CHAPTER II

LITERATURE REVIEW

2.1. Construction Management

The construction industry is the largest industry in the world which is an economic investment and its relationship with economic development is well posited. In order to ensure this contribution is continuous, every construction project must be managed properly based on the construction management guidelines. There are several phases in construction management, which are preliminary stage, feasibility studies design stage, contract stage, construction stage and completion and handover stage.

A study by Rezaian (2011) construction management focuses on time, cost and quality of the project. Time, cost and quality as three critical objectives of construction management are not independent, but intricately related time, cost and quality of a construction project are influenced by the decisions made by project manager (Golparvar et al., 2009). Most construction projects employ scheduling methods to monitor and control the progress of work and develop progress reports (Zubair et al., 2006). One of the method to monitoring construction progress is using Micro UAV which is also used in forest and agricultural applications, photogrammetry for 3D modelling and many more domains (Saari et al., 2011) This is mainly due to the low cost, fast speed, high manoeuvrability, and high safety of Micro UAV systems for collecting images.

2.2. Robotics In Construction Industry

A competitive, market oriented and rationalized construction tomorrow requires developing of automated and robotized construction system today. This includes industrialized process originating in a mining, construction material production, prefabrication of construction components, on site construction, facility management, rehabilitation and recycling (Thomas, B., 2008).

A study by Yukio (2006) It has enough capacity which handles big and heavy building structure members, and intelligence to do complicated operations easily. The robot body must have less weight as it easily escapes from the working place when it is not used. Today's construction projects are characterizing by short design and build period, increased demands of quality and low cost. These problems can be approached by a flexible automation using robots based on computer or smartphone assisted planning, engineering and construction management. (Thomas, B., 2008).

The author consider construction robotics technology as a key to rationalization. By automation, increased productivity could reduce high labor cost share of 40 or more percent. Automated and robotized construction process lead to a continuous working time through the year. Introduction of robotic technology would result in better working and health conditions, and advanced mechatronics know how and skills. The reduction of construction time would improve cost benefit analysis of construction project due to faster availability and return on investment of construction industry (Thomas, B., 2008).

According to Urzillo and Robbins (2017), one of the most widely used robots in the world of construction now days is the UAV or often referred to as *Drone*, this tool is used to conduct inspection and monitoring during the construction process is running without constrained time. In fact drones can collect data faster than either human surveyors or manned air crafts, and often with the same or greater detail, when drone fly nothing to worry to interrupt construction work and one of the adventage is make direct observations to the location that we want.

2.3. Unmanned Aerial Vehicle (UAV or Drone)

Drones are extremely intelligent machines that function at a high level of autonomy, and while they appear to operate effortlessly, there is a lot of technology packed into their lightweight design. A typical drone consists of either four, six, or eight motors, each with its own set of propellers, as well as several other components. A drone with four motors is known as a quadcopter, a drone with six, a hexacopter, and a drone with eight, an octocopter (Rising, J., 2016). Along with the motors, blades and more, most drones also contain some sort of onboard GPS system. This technology lets the user know the altitude of the drone, where the drone is located, and it even logs where the takeoff spot was in case the drone needs to land unassisted (Pullen, J.P., 2015).

Drones also come with a transmitter and receiver, or “remote control” using radio frequency. While many drones use a manual control stick specifically for the drone, more and more companies have also begun using apps on smartphones or tablets, which wirelessly connect to the drone via Bluetooth (J.P.

Pullen, J.P., 2015). Regardless the type of controller, all drones typically contain the same main controls – roll, pitch, and yaw. The roll command moves the drone side to side, the pitch command moves the drone forward or backward, and the yaw command makes the drone rotate (turn) left or right (Rising, J., 2016). The multitude of functions that drones can perform contribute to the versatility of drones in construction industry and other industries, because they allow the machines to complete complex tasks.

