting the video frames on a 2D or 3D map. Luciad is highly interested in OmniDrone's full 360 degree depth-aware video to overcome the small field of view and hence limited situational awareness of their current single camera systems. Luciad is interested to integrate the OmniDrone 720-degree camera system with their LuciadLightspeed and LuciadFusion toolsuite

12 https://www.vlaamsparlement.be/commissies/commissievergaderingen/1037570/verslag/1040446

FTA specializes in the development and manufacturing of easy to use, compact, extremely robust cameras with very high optical quality, with integrated video recording, image analysis, wireless image transmission and camera control via GSM network and / or satellite. They are interested to incease the capability of their camera's by adding 360-degree depth awareness.

Easics is a System-on-Chip design company, targeting designs in both FPGA and ASIC technology. It designs reliable and scalable (future-proof) high-performance, low-power embedded systems for leading product companies in multiple markets. Easics is already a very active player in hardware design for embedded vision, and has several of our IAC companies as its clients. They are highly interested in OmniDrone's embedded vision hardware architectures and are convinced OmniDrone's 720-degree vision system can bring significant competitive advantage compared to other embedded vision players.

Synopsys Inc. is a leader in electronic design automation (EDA) and semiconductor intellectual property (IP), with a comprehensive, integrated portfolio of system-level, IP, implementation, verification, manufacturing, optical and field-programmable gate array (FPGA) solutions. Synopsys' embedded vision processing IP group, as well as its processor designer team are important in light of OmniDrone. Recently, the interest for these groups has steadily been rising. Synopsys can introduce the developed processor architectures for 720° perception in its huge client base on embedded vision, including all large players world wide

2.2.2.6 Wider valorisation

The potential for OmniDrone technology is not restricted to the 4 selected focus areas. Both for the complete OmniDrone system technology, with static or UAV mounted 720° cameras, as well as for the individual developments for communication, vision and processing, there are many possibilities for exploitation beyond these 4 markets as well as we learned from our interactions with industry. We will illustrate this by listing (1.) a number of ideas for additional follow-up projects, next to the PoC follow-up projects that will already be prepared in the IAC WG's and (2.) additional application domains where we also see a lot of potential. Remark that both lists are not exhaustive and were constructed bottom-up following our contacts with industry while preparing CAMELIUS & OmniDrone and attending the Drone Conventions. Within the project wider valorisation will be pursued via the extended IAC and VB networking members.

Examples of follow-up projects

- UAV-based crowd monitoring over large areas (DroneMatrix)
- Integration of GNSS and vision technology for localisation (Septentrio)
- Ultra-light 720° enabled flying characters as show elements (Studio 100)
- Individualized big-data sport performance statistics gathering through sensor fusion.
- Visualization of 720-degree content on visualization devices, such as on handhelds, videowalls, operator desks and VR glasses (Barco)
- Enhancing video's with context information obtained from 3D depth info and semantic analysis (Luciad)
- Obtaining 3D radio progagation maps for predicting UAV coverage (Luciad)

More follow-up projects can be found in the letter of intents of the IAC members and the company profiles in Apppendix B.

Examples of Alternative Markets

A non-exhaustive list of examples, with some interested players or companies that introduced the market, is presented below. The list contains both UAV-based applications as well as static camera applications.

- **Disaster & Rescue**: operations at locations where it is too dangerous to send humans into, that are difficult to reach or cannot be reached quickly enough (fire, earthquake, nuclear disaster, heavy traffic accident) (e.g.. AbiWare)
- **Internet delivery**: to set-up a new (temporary) communication network or extend an existing one for supporting 'temporal' (extremely) high bandwidth needs (e.g. Orange)
- **Element in Sports activities**: capturing a sportsman training activities for further analysis and evaluation of his performance Flanders Bike Valley), an 'all seeing' arbiter in soccer matches (RPASWORK), control of the quality of the road before the start of a cycling race, …
- **Precision agri- and horticulture** (ILVO, AETOSDRONES)
- **Construction and inspection** (Hoogmartens, Confederatie Bouw Limburg,…)
- **The broader leisure industry** e.g. drone racing (Drone Racing Belgium), life events with Drones (Studio 100, Act Lighting Design)
- **Transport & Logistics**: e.g. for package delivery (e.g. DHK, Essers, …)
- **Video Conferencing:** Televic is still very interested in the OmniDrone technology (omniview video and FPGA accelerated merging of streams) for it's video conferencing application. Televic is interested to join the IAC, but

as it's interest is not related to the 4 focus area's, we will only further discuss possible follow-up trajectories with Televic during the Extended IAC discussions.

