

# CHOOSING BY ADVANTAGES (CBA) TO SELECT A DRONE FOR AN EDUCATIONAL SURVEYING PROJECT

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## ABSTRACT

Selecting drones for surveying and monitoring in construction projects is a complex multi-criteria decision-making problem, particularly in the context of Construction 4.0 and engineering education. This study applies the Choosing by Advantages (CBA) method to support the selection of a drone for photogrammetric surveying in an academic construction case study.

Four commercially available drones were evaluated using nine technical factors grouped into three categories: environmental (wind resistance, waterproof protection, operating temperature range), operational (maximum flight time, payload capacity, maximum flight speed), and data acquisition (camera resolution, frame rate, field of view). The results indicate that the drone achieving the highest total Importance of Advantages (IoA) score was the most suitable option, primarily due to the site's environmental and climatic requirements.

Overall, the findings highlight that advantages associated with environmental and contextual factors are the most influential in selecting drones for construction management education, surpassing operational performance and data capture capabilities. This provides an evidence-based reference framework for educational stakeholders when selecting drones for adoption in construction-related teaching, research, and training.

## KEYWORDS

Decision-making, Choosing by Advantages, drone, Construction 4.0.

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## INTRODUCTION

The construction industry is undergoing a transformation driven by digitalization and the adoption of advanced technologies, giving rise to the paradigm known as Construction 4.0, which integrates cyber-physical systems, automation, and data analysis to improve the productivity, safety, and sustainability of projects (Oesterreich & Teuteberg, 2016; Sacks et al., 2020). This approach promotes management based on reliable, real-time information, strengthening decision-making in increasingly complex environments (Dallasega et al., 2018).

Within this context, unmanned aerial vehicles (drones) have emerged as key tools in civil engineering, enabling topographic surveys, inspections, and monitoring of construction progress with greater precision, speed, and safety than traditional methods (Eisenbeiß, 2009).

Several studies show that the use of drones improves the quality of geospatial data and reduces the risks associated with working at height and in areas that are difficult to access (Gheisari & Esmaceli, 2019; Kim et al., 2020). However, selecting the most suitable drone is a complex decision-making problem, as it involves multiple technical, operational, and economic factors, which can lead to suboptimal decisions if structured methodologies are not used (Asadi et al., 2020). In this regard, multi-criteria decision-making methods have been widely used in the construction sector; however, traditional approaches such as AHP have limitations related to subjectivity and lack of clarity in the separation between value and cost (Zavadskas et al., 2018).

Choosing by Advantages (CBA) emerges as a robust alternative, basing the decision on an explicit comparison of the advantages between alternatives and keeping cost as an independent criterion (Jim Suhr, 1999). Its application in construction projects has been shown to improve transparency, reduce cognitive biases, and promote collaborative decisions aligned with the principles of Lean Construction 4.0 (McHugh et al., 2022).

Previously, CBA has been widely applied in construction-related decision-making problems, including the selection of subcontractors and design solutions (Arroyo et al., 2018; El-Kholy, 2022). However, existing CBA applications have primarily focused on traditional project procurement and design contexts. In contrast, Construction 4.0 adoption introduces decision conditions that are highly dependent on operational and environmental constraints, safety considerations, and usability requirements. Although drone selection has been explored in other fields such as disaster response and communication systems (Johnny et al., 2025), limited research has examined how decision factors should be structured and prioritized for construction-specific drone applications such as site mapping, surveying, progress monitoring, and volumetric analysis (Sridharan et al., 2024). Therefore, this study applies CBA for drone selection in a construction management educational context, providing an evidence-based and replicable framework to support transparent and value-driven technology adoption decisions.

## LITERATURE REVIEW

The adoption of unmanned aerial vehicles (UAVs), commonly referred to as drones, has expanded significantly across multiple industries due to their capability to collect high-resolution spatial and visual data efficiently. As drones continue to diversify in terms of technical specifications, sensor capabilities, and operational performance, the process of selecting an appropriate platform has become increasingly complex. Consequently, several studies have explored structured approaches for drone selection to support practitioners in identifying the most suitable technology for specific operational objectives.

Recent research has proposed drone selection frameworks mainly focused on emergency-related and environmental monitoring applications. For instance, Hristozov and Zavaleta (2018) developed a selection approach for drones operating under disaster conditions, emphasizing relevant factors to emergency environments where rapid deployment and robustness are critical.