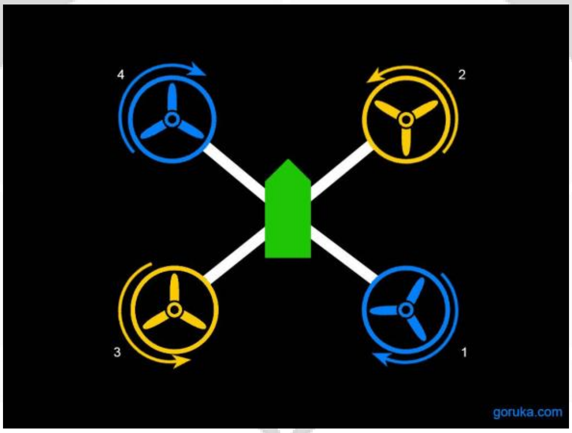

Figure 2.1

This figure shows a drawing of a basic representation of a quadcopter – a drone with four motors – with an 'X' structure shape

2.3.1. Functions of *Drone*

A journal study (Navigant.com, 2015) base on FAA (Federal Aviation Administration) stated that generally, drone has six (6) possible application :

1. Aerial photography to track job progress.
2. Aerial photography for logistics and production planning.
3. Aerial photography for marketing.

4. Inspection of areas difficult or impossible to access.
5. Safety monitoring and support.
6. Land surveying, thermal imaging, laser scanning or other data collection.

2.3.2. Classification of *Drone*

A journal study base on FAA (Federal Aviation Administration) stated that generally, drone classified three (3) main function :

1. Public Operations *(Governmental)*
2. Civil Operations *(Non – Governmental)*
3. Model Aircraft *(Hobby and Recreation Only)*

2.3.2.1. Public Operations (*Governmental*)

According to the function of this drone is used by the government for public and government interests including fire brigade, border patrol, natural disaster, SAR, military training and other government operations missions.

2.3.2.2. Civil Operations (*Non - Governmental*)

This function can be used by the *general public* without exception will still comply with the rules of use drones applicable in each country and region, as for its function is divided into 2, namely:

1. Commercial operation and environmental control with low risk level. Usually drone use is used for promotion, company profile, and other commercial activities.

2. Applied to help the design, construction, and manufacturing processes, including engineering processes, and so on. Some developed countries already use this tool in the construction process.

2.3.2.3. Model Aircraft *(Hobby and Recreation Only)*

In an era of increasingly advanced technology, many people have owned this tool for their own interests, such as for hobbies or for recreation without having to have a pilot drone license. There are also many campaign to provide information to the general public about how to use and. fly safely unmanned aircraft vehicle or drone.

2.3.3. *Drone* Requirements

1. *Drone* is in good condition, no problem, no crack under motor, normal running motor, camera normal.
2. No defect in the Propeller.
3. Normal battery, safe, no problem, indicated on battery description in DJI Go or Yuneec CGO application.
4. Remote in good condition, with battery, remote (transmitter and receiver) signal, and function still normal no problem.
5. The overall state of Aircraft and Remote is in the position of Safe To Fly (GPS). Which means that the drone is in a state of ready to fly and the GPS surrounding location has been locked properly. (DJI or Yuneec Safe Fly PDF, 2013)

2.3.4. Legal Requirements Related to *Drone* Use *(Indonesia Regulation)*

Today many people have and use drones, whereas on the other hand the use of this tool is very dangerous, especially in the world of aviation. Through the Regulation of the Minister of Transportation no. 90 of 2015 has been set the use of drones, among others:

1. The maximum use of the drone is 150 meters, and can be increased by requesting permission to the relevant agencies, in this case the police, local government, and the local transportation agency.
2. It is prohibited to enter the KKOP (Aviation Safety Operation Area) located in the area around the airport for flight operations.
3. Forbidden to enter the prohibited area / prohibited area, namely the ring 1 airport area that is permanent.
4. Prohibited from entering restricted airspace or area.

2.3.5. *UAV* Regulation *(International Regulation)*

Today From being completely unregulated, the boom in consumer-grade UAV has been forced to enforce new government regulations. These new laws clearly affect the commercial sector. In the US for instance, the Federal Aviation Administration (FAA) prevents companies for using UAVs for commercial purposes. New companies need to apply for a specific permit in order to be granted an exemption (Canis, B., 2015).