- **Static surveillance applications indoor:** several companies listed the need for static indoor supervision (elderly, exams)
- **Static safety camera's:** detecting vulnerable road users in a truck's blind spot zone. Also for fixed camera systems, the system can be used to protect people's safety in the immediate vicinity of e.g. industrial machines or moveable bridges (e.g., FTA)
- **Non-flying unmanned vehicle market**: as the core technology for semantic reasoning, 3D person detection can also be used on ground vehicles (or self-driving cars).

2.2.2 Valorisation objectives

The overall OmniDrone valorisation objective is to enable the identified market potential with the breakthrough 720 degree UAV technology that is reliable and easy-to-use. To achieve this, we identified for each of our focus-1 areas some market problems (MP, see section 2.2.1) for which a technological solution is really a **must have**: traffic monitoring (TM), surveillance (SS), precision inspection (IN) and professional video broadcasting (PV). The OmniDrone scientific proof-of-concepts and objectives are clearly driven by those 4 identified focus-1 areas and must have technology solving Market Problems (MP) identified per area. In this section, we will map the many identified MPs to specific OmniDrone must have scientific outcomes, that were already mentioned during the summary and are more detailed in Part 3, Section 3.3. As there is a one-to-one mapping of the 4 focus-1 areas to the PoCs, the interest of companies in the PoC demonstrations is straightforward and not further repeated here.

Table 1: Mapping of OmniDrone must have technology solving Market Problems (MP) to the Scientific Objectives (SO).

Objectives solving Market Problems	SO1: 3D 720 stitching	SO2: 3D person tracking	SO3: 3D embedded	SO4: reliable UAV link	SO5: sense & avoid	SO6: easy-to-use autonomy	SO7: self-configuring link	SO8: merging of streams
MP_TM1	Situational awareness	People awareness						
MP_TM2	Easy orientation			Wireless link		Ease of control	Wireless configuration	
MP_TM3	3D depth info needed		Embedded depth info					
MP_TM4			Processing efficiency					
MP_SS1	One for all directions	People tracking	Cheap on-board					
MP_SS2			Embedded for autonomy		Safe UAV	Automated	Self-configuring	
MP_SS3	No blind spots	Localisation	Embedded for indoor	Reliable	Safe UAV			
MP_IN1					Safe UAV	Human safe in remote area		
MP_IN2	Faster inspection			Control of remote sites				
MP_IN3	Faster inspeciton				Safety despite human errors	Easy-to-use		
MP_IN4				Reliable wireless			Self-configuring	
MP_PV1	Appealing productions		Embedded for low price	Cheap comm.				Merging of streams
MP_PV2		Personalised events	Personal devices	On smart phone				
MP_PV3				Reliable UAV use				Video merging
MP_PV4				Reliable UAV use	Safe UAV use			
MP_PV5				Communication efficiency				Video merging

2.2.3 Environmental factors

Besides the technical success of the project and the market potential, a third group of aspects that could influence the valorisation potential of the OmniDrone project results are environmental factors, such as regulations and policy measures. Identified potential positive and negative impacts are discussed below, and will be studied in more detail during the course of the project.

External factors positively impacting OmniDrone valorisation:

- Drone usage and regulation receiving serious attention from Flemish Government and Industry
  Many start-ups are arising in this area. Recently several of these companies also start to group into broader

company consortia, such as EUKA, a knowledge and technology centre with their roadmapping project ANSECUR[13], supported by the Flemish Government (Agentschap Ondernemen – Vlaanderen in Actie). Sint-Truiden is starting to profile themselves as a "Drone Valley", actively attracting drone development companies to their county[14]. Even the first "drone school" has been opened recently in Flanders[15].

- Across Europe a new era for aviation awakes

  As civil aviation is evolving itself towards more automation, drones' technologies will also be crucial for the competitiveness of the European aeronautics industry as a whole. In 2014, the European Commission launched an initiative to regulate appropriately the development and use of Drones within the context of the single aviation market (Communication of 8 April 2014, COM(2014) 207 final and public consultation August-October 2014). The interdisciplinary nature of OmniDrone can help provide insight in the importance of interconnectivity and the need for harmonization of legal and technological requirements regarding civil drones[16].

- Decreasing cost and size of hardware due to Moore's law

  Drones were cited to be one of the "Technologies That Will Go Big in 2015" (E.g. SingularityHub [17]), due to their decreasing cost and size. Other clear indications are that drones got their own section of CES in 2015 with a new "unmanned systems" zone, and the many start-ups exploiting and designing miniature drones, such as Wales' Torquing Group's Zano, a Kickstarter-backed quadcopter small enough to fit in your hand but still capable of high-definition video capture.