Similarly, Gul (2025) proposed a drone selection methodology tailored to forest surveillance and fire detection tasks, where factors such as thermal sensing capabilities, endurance, and coverage performance become central. Johny et al (2025) further extended this line of research by addressing drone selection for disaster response scenarios, reinforcing the importance of multi-criteria decision-making frameworks to manage the complexity of emergency operations. Collectively, these studies demonstrate that structured selection methodologies can support practitioners by providing a systematic way to compare alternatives beyond simplified cost-based approaches.

In parallel, some researchers have attempted to generalize drone selection by reducing the complexity of decision-making into a limited set of dominant factors. For example, Sohaib et al (2021) proposed a drone selection method using multi-criteria decision-making (MCDM) techniques, emphasizing key factors such as cost-benefit tradeoffs, remote operational range, and flight time. While such simplified models can be useful in broad applications, they may not adequately represent the unique operational requirements of construction projects. In construction settings, for instance, remote range may not be a critical factor due to the localized nature of jobsite operations. Likewise, limitations in flight time can often be mitigated through practical strategies such as the use of multiple battery sets or staged flight planning. Therefore, the factors identified in generalized drone selection studies may not fully capture the context-specific needs and constraints of construction applications.

Drones in the construction industry are increasingly used for tasks such as site mapping, volumetric analysis, measurement verification, and progress monitoring. Sridharan et al (2025) emphasized the growing relevance of UAV-based workflows for construction management, highlighting their ability to improve documentation, enhance project monitoring, and support decision-making through timely spatial data. These construction-specific applications impose distinct requirements related to environmental jobsite conditions, safety constraints, operational feasibility, and data capture needs. As a result, the selection of drones for construction projects cannot be effectively addressed through generalized decision frameworks developed for disaster response or environmental surveillance contexts. This indicates a gap in the literature regarding the identification of decision and evaluation methods tailored specifically to drone selection in construction-related applications.

Furthermore, decision-making in construction practice has traditionally been driven by simplified single-variable approaches, where cost is often treated as the primary determinant of procurement and technology adoption. Although cost remains an important factor, this approach may lead to suboptimal outcomes when other relevant factors cannot be easily expressed in monetary terms, such as safety risks, operational constraints, usability, or environmental performance. In response to such limitations, Choosing by Advantages (CBA) has gained attention as a structured decision-making system that emphasizes value-based evaluation rather than purely cost-based comparison. CBA provides transparency in decision-making by allowing decision-makers to prioritize the importance of advantages based on their relevance to the problem context.

The construction management literature has documented several successful applications of CBA in traditional decision scenarios. Arroyo et al (2018) demonstrated the use of CBA for selecting design alternatives, showing how the method supports transparent tradeoff evaluation among competing options. Ahmed and Arrocho (2022) applied CBA to the selection of mass timber building materials, reinforcing its ability to integrate technical and qualitative decision factors. El-Kholy (2022) applied CBA for subcontractor selection, while Brioso et al (2019) demonstrated its use for safety-related equipment decisions such as fall protection systems. Additionally, Besiktepe et al (2023) applied CBA in facility management contexts, indicating its usefulness not only during project delivery but also during the operational phase of built

assets. These studies confirm that CBA is a well-established decision-making framework within construction research and practice.

However, although CBA has been applied extensively in construction-related decisions, most documented applications focus on conventional project choices where evaluation factors are already widely understood by construction professionals. In contrast, Construction 4.0 introduces emerging technologies that require decision-making under unfamiliar conditions, where stakeholders may lack established reference factors. In the specific case of drone adoption, construction practitioners may not have sufficient guidance regarding which factors should be prioritized when selecting a drone for construction tasks such as mapping, progress tracking, or volumetric measurement. This gap highlights the need for research that identifies and prioritizes drone selection factors specifically for construction management contexts.

Therefore, this study addresses the identified gap by applying CBA to drone selection for construction-related applications. By engaging construction stakeholders with practical drone experience, the study aims to determine the most critical decision factors and evaluate their relative relevance in construction settings. CBA provides a transparent reference for construction managers, educators, and practitioners seeking to adopt drone technologies in Construction 4.0 initiatives. Through a case study focused on drone procurement for educational and training purposes in civil and construction engineering and management, this research contributes a structured and replicable approach that supports more informed and value-driven technology selection decisions.