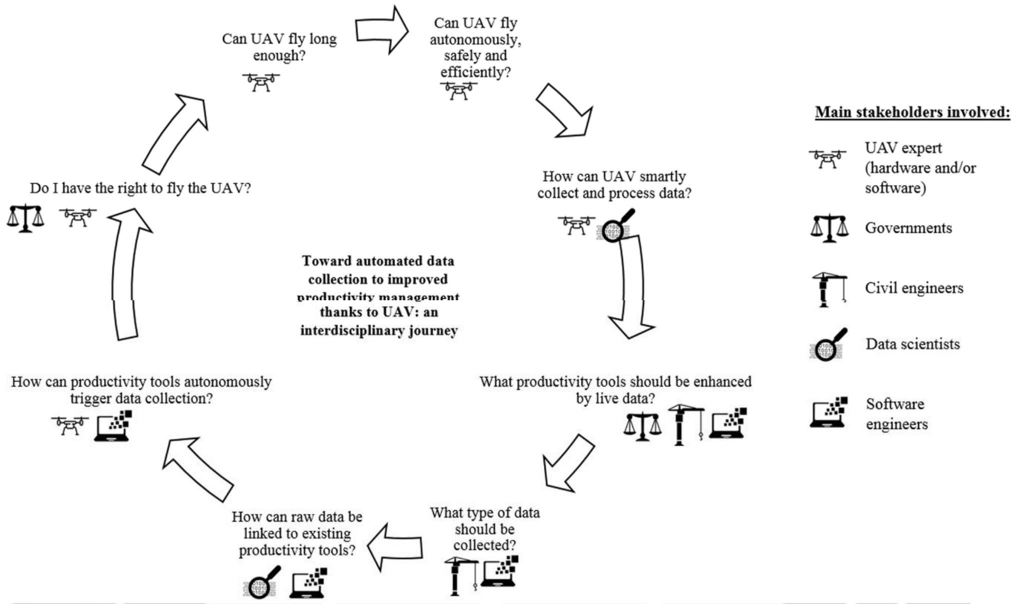

Figure 2.2 Review of the stakeholders icon graphics.
Source : Flaticon, http://www.flaticon.com/

In France, certified flights must (1) remain out of specific areas; (2) provide a clear and secured ground area; (3) refrain from flying above individuals within urban areas; (4) stay within the line of sight of a safety pilot Drone regulations in, Ministere de l'environnement, de l'energie et de la mer (Ministry of envionment, energy and sea, 2015). Lobbying is quite intense between UAV operators and government. We can expect the laws to evolve rapidly (Flaticon, http://www.flaticon.com/).

2.4. UAV Usabillity and User-Centered Systems

Systems have traditionally been designed and developed through a technology-center perspective (Endsley et al. 2003). In such a perspective the designers would accept the technology as is and would try to apply the very same technology in different domains without considering the very important element of the ultimate end-user (human). In a technology-centered perspective, the end user and all its requirements would be considered improperly identical in different domains. A user-centered approach was employed. Unlike the technology-centered approach, the very first issue that should be resolved in a user-center perspective is whether the technology is usable considering the real users' experience and their own requirements in a specific domain.

This user-centered usability based step would provide a grounded base for understanding the requirements for practical application of the technology in a domain. Having the drone technology might seem very useful for safety inspection practices but the very first issue that should be resolved is whether this technology would be usable for both safety managers and construction workers. A usable system should be easy to use and learn to work with while having the least number of design errors that makes it efficient enough to be ideally used

As Figure 2.4 illustrates and discussed in section 2.3, within the current construction environment the managers usually have direct face-to-face and vocal interaction with construction workers. But using the drone technology would change this direct interaction between workers and managers by adding the two elements of aerial drone and the user interface to the interaction process (Figure 2.4). The aerial drone part of the drone system would usually fly as a inspector assistant over the jobsite and would provide a real-time view of the jobsite on the manager's mobile handheld device (user interface) (Javier et al, 2012).