These trends clearly indicate that the surrounding circumstances for this research are excellent and that this research project comes at the right point in time

External factors negatively impacting OmniDrone valorisation:

- European/Belgian regulatory framework developing at a high pace[18]

  The European Commission has developed a strategy to support the progressive development of the civil drones market in Europe while addressing potentially related concerns like safety, privacy, liability or public acceptance. It has proposed to set new standards for the regulation of the operations of civil drones covering safety, security, privacy, data protection, insurance and liability. The development of standards within each of these fields must be monitored for its relevance within OmniDrone.

  The EASA, the European Aviation Safety Agency is currently developing EU-wide standards for SAFETY and will start work to develop the necessary SECURITY requirements, particularly to protect information streams. These and other proposed specific legal obligations (e.g. for air traffic management, the operator, the telecom service providers) will also need to be watched for its impact on OmniDrone.

  With respect to the implementation of the new technologies insurance and liability issues must be addressed, ranging from personal injury and invasion of privacy to aerial surveillance and data collection to see if the current legal framework is capable of dealing with these new developments .

- Privacy and dataprotection

  Drones may become extremely powerful surveillance tools. With respect to the use of cameras, compliance with the relevant regulations regarding the use of (CCTV) camera surveillance must be ensured. When personal data is processed by drones operated in the EU, the EU legal framework for data protection applies in principle. Respect for data protection requirements and for the right to private and family life will enhance the development of the market of drones within the EU.

- Reform of data protection legislation

  In 2012, the Commission proposed a major reform of the EU legal framework on the protection of personal data[19]. In April 2016, the text of a new regulation on data protection, has been approved by the EU Parliament[20]. The further process of implementation of the regulation has to be closely watched in order to assess the consequences for the OmniDrone project.

[13] http://www.ansecur.com/en/news/posts/2014/october/ansecur-announces-euka-dutch.aspx
[14] http://www.madeinlimburg.be/nieuws/sint-truiden-wil-drone-valley-van-vlaanderen-worden/
[15] http://www.hln.be/regio/nieuws-uit-koksijde/eerste-droneschool-opent-in-koksijde-a2140671/
[16] http://ec.europa.eu/enterprise/sectors/aerospace/uas/
17 http://singularityhub.com/2015/01/06/2015s-11-biggest-new-technologies-to-watch/:
[18] http://europa.eu/rapid/press-release_IP-14-384_en.htm
[19] Directive 95/46/EC and Directive 2002/58/EC
[20] (Belgium)The Act of 8 December 1992 on the protection of privacy in relation to the processing of personal data

2.3. Valorisation strategy and valorisation approach of the project

This section elaborates on the valorisation strategy that will be adopted in the OmniDrone project (2.3.1). Section 2.3.2 detailes the valorisation approach, including the intended dissemination strategy, as knowledge transfer is considered an essential part of valorisation. This section also includes valorisation KPIs (2.3.3), valorisation risk (2.3.4) and SWOT analysis (2.3.5).

2.3.1 Valorisation strategy: valorisation via collaborative follow-up projects

To transfer the OmniDrone R&D results to the stakeholders in the value chain, there exist two basic models, i.e. either the licensing model or the spin-off model. Given the strong industrial interest in the outcomes of the OmniDrone project, we see real potential to transfer the OmniDrone results into the existing Flemish industrial landscape. As such the creation of a spin-off company will NOT be the primary valorisation goal of the OmniDrone project. Nevertheless it should be noted that during project execution, while working out business cases and licensing models for specific project results, the spin-off creation opportunity will always be considered an alternative solution to licensing. This consideration will be made on a case-by-case basis.

The transfer of the results into the existing industrial landscape will be supported by follow-up projects with (a group of) companies. For each of the focus-1 area's at least one follow-up project will be prepared with the IAC members during project execution. These projects will be a direct follow-up on the research PoC outcomes of WP4 and tend to translate the OmniDrone solution into an operational environment. Besides we expect multiple other follow-up projects come into life as well, either with individual companies or groups of companies, in one of the focus-1 domains or beyond, and involving a complete OmniDrone solution or specific parts of it. Some examples, that popped-up during discussions with industry while preparing CAMELIUS & OmniDrone, were listed in section 2.2 or the LoI's of the IAC or VB members.

Concrete IPR rules and corresponding licensing arrangements will be fixed when setting up these projects and working out the respective consortium agreements. A detailed Freedom-to-Operate study will also be done before the start of each follow-up project, when details about the technology are already available. All companies in the IAC are aware that they have no direct rights on the project results. They did not ask for exclusivity although some of them asked not to have direct competitors in the IAC and especially the individual WG's. So far we took care of this, in order to guarantee a proper functioning of the IAC, and will continue doing so whilst setting up the extended IAC.