## **POINT OF DEPARTURE**

Previous research has examined drone selection for applications such as communication, forestry, and disaster response, identifying key decision factors for those contexts. However, in construction, technology selection is still often driven by a single dominant criterion—cost. Although cost-benefit approaches are common, many important criteria in construction technology decisions are difficult to quantify in monetary terms. To address this challenge, Choosing by Advantages (CBA) has gained popularity in construction decision-making. Prior studies have applied CBA to traditional construction management problems such as evaluating design alternatives, subcontractor selection, facility management, and equipment selection, where decision criteria are generally familiar to industry professionals.

With the rise of Construction 4.0, construction managers must evaluate emerging technologies using criteria that are not yet well established in research or practice. Drone selection is one such example. In many cases, construction drone procurement may still be treated as a cost-based decision, overlooking critical factors such as jobsite conditions, data requirements, autonomy, operational performance, and compatibility with tasks such as site mapping, progress monitoring, volume estimation, and field measurement. Therefore, this paper aims to identify the key factors that should guide drone selection in construction projects. To achieve this objective, a collaborative CBA session was conducted with construction stakeholders experienced in drone use. A case study on procuring a drone for university-level training in civil engineering and construction management was developed to provide a realistic decision context. The identified factors and their relative weighting are expected to support construction managers with limited procurement experience and serve as a baseline reference for construction applications.

## **METHODOLOGY**

A case study methodology was selected because the research seeks to answer the question of how to implement CBA for drone selection in a real-world decision-making context, where researchers have limited control over events and the phenomenon under study is contemporary.

The case study was conducted in an academic setting at Purdue University, as part of the activities for educational purposes for Civil and Construction Engineering courses at graduate and undergraduate levels. In these courses drones are used for capturing the latest state of physical progress, photogrammetry, and video recording of work in progress.

The objective of the decision was to select a drone suitable for photogrammetric surveying and orthophoto mosaic generation in a small, controlled area close to campus, located within 0.2 Nautical Miles of the Lafayette Airport (LAF). This context was selected because it represents a realistic and repeatable scenario, similar to surveying and inspection activities in construction projects. The case study followed the steps described below.

Prior to the decision-making sessions, a document review was conducted, including literature on drone applications in construction, manufacturer technical specifications, and photogrammetric survey requirements. This review allowed the identification of feasible drone alternatives and preliminary selection factors.

The case study focused on a photogrammetric flight to generate orthophotos and a digital elevation model (DEM) for analysis and documentation of physical progress. In addition, video recordings of the work in progress might be required to document the efforts deployed by the students in a senior course. This context enabled the evaluation of key performance aspects such as image quality, operational efficiency, and ease of use.

Mandatory requirements were then defined, including photogrammetric capability, compatibility with common processing software, adequate image resolution, and safe operation in an academic environment. Alternatives that did not meet these requirements were excluded.

A multidisciplinary decision-making team with expertise in construction, BIM, surveying, and digital technologies was formed to promote diverse perspectives consistent with Lean Construction principles. Prior to applying the method, participants received training on the fundamentals of the Tabular Choosing by Advantages (CBA) method to ensure a shared understanding.

Finally, the CBA method was applied by identifying differentiating factors, defining criteria, comparing advantages, assigning Importance of Advantages (IoA) scores collaboratively, and introducing cost information at the final stage to support a transparent value–cost comparison.

## **RESULTS**

### **CASE STUDY**

Spring weather conditions in Indiana vary considerably, with wind speeds averaging approximately 15 mph, sub-zero temperatures occurring during January and February, and occasional precipitation events. To ensure safe flight operations, students use the UAV Forecast application to assess environmental conditions and plan missions accordingly. Figure 1 presents a top-view orthomosaic and a point cloud representation of the flight site generated using Propeller (Fig. 1a) and D2S (Fig. 1b).