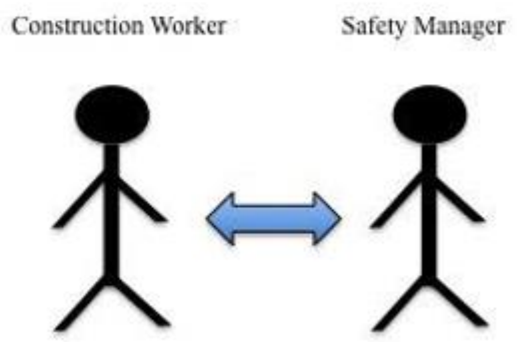

Figure 2.3. Construction worker and manager direct interaction

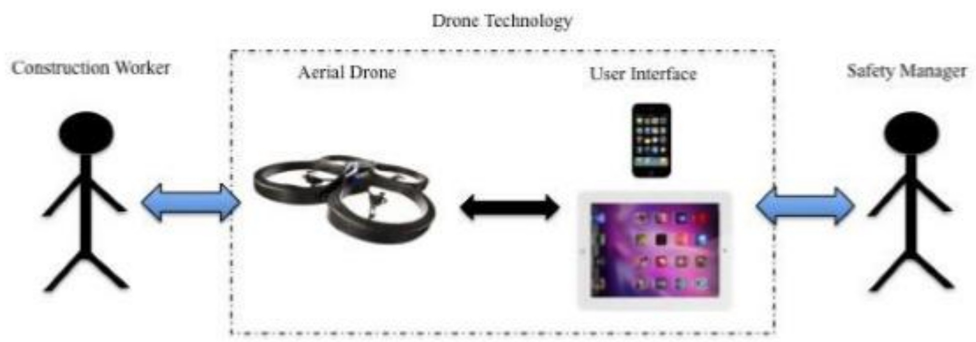

Figure 2.4. Construction worker and manager indirect interaction through drone technology

In such new condition, workers would see the drones flying around the jobsite and they would have to interact with them as they would interact with a manager. At the same time, the manager would get a real-time view of the jobsite and workers on the interface of the drone system. This interactive window of the jobsite would be a safety manager's center for interaction with workers and performing inspection tasks. Having the drone technology for construction safety practices embeds two parts, the *aerial drone and the user interface*. The construction workers usually interact with the aerial drone part of the drone technology while the managers would mostly interact with the user interface part.

The focus of this research is on the inspection part and how a drone can play the role of a safety inspection assistant. In such environment, where approximately all the safety manager's interaction with the drone technology would happen within the interactive physical interface of the system, concentrating on the user interface is justified. The user-centered approach together with the usability assessment scope of this research led to two different usability assessments and manager's user experience measurement while performing a safety related task using the system.

2.5. Direct Field Observation

Data collection using this method is study by two different observation methods because the observations are done from two different projects, and the supervisory methods are different. The first observations were using *drones as a supervisor* of the construction process, while the second observation was made by conducting construction *supervision manually*.

2.5.1. Observation Method With Drone

1. Here is a picture when the observation by using the drone is done. Drone observed the construction process by turning around the building. In the drone observation will rotate around the building on each floor. It is intended that the observations made can cover the area in detail.

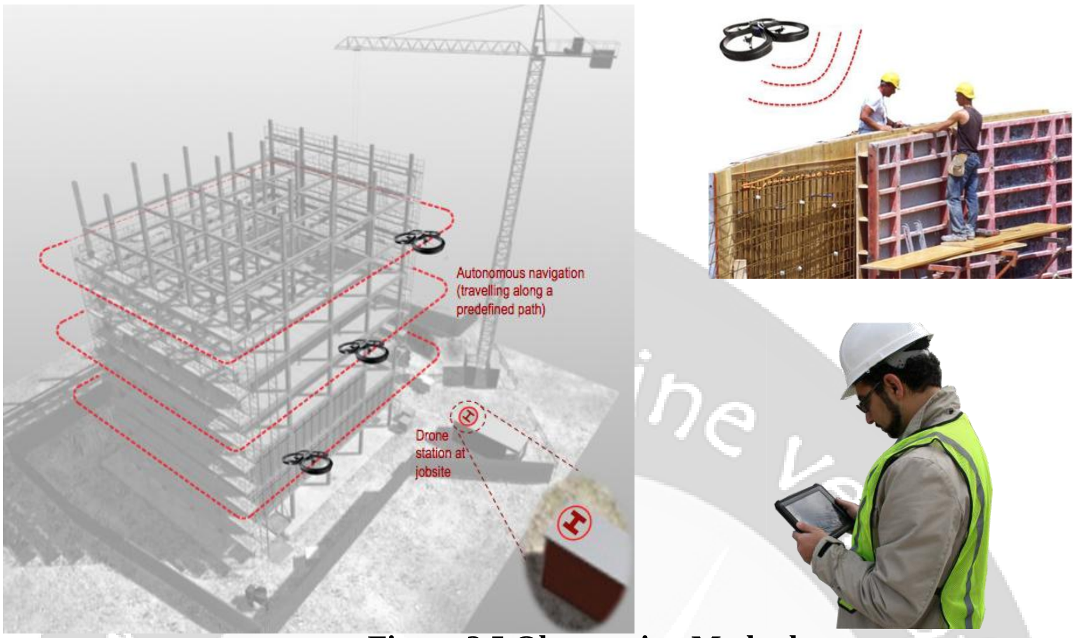

Figure 2.5 Observation Method
Source: Javier et al,. September 2012

2. In addition *drones* will do observation around during construction supervision, *drones* also conduct random or random surveillance, this is intended to get a detailed observation, not only from the edge of the building alone. Fly and get around the location that the worker is working on. When doing observations using drones, videos and photos still running, it works to see live or direct monitoring

2.5.2. Manual Observation Method

Observations are made by observing or supervising directly to the project site, using only stopwatch, recording duration form, and camera. On manual observation is done on the location of construction work.