Our strong believe in the success of this valorisation approach is based on the following observations:

(1) The sincere interest of the members of the IAC in the results of the project is clear from their letters of intent and the several concrete potential follow-up trajectories defined so far.

(2) Many IAC members have an impressive historical track-record in collaboration with the OmniDrone partners and with other members of the IAC within and outside the scope of OmniDrone related research. This tight collaboration network (as shown in Figure 8) between the project partners and the IAC illustrates intensive knowledge transfer taken (and taking) place.

(3) The presence of new companies, we have never been working with before, is an opportunity to extend our reach also beyond our current play-field.

(4) The case leaders and project coordinator have a track-record on setting up projects with industrial partners. E.g. S. Pollin's track-record in valorising SBO research is an additional asset in this respect. She succeeded in setting-up three follow-up projects (2 ICON & 1 FP7) for the ESSENCES SBO project, and the CELTIC O&O project ROCCS for the SINS SBO, and recently submitted a VLAIO project with Blooloc to valorise part of the SBO SAMURAI outcomes. The LICT valorisation coordinator has initiated multiple projects in e.g. CELTIC, ITEA & ECSEL context, among which the 3D Safeguard project.

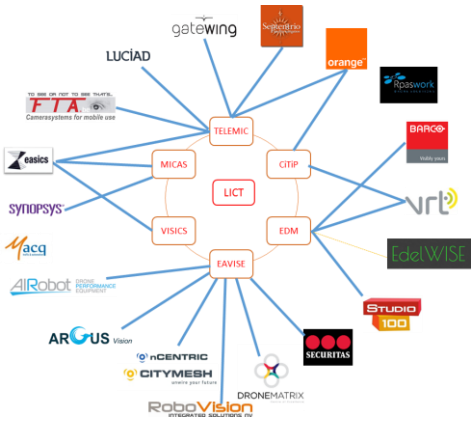


Figure 8: Collaboration network between IAC members and OmniDrone partners

The collaborations between the different IAC members, we learned about while preparing this proposal, and of which some are highlighted in section 2.2 and the Letters of Intent illustrate the existence of an economic ecosystem needed for successfully bringing 'complete' UAV solutions to the market.

2.3.2 Valorisation approach

In order to streamline and optimize the valorisation activities (1.) a specific work package has been foreseen, (2.) two support-boards have been created: an Industrial Advisory Committee (with a working group and an extension layer) and a Valorisation Board and (3.) a part-time OmniDrone valorisation account manager will be appointed, supporting the LICT valorisation coordinator and case leaders in order to speed up valorisation beyond the initial focus areas. For

the valorisation WP we refer to the description in part 3 of the proposal, the other aspects will be discussed below.

The OmniDrone governance structure supports our 2-stage valorisation approach that was introduced in section 2.1. and is presented in Figure 10. The figure actually shows the existence of three boards: a technical board, a valorization board and the Industrial Advisory Committee (IAC). The technical board unites research representatives of all partners and will go over all technical aspects of the project. Both the Valorisation Board and the Industrial Advisory Committee are important for the realisation of the valorisation objectives.