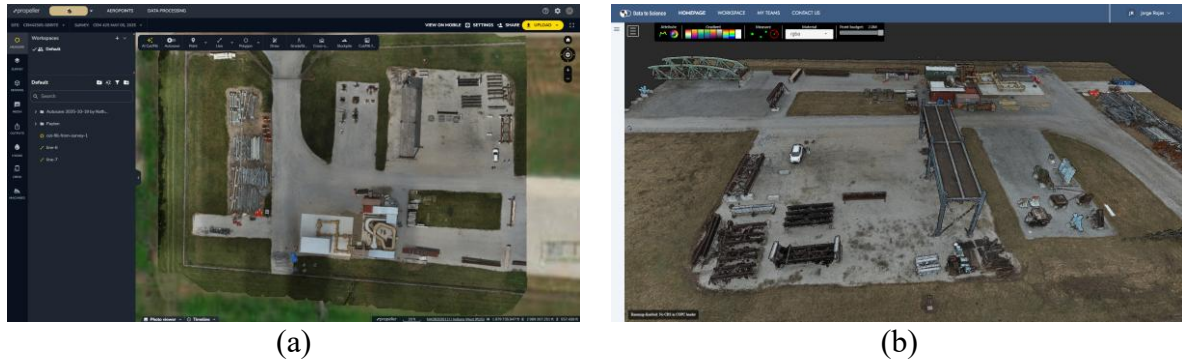


Figure 1: SBRITE Flight mission site. (a) Propeller aero platform with an orthoview of the flight. (b) 3D Point cloud data uploaded to D2S platform using Agisoft Metashape.

## DRONE DECISION MAKING FACTORS

When procuring a drone, several factors must be considered, including the environmental conditions at the operating location, the operational or application requirements, and the data capture requirements. Environmental conditions define the limits within which a drone can operate safely, while operational factors relate to flight performance and payload capabilities. Data capture requirements depend on the intended application and sensor configuration.

### ENVIRONMENTAL FACTORS

**High Wind Speed.** Wind is a critical factor affecting drone operations and can be characterized by both wind speed and wind gusts. Wind speed refers to the average wind velocity over a longer period (several minutes), whereas gusts are short-duration spikes lasting only a few seconds. Both can significantly impact flight stability and safety, particularly during mission execution.

**Extreme Temperatures.** Understanding the temperature range within which a drone can operate safely requires consideration of both low and high extremes. Low temperatures can significantly degrade battery performance and reduce overall battery lifespan, while high temperatures may lead to battery overheating and swelling. Therefore, mission planning should include an assessment of the expected ambient temperature during flight operations.

**High Humidity and Precipitation.** Precipitation, including rain and snow, can adversely affect both drone operation and data quality. One major issue is that water droplets may falsely trigger obstacle avoidance sensors, causing the drone to halt or abort a mission prematurely (Adam Shore, 2026). In general, flying in rain, mist, fog, or high-humidity conditions is not recommended, as ventilation openings may allow moisture to reach internal electronics.

### OPERATIONAL FACTORS

**Flight Speed.** Maximum flight speed plays a critical role in mission planning, as it influences total mission duration, battery usage, and the size of the area that can be covered without landing. Higher speeds may reduce the number of battery swaps required and increase operational efficiency. Conversely, minimum flight speed is closely tied to data accuracy. Slower flight speeds can improve image quality, particularly when combined with high shutter speeds and appropriate ISO settings.

**Flight Time.** Flight time refers to the duration a drone can remain airborne and is typically divided into multiple segments separated by landings and battery swaps. The maximum uninterrupted flight time is largely determined by battery capacity and is strongly influenced by environmental conditions such as wind resistance and ambient temperature.

**Payload Capacity.** Payload capacity refers to the maximum additional weight a drone can carry beyond its own structure and propulsion system. This includes sensors (e.g., cameras or LiDAR units), delivery packages, or specialized tools. The combined weight of the drone and its payload is known as the Maximum Takeoff Weight (MTOW).

## DATA CAPTURE FACTORS

Mapping and surveying represent the most common drone applications in the construction industry, relying on various reality-capture sensors. Common sensors include standard and high-resolution RGB cameras, thermal cameras, LiDAR scanners, and multispectral cameras.

Among these, high-resolution cameras combined with photogrammetry techniques offer a cost-effective solution with relatively low payload requirements, making them particularly suitable for terrain mapping applications. This paper focuses exclusively on RGB camera-based data capture factors.

**Camera Resolution.** Camera resolution refers to the number of pixels captured by the sensor and typically ranges from 2 to 50 megapixels in drone applications. Higher resolutions generally result in smaller Ground Sample Distance (GSD) values when sensor size remains constant (e.g., full-frame, APS-C, or Micro Four Thirds), leading to improved spatial accuracy (Propeller Aero, 2026). GSD represents real-world size of each pixel in an image, typically measure in “cm/px”, and is influenced by flight altitude, camera resolution, and sensor size, making these parameters central to mission planning and data quality.