2.6. UAV Cost-Effective Considerations

Aerial photography via conventional plane or helicopter can be an expensive items for a construction project. Operational costs of hundreds of dollars per hour place these periodic costs beyond the budgetary abilities of many projects save for brief periods of time over the course of a project. In contrast, the operational costs of a UAV are significantly less since both equipment costs and operational costs are far lower compared to helicopters. It takes less time and skill to learn to capably operate a UAV as opposed to piloting planes and helicopters. Time savings also accrue to the project since the UAV is stored, when not in use, at the project site in the job trailer or in a vehicle's trunk. Conventional planes and helicopters require basing remotely at an appropriate facility that is often at a significant distance from the project site. This remote-basing also creates its own separate cost structure for storage (Banik. G, 2015).

2.7. Cost and Selections

According to Banik (2015), usually contractors and consultants don’t like to spend a significant amount of money on UAVs - a few hundred dollars to several thousand dollars. UAV toys would be those items typically costing in the range of $100 or less, can complete some works. While these toy units have a very favorable purchase price, they have significant limitations. UAVs require maintenance with parts replacement due to items simply wearing out or from crashes due to operator error, mechanical failure, fuel/battery issues, and other reasons. Another problem with these toys is that their capabilities have significant limitations including environmental issues, flight-time issues, short flying time and payload issues. To be useful, UAVs need to be able to carry a payload consisting of a camera, thermography detection unit, or other tools. Toy UAVs do not have this ability or that ability is severely constrained such that a camera payload is sharply limited to low-capability cameras.

Instead, contractors need to spend more when acquiring UAVs to satisfy their requirements. An expenditure of a few hundred dollars for the UAV itself currently represents a reasonable floor for purchase costs. Some UAVs come without dedicated ground-control units but have downloadable apps that enable the user to operate the unit with a smartphone. These UAVs therefore offer a slightly-lower price since the control unit is not part of the system package. Higher expenditures yield UAVs with greater payload capacities, longer flight times, and better abilities to achieve flight objectives in windy environments. In this class are units that have GPS capability and return-to-home features. GPS capability can allow a UAV, once on location, to hover at a set point and take video/still photography or perform other work requiring this ability.

These more up-market UAVs can operate in minimum/maximum temperatures of -13ºF to 100ºF and in maximum winds of up to 18 mph. With conventional helicopter flight costs at four-to-five-hundred dollars per hour versus less than one-hundred dollars per hour for a UAV, this price delta can be made up fairly quickly on a series of projects. The bulk of the one-hundred dollars or less in this case would be salary/benefit costs for whoever operates the unit.

2.7.1 <u>Cost Related to UASs Use</u>

An aspect of UAS application on construction sites that is still not clearly defined is the costs associated with their use. There are several items that could contribute to these costs such as obtaining the required authorization for use, the UAS itself, the training for personnel who would operate the UAS or paying a service to operate the UAS,and insurance costs. Because the use of UASs is not widespread and can greatly vary from project to project, a detailed estimate of the costs that would apply to all projects may not be possible at this time. However, based on the exploratory case study performed, an estimate of these costs is presented in figure 2.6. Some of the estimated costs presented in figure 2.6 would apply under current FAA regulations. However, once the final version of the regulations is in place in approximately 2017, these costs could change and some would likely decrease. For example, the process of obtaining authorization for the use of UAS would be simpler under the proposed regulations, and the associated cost for the operator would decrease.It is expected that operators would have to take only a written exam, which would be a fraction of the cost of obtaining a pilot’s license as is now required (Javier et al., 2016)