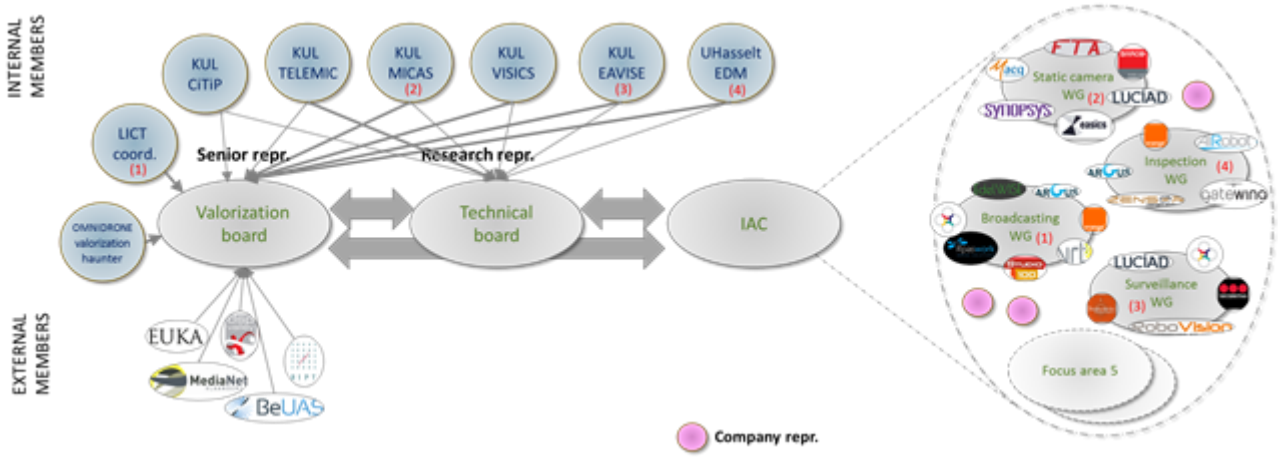


Figure 10: OmniDrone governance structure

The OmniDrone **Industrial Advisory Committee (IAC)** represents the external "market" for the project results and will act as a critical sounding board towards the project consortium both for the scientific and technological solution. As introduced in section 2.1, in order to be able to deal with the huge market potential for OmniDrone technology and at the same time keep the research and valorisation focused and manageable, we adopted a 2-stage valorisation approach, where we start focusing on the 4 carefully selected focus-1 area's, but do not neglect the broader potential neither. This approach is also reflected in the structure and way of working of the IAC. Within this IAC we will have 2 layers: a working group layer and an extension layer.

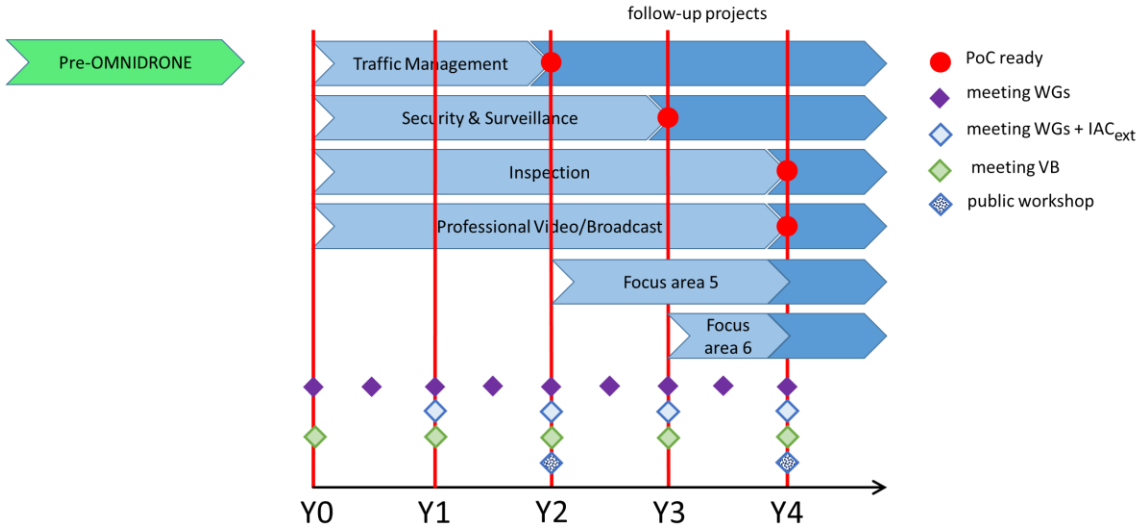
The first layer is the **working group layer**. On this level working groups (WGs) are organised for each of the focus-1 areas. Each WG has a limited, but for the case representative, group of (non-competitive) company members and is chaired by an OmniDrone senior representative: Toon Goedemé (EAVISE) for "Security & Surveillance", Greet Bilsen (LICT valorisation coordinator) for "Professional Video/Broadcast", Sammy Rogmans (EDM) for "Inspection" and Marian Verhelst (MICAS) for "Static 720° camera Traffic Monitoring". Within the WGs, the application of OmniDrone technology and results in the related focus area will be discussed and follow-up project(s) will be conceived. Also the eventual set-up of the PoCs and potential in-kind industrial contributions will be defined. The initial WG layer members have been presented in section 2.2.1 when discussing the valorisation potential. Depending on the needs and evolution in the project new members might be added to a WG.

WGs will meet at least every 6 months preferrably in a cross-WG setup. A typical meeting will start with a detailed status update by the team-members on the technological solutions developed so far, followed by discussions within the individual WGs. To close the meeting the different groups will join again to share results and discuss common concerns. We are convinced this cross-fertilisation between the different WGs will strongly benefit the project. If not possible to bring together all WGs on the same day, seperate meetings can be organised as well as intermediate ad-hoc WG meetings. The latter might especially be needed when concretely setting up a follow-up project. WGs will exist at least until the finalisation of the related PoC, but can go on till the end of the project. In the former case the WG members can join the extension IAC or another WG.