**Camera Field of View (FOV).** The field of view (FOV) defines the extent of the observable scene and is measured in angular units (degrees). It is commonly described as diagonal (DFOV), horizontal (HFOV), or vertical (VFOV). FOV is determined by both focal length and sensor size. In drone applications, FOV is critical because it affects image framing, mapping accuracy (via GSD), coverage area per flight path, and image overlap requirements during photogrammetry mission planning (LITCHI, 2026).

**Camera Frame Rate (FPS).** Frame rate, measured in frames per second (FPS), represents the number of individual images captured per second during video recording. FPS directly affects the smoothness, clarity, and overall quality of video footage. Higher frame rates are particularly important for capturing dynamic scenes, as they improve motion continuity, visual detail, and post-processing flexibility, including slow-motion analysis and cinematic effects (Adam Shore, 2026).

## CHOOSING BY ADVANTAGE WITH DRONE EXPERTS

The application of the steps of the CBA Tabular Method (Table 1) is explained below:

**Step 01: Identify the alternatives.** Information related to the available alternatives was collected and systematized based on expert judgment consulted for the present case study, supported by previous experience in drone-based photogrammetric surveying applications. At this stage, four (4) drones were identified as viable alternatives for the equipment selection process to be used in surveying and monitoring activities within an educational setting at Purdue University.

**Step 02: Define the factors.** The team conducted a structured brainstorming session to define the selection factors, considering the specific conditions of the study area at Purdue, the geographical and operational characteristics that the drone would need to address during the surveying activities, as well as the specific context of the research project. As a result of this process, nine (9) relevant factors were identified to proceed with the selection process.

**Step 03: Define the criteria.** The team defined the criteria associated with each of the previously identified factors, which serve as guiding principles to clearly determine when one alternative presents an advantage over another. For example, for Factor 01: Wind resistance,

the associated criterion was defined as: “The greater the drone’s wind resistance, the better.” This same approach was consistently applied to define the criteria corresponding to the remaining eight (08) factors. Furthermore, the criteria established for each factor were classified as either mandatory [*must*] or desirable [*want*], providing a structured basis for the subsequent stages of analysis.

**Step 04: Summarize the attributes.** The attributes inherent to each alternative were systematized and transferred into a tabular format, using objective and verifiable information obtained from the technical datasheets of the drones identified in Step 01.

**Step 05: Decide on the advantages.** For this step, the team identified the least preferred attribute for each factor and established it as the reference for comparison. Subsequently, an objective comparison was performed between the attributes of the remaining alternatives and the reference attribute, considering that the observed differences represent the advantages of each alternative with respect to the evaluated factor.