Estimate of Costs Associated with UAS Use on Construction Sites

Item	Cost	Comments
Certificate of Authorization (COA)	$6,000 to $9,000 per certificate (D. Price, personal communication 2015)	This cost can vary depending on the location of the project, the area to cover, and the UAS to be used. The cost is per certificate, and depending on location a COA could apply to multiple sites. These costs are applicable to the sites used in this study
Equipment	$1,800	DJI Phantom vision 2+
Insurance	Example estimates of premiums: $1 million insured: $500 $2 million insured: $650 $5 million insured: $1,000 $10 million insured: $1,850	These premium example estimates are for third party liability (J. Gadbury, personal communication, 2015)
Operator (pilot)	$120 perhour × 1 hour pervisit = $120 (GTRI 2015))	These are estimated costs and were not actually incurred because the operator was part of the research team

Figure 2.6. Estimate of Costs Associated with UAS Use on Construction Sites

The use of UAS would provide benefits to projects such as reduced time for aerial photos to be delivered to site, no limitations on the number of photos other than flight time and memory card capacity, no limitations on view angles and elevation of photos except for the FAA-imposed elevation limits, and availability of videos from the same perspective and elevation as aerial photos.

2.8. UAV Jobsite Safety and Insurance Concerns

Operators utilize UAV must have safety as a key concern on any jobsite. UAV helicopter blades turn at thousands of revolutions per minutes (RPM) and have the potential to cause more injuries compared to UAVs (Nisser and Westin, 2006). UAV operators usually read and follow manufacturer's safety or operational instructions related to their particular unit before the operations to ensure that they don't create their own safety hazards on a project. Construction workers have enough safety concerns in the field without also having to worry about UAVs.

Prior to flight within the constraints and complexity of a jobsite, the operator should first practice and hone their skills in open areas. A UAV can quickly fall to the ground with little or no warning due to mechanical failure or loss of power. Due to these considerations, the operators when possible should avoid hovering or flying the unit over areas of the project where people are on the ground. For inspection or photographic tasks in occupied areas, UAVs can be used in after work or on even weekends.

In order to minimize the possibility of failures while in flight, the UAV operator should perform a pre-flight check wherein parts are checked for correct tightness and other considerations. Battery life should be monitored and a safety margin left to minimize the possibility of a failure. Therefore, if a flight time maximum of twelve minutes with fully-charged batteries is allowable, at ten minutes the operator should be landing the unit. If additional flight time is then required, a fresh battery pack can be installed to continue the work. If a UAV crash takes place, the unit should be carefully checked prior to again placing the unit in operation. With all the advantages of using UAVs, uses also brings several liability and insurance issues which are:

- Operator errors causing personal injury and property damage to others including operators
- Damage itself and associated equipments
- Product liability of manufacturers, suppliers, assemblers, installers and apparent manufacturers
- Invasion of privacy, trespass and property rights

Although currently USA does not need to have insurance for commercial and recreational uses, but multiple companies are offering UAV insurance to minimize liabilities.

2.9. <u>Common UAV Construction Applications</u>

According to Opfer and Shields (2014), contractors utilizing UAVs are involving them in a wide variety of project applications. The UAV is only application-restricted due to its practical ability to be able to see an item from its perspective. While it can't practically replace a physical person for every relevant task with a camera or other device, it can provide a supplement on a wide range of construction project tasks. In essence, the UAV is a force multiplier in saving personnel time on a project over a variety of tasks or allowing work to be performed from a safer vantage point through remote-control cameras.

Applications besides standard aerial photography can include inspection tasks, productivity surveys, marketing and interference documentation related to construction claims.

2.9.1 Job Progress Aerial Photography

Currently the most common utilization for UAVs is with aerial photography inside and outside at project sites . This is typically done to monitor job progress. These photographs are often required on a weekly or monthly basis. The UAV can provide unique overall perspectives of the job's progress with a fraction of the cost of conventional alternatives involving planes or helicopters. The UAV also offers the advantage of being able to visually capture a certain construction operation on short notice whereas conventional plane/helicopter work requires advanced scheduling (Opfer and Shields, 2014).

2.9.2 Construction Estimating

Site visits to a proposed project site are a key element prior to estimating the cost of a project. Site visits can also be time consuming for estimating staffs that typically face significant time constraints. Environmental barriers such as fences and ditches may prevent vehicular travel to portions of a greenfield site thus requiring foot travel. The UAV can obviously travel at much faster speeds than a person on foot while acquiring aerial photo and video site documentation at the same time. Utilization of a UAV launched at the site can photograph wide areas at high resolution. The UAV can fly close to the ground to also inspect the area for any potential issues impacting the construction estimate. There are some roofing contractors that utilize UAVs for roofing estimates (Opfer and Shields 2014). Certain roofs such as those with slate or clay tile are problematic to walk on since foot traffic may damage the roof. With steep slope roofs there are safety considerations. On other roofs, access to a certain roof area may be problematic and time consuming requiring difficult climbing works. Roofing contractors therefore can utilize UAVs to yield both safety benefits and time savings in their estimating work.