With the **extension layer** we aim to reach parties that show sincere interest in exploiting OmniDrone results, but do not fit in either one of the selected focus-1 areas. They will represent alternative application domains for either complete OmniDrone systems (camera mounted or not) and partial results on vision, communications and processing. The "IAC-ext" will become operational one year after the start of the project and will continuously be open for additional members, as long as they are not direct competitors of actual WG members. Following our industrial contacts during the CAMELIUS and OmniDrone preparation phase, we already have a list of potential prospects for joing the IAC-ext. Additional players can also be proposed by the networking organisations that are part of the Valorisation Board (DSP Valley, EUKA, BeUAS and MediaNet Vlaanderen).

IAC-ext members will meet at least once a year, on the same day as the WG members. The entire IAC will be jointly informed on the technological progress and will be challenged to give feedback on both technological and commercial aspects and discuss alternative valorisation opportunities. Based on the interest of the IAC members new focus areas and related working groups will be defined during the project, each with its own specific theme, core members and

case responsible. The idea it to start up one new group by the end of Y2 and a second one by the end of Y3.



The role of the OmniDrone **valorisation board** (being an internal marketing and business development group of the project) is to coordinate the valorisation-oriented activities in order to define and implement optimal strategies for the valorisation of the project results. The board unites both representatives of the project consortium (senior members of each of the partners, case leaders, the KU Leuven-LICT valorisation coordinator Greet Bilsen and starting Y3 also the OmniDrone valorisation account manager) as well as some external experts. The entire valorisation board will meet at least once a year, whilst the partner representatives meet every 4 to 6 months.

As the regulation (both privacy regulation as well as spectrum regulation) is crucial for the eventual break-through of civil UAV usage and represents a non-neglectable valorisation risk if not being taken into account properly, the valorisation board will have a special role in considering actual regulation restrictions and requirements whilst defining UAV technology based solutions. As such a special sub-group within the valorisation board will be set-up to discuss on these issues. This group will be headed by the legal partner in the consortium, CiTiP. The exact constellation will be defined upon the start of the project.

Up to now, 5 organisations have accepted to join the OmniDrone valorisation board. Their motivation can be found in the Letters of Interest in Appendix B.1. They can be divided in two categories:

On the one hand there are networking organisations. As they represent an entire sector, they are ideal partners to communicate market needs, help with market/business analyses, define "new" applications and concrete follow-up projects, support in finding additional IAC-ext or WG members and help in disseminating the results towards their member base. Within this category we have: DSP Valley for the Smart Systems community, MediaNet Vlaanderen for the mediasector and EUKA for the Drone Industry.

On the other hand we have some experts on regulation like BeUAS (for the Drone sector) and BIPT (for communication spectrum regulation). They will be standard members of the regulation sub-group of the VB.

OmniDrone valorisation account manager

Valorisation preparation in the different focus area's will initially be the responsibility of the respective WG leaders, with support of and coordinated by the LICT valorisation coordinator. WG leaders will join with the technical PI's and the LICT coordinator on a regular basis to align and exchange ideas during the internal VB meetings. During these meetings also alternative valorisation trajectories, that popped up during WG, IAC and VB meetings or in contacts with the external world, will be discussed. Besides for defining concrete follow-up projects the internal VB will also be responsible for other typical valorisation-related activities like: studying (additional) relevant target applications & markets; defining & executing a solid IPR management and confidentiality policy; assuring that OmniDrone technological activities remain in line with market evolutions and adjusting the project when needed; disseminating project results and last but not least managing the valorisation risks.

As the project evolves valorisation focus will become broader extending the (initial) focus area's. In order to support this broader valorisation and bring it on a higher level towards the end of the project, a **valorisation account manager**, supporting the LICT valorisation coordinator, will be assigned part-time to the project starting Y3. He/she will be responsible, in dialog with the PI's and the LICT valorisation coördinator, to pursue and prepare valorisation trajectories beyond the 4 basic demonstration projects defined within the scope of the WG's. Different options are open for filling in this position. Preferably the valorisation manager is a post-doc or last stage PhD student with clear interest for research valorisation and with 'sufficiently broad knowledge' on OmniDrone technology. He/she will be asked to follow the Doctoral school training course "Exploitation of research - technology & knowledge transfer". Alternatives would be to 'hire' an external party from a business school or to make more intensive use of the services of the LICT valorisation coordinator or potentially an IOF manager/ research manager in

function with one of the OmniDrone research groups at that time. A decision on which direction to take and assigning the right person(s) to the job is expected Y2Q3.