Table 1: CBA of Drone Decision Making

| General Information                                                              |      | Alternative 01:<br>Matrice 300    |     | Alternative 02:<br>Phantom 4 |     | Alternative 03:<br>Mavic 3  |     | Alternative 04:<br>Evo II         |     |
|----------------------------------------------------------------------------------|------|-----------------------------------|-----|------------------------------|-----|-----------------------------|-----|-----------------------------------|-----|
|                                                                                  |      | IoA                               |     | IoA                          |     | IoA                         |     | IoA                               |     |
| Factor 01: Wind speed resistance [m/s]                                           | Att. | 15 m/s                            |     | 14 m/s                       |     | <u>12 m/s</u>               |     | 14 m/s                            |     |
| Criteria: The more wind resistance, the better [must]                            | Adv. | 3 m/s more resistance             | 90  | 2 m/s more resistance        | 85  | -                           |     | 2 m/s more resistance             | 85  |
| Factor 02: Working temperature range [°C]                                        | Att. | -20 °C to 50 °C                   |     | <u>0 °C to 40 °C</u>         |     | -10 °C to 40 °C             |     | <u>0 °C to 40 °C</u>              |     |
| Criteria: The more drone's resistance to extreme temperatures, the better [must] | Adv. | -20 °C and +10 °C more resistance | 100 | -                            |     | -10 °C more resistance      | 95  | -                                 |     |
| Factor 03: Maximum flight Speed [m/s]                                            | Att. | 23 m/s                            |     | <u>14 m/s</u>                |     | 21 m/s                      |     | 20 m/s                            |     |
| Criteria: The higher the drone's maximum flight speed, the better [must]         | Adv. | 9 m/s faster                      | 70  | -                            |     | 7 m/s faster                | 60  | 6 m/s faster                      | 50  |
| Factor 04: Camera resolution [p]                                                 | Att. | <u>960 p</u>                      |     | <u>960 p</u>                 |     | <u>960 p</u>                |     | hasta 1080 p                      |     |
| Criteria: The better the camera resolution, the better [must]                    | Adv. | -                                 | -   | -                            |     | -                           |     | 120 p more resolution             | 30  |
| Factor 05: Camera Field of View (FoV) [°]                                        | Att. | <u>75 °</u>                       |     | 84 °                         |     | 84 °                        |     | 82 °                              |     |
| Criteria: The wider the camera field of view, the better [must]                  | Adv. | -                                 | -   | 9 ° wider FoV                | 40  | 9 ° wider FoV               | 40  | 7 ° wider FoV                     | 30  |
| Factor 06: Frame rate (frames per second) [fps]                                  | Att. | 30 fps                            |     | 30 fps                       |     | 30 fps                      |     | 30 fps                            |     |
| Criteria: The higher the camera fps, the better [must]                           | Adv. | ---                               | -   | -                            |     | -                           |     | -                                 |     |
| Factor 07: Maximum flight time [min]                                             | Att. | 55 min                            |     | <u>30 min</u>                |     | 45 min                      |     | 36 min                            |     |
| Criteria: The longer drone's maximum flight time, the better [want]              | Adv. | 25 min more flight capacity       | 60  | -                            |     | 15 min more flight capacity | 30  | 6 min more flight capacity        | 15  |
| Factor 08: Maximum payload [kg]                                                  | Att. | 2.7 kg                            |     | 2.8 kg                       |     | 2.7 kg                      |     | <u>2.5 kg</u>                     |     |
| Criteria: The greater the drone's maximum payload, the better [want]             | Adv. | 0.2 kg more payload               | 5   | 0.3 kg more payload          | 10  | 0.2 kg more payload         | 5   | -                                 |     |
| Factor 09: Precipitation resistance                                              | Att. | IP45                              |     | <u>No</u>                    |     | <u>No</u>                   |     | IP43                              |     |
| Criteria: The greater the drone's resistance to precipitation, the better [want] | Adv. | 5 more protection against liquids | 50  | -                            |     | -                           |     | 3 more protection against liquids | 10  |
| IoA Total                                                                        |      |                                   | 375 |                              | 135 |                             | 230 |                                   | 210 |

**Step 06: Decide the importance of the advantages.** In this step, the team conducted a structured discussion using the information previously centralized in the tabular format. First, a 0 to 100 scale was defined for assigning the Importance of Advantage (IoA). Subsequently, the set of most favorable advantages was identified, one (01) representative advantage for each

evaluated factor. Collaboratively, the team analyzed these advantages and determined the paramount advantage, which was assigned an IoA score of 100, corresponding to “−20 °C to +10 °C additional temperature resistance”. This advantage was considered the most relevant compared to the others. Based on this reference, the IoA of the remaining most favorable advantages was weighted relative to the paramount advantage. Finally, IoA scores were assigned to the remaining advantages by comparing them with the most favorable advantage corresponding to each factor. Once IoA scores were assigned to all advantages, the final IoA was calculated, representing the value of each alternative (Table 1).

**Step 07: Evaluate the cost information.** Only at this stage of the decision-making process did the expert judgment team involved in the drone selection gain access to the cost information of each alternative, with the purpose of avoiding bias during the earlier stages of the analysis. Based on this information, the Cost vs. Importance of Advantage (IoA) chart (Figure 2) was developed, allowing for an integrated evaluation of the value offered by each alternative in relation to its advantages and associated cost.

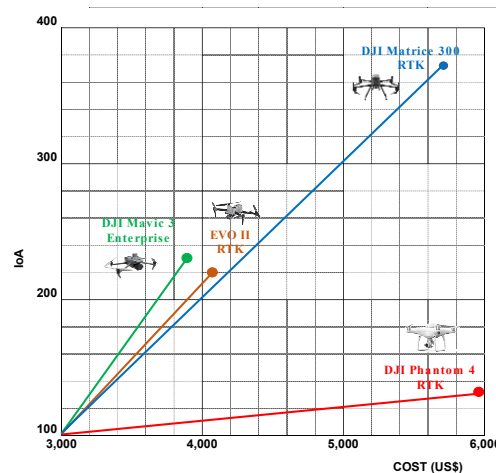


Figure 2: Cost vs IoA

## DISCUSSION

Consistent with prior CBA studies, the present case confirms that CBA supports transparent and collaborative comparison among alternatives by making the advantages explicit and separating value discussion from cost discussion. Unlike prior CBA applications focused on traditional construction decisions such as design alternatives, subcontractor selection, or safety system selection, this study addresses an emerging technology adoption decision in a Construction 4.0 context, where decision criteria are less standardized and more dependent on operational and environmental constraints.