2.9.3 Construction Inspection

UAVs can assist in certain construction inspection tasks but have limitation to non-contact inspection work on a site. Therefore, a task such as inspecting the torque readings of structural steel bolts with a torque wrench is clearly outside the capabilities of a UAV. The applications for a UAV with a conventional camera can assist construction inspectors in their work in a number of areas (Eschmann et al., 2012). Inspectors are often constrained in their visual surveillance on a site because a view is unavailable in hard-to-see locations such as outside the building envelope, or there are significant personal safety issues in attempting the surveillance. The UAV allows the inspector to see in first person point-of-view through a remote-controlled camera these areas from a safe vantage point.

The main focus of using UAVs is clearly on the data acquisition of the infrastructure to be inspected. To generally fly around an object, a preliminary flight track planning is needed, which is usually done by using a common software based on GPS waypoint navigation. However for inspecting a building GPS navigation becomes insufficient due to the precision required to the façade to be monitored and the threat of any shadowing effects resulting from near by buildings. Moreover GPS does not allow accurate flight altitude control which is an essential factor under flight planning aspects.

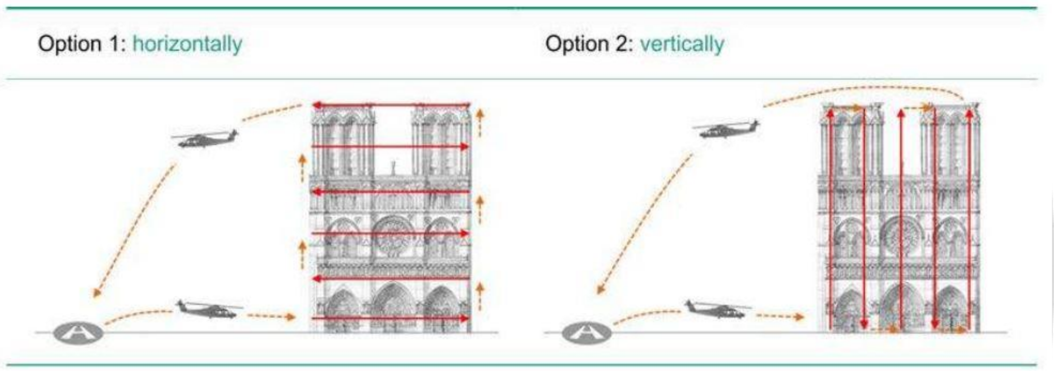

Figure 2.7. Options for on-site flight pattern

In order to have a images easily allocated to the real object in a structured way there are two options of flight patterns available when using an UAV for on-site building inspection (Figure 2.7). On the one hand, the flight path can be allocated horizontally as a storey-wise scanning of the building, and on the other it can follow vertically aligned slices.

With regard to the usability of the aerial photos, the flight pattern option 2 was eliminated for UAV inspection as the main vertical movement increased lens-induced effects negative for stitching. Additionally the horizontal speed has to be quite limited while recording images such that fast bank angle changes effecting images are reduced and not be leveled by the automatic stabilization of the camera pod. For data recording, the integrated digital camera is controlled by an automatic photo-firing sequence, which can be set to a frequency of up to 3 pictures per second. Due to the automatic triggering of the camera, each flight generates a large amount of data, e.g. in a 15 minutes flight normally more than 1200 photos. This amount is far more than what is needed for a subsequent inspection, but as a result of the not completely stable hover a relatively high incidence of unusable image data is produced, a consequence of the not fully filtered out vibrations from the platform or external influences such as wind gusts. Additionally there is often a very high overlap of the area captured on each image, which varies depending on the hover speed parallel to the building façade. Accordingly unnecessary records are eliminated in case of too high overlapping to avoid double-or multiple-information within the images and to keep the image data base as small as possible without loss of quality (Eschmann et al., 2012).