Options for dissemination

As result dissemination is an essential activity in our valorisation strategy we will present in the next section some channels that we intend to use for this:

- Dissemination towards the WGs, extended IAC and VB will happen on a 6 monthly, resp. yearly basis as described above.
- A public workshop will be organised when the project is half-way and at the end of the project. This will be done in close cooperation with the LICT coordinator, having experience with this kind of workshops. During these public workshops OmniDrone research will be presented next to some keynote presentations or testimonies of IAC members. Communication channels of the VB networking members will be used to reach a broader public or attract inspiring keynote speakers.
- A project website will be set-up with a part for internal communication between the partners and the IAC and a public part where selected project results will be made available to industrial players.
- The standard channels of the scientific community will be used to further disseminate the results of the OmniDrone project. These channels are scientific publications in international journals, presentations at international conferences, PhD theses and bachelor/master projects.
- Presentation of the OmniDrone project at technical and networking events organized by members of the valorisation board (DSP Valley, EUKA, MediaNet Vlaanderen, BeUAS, …) as well as on iMinds the conference[21]. Special focus will be on having a presentation or booth at the yearly Drone Convention.
- Open demonstrations at several test-sites both internal to the KU Leuven or within premises provided by one of the members of the IAC and VB
- Presentation of the project results in the DSP Valley Newsletter and other technical newsletters. We plan at least one technical contribution per year in the DSP Valley Newsletter as well as visibility through the EUKA website and Newsflashes.

2.3.3 Valorisation KPIs

In order to be able to evaluate OmniDrone valorisation progress we define specific and measurable KPIs. Follow-up of these KPI's is the responsibility of the LICT valorisation coordinator and project coordinator (Yx is end Yx).

- Define at least 4 follow-up projects, one for each of the cases: 1 by end Y2 (static camera traffic monitoring), 1 by end Y3 (security & surveillance) and 2 by end Y4 (professional video/Broadcasting and inspection);
- Define 2 new focus areas with related working group and case leader: one by end Y2 and one by end Y3;
- Hire a dedicated OmniDrone valorisation account manager at the start of Y3;
- Have an initial extended IAC (e.g., including companies from CAMELIUS IAC not yet in OmniDrone IAC, if relevant) installed by the end of Y1;
- Organise at least 9 WG meetings, 5 VB meetings and 4 meetings with the broader IAC;
- Organize 2 public workshops;
- Have project website ready by M1;
- Have at least one presentation a year at events organised by partner organisations, including Drone Convention;
- Have at least one publication a year in a technical newspaper (DSP Valley Newsletter).

2.3.4 Valorisation risks and management

- **Intellectual Property Rights (IPR) and Freedom to Operate:** An initial rough screening of the patent database around some specific keywords did not report problems during this proposal writing phase (see summary in Appendix B.6). A detailed Freedom to Operate study can not be done at this stage, as the algorithm and technology details that will be proposed in OmniDrone are not yet ready. As situations change, we plan to repeat this analysis during the actual execution of the OmniDrone project to assess whether a proposed conceptual solution has already been patented or has any "strings attached", i.e. is critically depending on existing patents. **The ideal time to do a detailed Freedom to Operate study is after the PoC, just before the start of the follow-up trajectory**. For these patent searches the OmniDrone partners will be supported a.o. by KU Leuven LRD and UHasselt TTO.
- **Valorisation potential dependent on OmniDrone quantitative project results**: Continuous assessment of the market potential by the valorisation board and IAC will ensure timely adaptation to moving valorisation targets, allow us to identify new cases, and if needed stop the research towards one of the cases if the market potential or

[21] or its successor following the fusion of IMEC and iMinds

interest from industry would disappear. Depending on the evalutions in UAV market and regulation, we can focus more to static (on the ground) or flying (on the UAV) cases.

- **Partner agreements**: As the project contains multiple parties, clear IPR rules will have to be discussed. A term sheet will be elaborated in close collaboration with KU Leuven LRD and the UHasselt TTO. The basic ground of the term sheet will be an exclusive access to foreground knowledge/IP generated by a single partner and shared access to IP/knowledge generated by multiple partners in collaboration. The concrete IP regulations will be worked out further by the time the term sheet is needed in September.
- **Regulation and certification:** As mentioned before, safety and privacy regulations exist regarding the usage of camera-equiped UAVs in specific application domains. Also the usage of the wireless spectrum for communicating the UAV images and video streams is strongly regulated. By including CiTiP as a partner in the project and having organisations like BeUAS (and potentially) BIPT within the valorisation board we will be able to follow-up all restrictions and anticipate on dealing with them either in the OmniDrone project itself or (what is more likely) in the domain specific follow-up projects. While preparing the follow-up projects, certification needs and certification budget will be considered and foreseen in the related proposals.

2.3.5 Valorisation SWOT analysis

As indicated before the valorisation strategy of OmniDrone has been seleced carefully following our discussions with industry and organisations and an analysis of the industrial landscape. A SWOT analysis of this strategy can be found in the table below.