During the application session, the expert judgment composed of a team of specialist professionals, developed a collaborative brainstorming process that allowed for a structured evaluation of the four (4) previously identified drone alternatives. The discussion focused on technical and operational factors which were considered critical to the drone's performance in the context of the research project.

First, participants objectively analyzed the technical attributes of each alternative, highlighting clear differences between the drones evaluated. Some participants emphasized, for example, that certain alternatives had better specifications in terms of autonomy and image quality, while others pointed out significant operational limitations in variable weather conditions. This diversity of opinions enriched the identification of real advantages, avoiding evaluations based solely on individual preferences. At this point, some participants agreed that

greater temperature resistance was a decisive advantage, as it allowed for more continuous use of the drone throughout the year, reducing operational restrictions and increasing the reliability of photogrammetric surveys. This assessment was reinforced by other experts, who pointed out that this advantage had a cross-cutting impact on flight planning, operational safety, and project continuity.

During the assignment of IoA, the team held an explicit and transparent discussion regarding the relative relevance of each advantage. It was observed that some participants initially gave greater weight to factors such as sensor quality or flight autonomy; however, as the discussion progressed, a consensus emerged around the idea that operational robustness in adverse environmental conditions generated greater overall value for the project. As a result, the advantage associated with “additional -20°C to +10°C temperature resistance” was agreed upon as the primary advantage, receiving the maximum score of 100 IoA and serving as a reference for weighting the other advantages.

The discussion also highlighted how the CBA method facilitated the integration of different technical perspectives on the use of drones in construction projects, allowing participants to constructively and fact-based compare their arguments and apply them to the context of the case study. Calculating the total IoA for each alternative made it possible to clearly see which of the drones offered the greatest added value in relation to the identified advantages, providing a solid basis for the final decision.

Finally, the Cost vs. IoA graph provided an integrated view of the relative value of the alternatives evaluated. The DJI Matrice 300 RTK alternative obtained the highest IoA score, demonstrating a greater number of technical and operational advantages relevant to the case study; however, it also had the highest cost among the options analyzed. During the discussion, the expert judging team evaluated whether the difference in advantages between this alternative and the next best-ranked alternative—*mainly the DJI Mavic 3 Enterprise*—was significant enough to justify the higher associated cost.

The participants agreed that the additional advantages of the DJI Matrice 300 RTK, related to its operational robustness and performance in variable environmental conditions, could be decisive in projects with high technical requirements. However, it was also noted that alternatives with a slightly lower IoA and lower cost could offer better value for money in contexts where such additional capabilities are not strictly necessary. In this sense, the chart facilitated an explicit discussion of the trade-off between cost and advantages, reinforcing the Lean approach to value-based decision-making and allowing the final selection to be based on the specific context of the project.

## CONCLUSION

This study found that the selection of drones for surveying and monitoring in construction management education depends not only on cost or standard technical specifications, but also on the operational context in which the technology is expected to perform. The results showed that environmental and contextual criteria were the most influential in shaping the final ranking of alternatives, suggesting that robustness under site and weather-related conditions may be more critical than cost-driven considerations in this type of Construction 4.0 decision.

Beyond the ranking of alternatives, the study contributes by showing the importance of explicitly structuring and prioritizing decision criteria in emerging technology contexts where evaluation priorities are not yet standardized. In this case, the decision process was organized around criteria related to environmental exposure, operational feasibility, and data capture needs, providing an evidence-based framework that can support more context-sensitive drone selection decisions in construction-related teaching, training, and practice.

At the same time, the findings are bounded by the characteristics of the case. The prioritization of advantages relied on expert judgment and therefore reflects the experience and

perspectives of a specific participant group. Likewise, the evaluation considered a limited number of drone alternatives within a single educational context, which limits the transferability of the ranking to other operational environments or technology portfolios. Future studies should test the stability of these findings across broader participant groups, alternative project settings, and other emerging Construction 4.0 technologies.

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