2.9.4 Construction Site Security

Security guards are commonly used on many construction sites for site safety. Due to the large size of certain construction sites it is particularly difficult for these guards to adequately see the project during the night. People and vehicles give off "heat signatures" as compared to their background environment. A UAV equipped with a thermographic camera operating at night can help to spot a potential thief hiding in the darkness on a project by visually detecting these "heat signatures." Pinpointing the heat signature from a recently-parked vehicle outside a security fence or that of an intruder inside the site then helps direct the security force to potential trouble (Opfer and Shields 2014). Whether company likes to take preventative measures to make sure the job is being done right and safely, or needs to verify the actions of someone in particular, today's camera-equipped drones can be very helpful.

2.9.5 Construction Productivity Improvement

According to Opfer and Shields (2014), overview of a site from the air can readily pinpoint productivity constraints that otherwise would not be readily noticeable from a ground view. Aerial views of equipment, material, and craft flow can therefore assist project management in improving productivity. Project management observing an operation closeup may unnerve craft personnel and their supervisors. The UAV perspective with camera abilities to zoom in from distant perspectives can help to eliminate these issues.

If company likes to keep its workers safe and productive, Drones can patrol the area to keep an eye on everyone in general or to conduct surveillance on a specific person or group who might not be following protocol. Today's drones are non-invasive and in many instances the workers may not even be aware that they are under surveillance.

2.9.6 Marketing and Promotions

Savvy construction companies may use drones to film aerial shots of the area prior to development. Along with scale models and 3D renderings of the finished product, sky-high shots of the area from multiple angles help potential clients visualize the transformation of the barren land. If company likes to stand out to potential clients and help them see how their ideas can become reality, some construction companies consider adding drone photography and videos as a sales tools. This strategy can also be used to convince communities, task forces and policy makers of the viability of the project. Its also a helpful way to provide updates to clients who are unable to visit the area (Opfer and Shields, 2014).

2.9.7 Construction Claims

Certain construction claims arise on jobsites including those from issues of weather delays, work interference, site restrictions, and site constraints. Aerial photography taken on a contemporaneous basis can document these issues to refute construction claims.

Aerial views can often illustrate these issues with enhanced clarity as compared to ground-based photographs. The aerial photography from a UAV is immediately available rather than relying on a request for a conventional plane or helicopter that may be days away or into the next week. Given the costs of project delays and liquidated-damages issues, the cost of the UAV work provides a significant benefit in either proving or disproving a potential claim (Opfer and Shields, 2014).

3.0. Productivity

3.0.1 Productivity Concept

Increased productivity and efficiency are a major source of growth for sustainable development. Conversely, high and sustainable growth is also an important element in maintaining a continuous increase in long-term productivity. Thus, growth and productivity are not two separate or one-way relationships, but both are independent with dynamic, non-mechanistic, and complex relationships.

In general the concept of productivity is a comparison between output and input unity of *time.* Productivity can be said to increase if : (1) The number of outputs / outputs increases with the same number of inputs / resources. (2) Production / output amounts are equal or increased with less input / resources and, (3) Increased production / output is obtained by the addition of relatively small resources (Soeripto, 1989; Chew, 1991 and Pheasant, 1991).

The concept can certainly be used in calculating productivity in all sectors of activity. According Manuaba (1992) increased productivity can be achieved by minimizing all sorts of costs including the use of human resources (do the right thing) and increase the maximum output (do the thing right). In other words that productivity is a reflection of the level efficiency and effectiveness of work in total.

3.0.2 Definition of Productivity

According to Hasibuan (1996) productivity is comparison between output (result) with input. The productivity can possibly increase because there is efficiency increases (duration, materials and labor) and work system, production technic and skill increases of the worker. Furthermore, Riyanto (1986 : p. 22) says technically productivity is a comparison between the result achieved (output) and the whole resources required (input). Productivity implies a comparison between the results achieved with the role of labor per unit time.

From the above definitions it can be concluded that labor productivity is the ability of employees in production compared to the inputs used. An employee who is able to produce goods or services in accordance with expected within a short time or right can be said as productive employee.

3.0.3 Factors Affecting Productivity

Ervianto (2008) states that factors affecting project productivity can be classified into four main categories, including:

1. Method and technology, consisting of factors: engineering design, construction method, work order and work measurement.
2. Field management, consisting of factors: planning and scheduling, field layout, field communication, material management, equipment management, labor management.
3. Work environment, consisting of factors: work safety, physical environment, quality of supervision, job security, work training, participation.
4. Human factors, including the factors: the rate of wages of workers, job satisfaction, incentives, profit sharing, worker-worker relationships, peer relationships.