Strengths	**Weaknesses**
• Main focus is on the UAV market: market in full expansion with (worldwide) a very high potential and also in Flanders a driven UAV community in full expansion • Additional valorization outside UAV market is explicitely pursued by selected static camera case, on the one hand, and by inviting stakeholders from other domains to be part of extended IAC. • Staged approach, with 2 layer IAC, allows to tackle some low-hanging fruit, very promising markets, first whilst keeping track of broader valorization possibilities • Access to industy not only via companies in IAC, but also via 5 (cluster/network) organisations being members of the valorization board • Focus on transfer to industry via follow-up projects is completely in line with and focuses on on synergy between the existing and arising industrial landscape • Timing: legislation for autonomous UAV's is expected by 2020 • De OmniDrone partners have strong track-record in collaboration with Industry and the IAC represents a good mlix between known and new companies	• UAV players in Flanders are mainly small companies and the ecosystem in still in evolution • Strong focus on selected application domains, might delay valorization in other domains
Opportunities	**Threats**
• "Civil" UAV market is currently under development, with still many hidden applications • Strong vision and wireless market and reserach groups in Flanders • Dynamic UAV ecosystem in Flanders, with a large number of small companies, but also links to established strong UAVs (Luciad, Septentrio) and large companies (SECURITAS, Studio 100, VRT,…).	• Legislation staying too strict and lagging behind; EU regulation delayed or also too strict. • Competition from neigbouring countries where legislation is ahead of ours and where solutions can be tested and demonstrated earlier in time

2.4. Added value in the area of sustainable development (if applicable)

OmniDrone's targeted 720°-aware UAV will bring an important contribution towards environmental sustainability. More specifically, the R&D follow-up projects will bring important contributions towards 4 out of the 8 postulated environmental innovation objectives, as described in the Sustainable Development (SD) Guidelines for industrial projects at the Agency for Innovation and Entrepreneurship. We will detail this for each of the relevant environmental innovation objectives, and illustrate this with the related follow-up projects planned with the OmniDrone IAC:

1. *Reducing emissions of environmentally harmful substances:*
   - The OmniDrone outcomes enable the deployment of robust, flying-assisted UAVs for affordable remote monitoring and inspection tasks. This avoids long and high transportation costs, along with a direct reduction in carbon footprint.
     Follow-up project & valorization target ➔ UAV-based inspection
   - The static 720-degree camera system targeted in OmniDrone enables improved monitoring of traffic flows on roads, in harbors and airports. Studies in the UK have clearly shown important and prooven impact on traffic reduction by finer grain toll systems through more intelligent traffic monitoring[22].
     Follow-up project & valorization target ➔ Static 720° camera Traffic Monitoring
2. *Increasing safety and health at work*
   - The OmniDrone project targets the deplyoment of safer UAVs, which automatically stay at a safe distance from people. This significantly increases the safety of both the audience as well as the crew when e.g. filming with UAVs.
     Follow-up project & valorization target ➔ UAV-based professional video/broadcast
   - The OmniDrone project targets the deplyoment of UAVs for surveillance applications, where guards do not have to go around themselves anymore on e.g. large industrial sites, but can do remote, and UAV-assisted surveillance. This clearly increaeses safety of these professionals.
     Follow-up project & valorization target ➔ UAV-based security & surveillance
3. *Increasing the lifespan of products and processes*
   - The OmniDrone project targets remote infrastructure inspection using UAVs which have learned to do the inspection autonomously through imitation learning. This enables more frequent and more accurate inspection of industrial equipment, as well as inspection of remote, hard to reach locations. Several industrial players in our IAC have indicated that this will solve a very important bottleneck in their equipment monitoring and maintenance (e.g. of on-sea windmills), increasing the lifespan of these products (and of buildings), and making maintenance more cost-effective and sustainable. In the context of specialized environmental policies (such as e.g. BREEAM, ISO 15686, etc…) that perform full life cycle analysis (LCA) methods, this means an improved environmental impact.
     Follow-up project & valorization target ➔ UAV-based inspection
4. *Energy savings*
   - OmniDrone targets a lower energy consumption of al electronics involved in embedded image processing, as well as in robust communication. This is done through the creation of efficient and scalable image processing algorithms, through reconfigurable communication schemes and through custom hardware implementations. E.g. for the static 720° camera system, a power budget below 10Watt is predicted, which is at least an order of magnitude lower than GPU-based systems that are currently deployed.
     Follow-up project & valorization target ➔ Static 720° camera Traffic Monitoring

[22] (http://www.go-etc.jp/english/about/ and Eliasson, Jonas. "A cost–benefit analysis of the Stockholm congestion charging system." Transportation Research Part A: Policy and Practice 43.4 (2009): 468-480.