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**Petr ROZEHNAL, PhD (corresponding author)**
petr.rozehnal@vsb.cz
VSB-Technical University of Ostrava, Ostrava, Czech Republic

**Taťána FUNIOKOVÁ, PhD**
tatana.funiokova@vsb.cz
VSB-Technical University of Ostrava, Ostrava, Czech Republic

**Ivana ČERMÁKOVÁ, PhD**
ivana.cermakova@vsb.cz
VSB-Technical University of Ostrava, Ostrava, Czech Republic

# Cost-Effective Analysis of UAV Implementation for Visual Outputs in Small Organizations

**Abstract.** *Unmanned Aerial Vehicles (UAVs) are increasingly being adopted by organizations outside the aerospace sector as tools to enhance efficiency and decision-making through visual data collection. However, while the technical aspects of UAV deployment are widely discussed, the economic implications remain underexplored. The article aims to provide an economic perspective on the implementation of UAVs in organizations for which UAV operation is not a core business, but rather an opportunity to improve or make it more efficient. The article compares cost models for typical UAV implementation scenarios, evaluating internal, external, and hybrid solutions. The analysis focuses on the economic return of each approach depending on the frequency of UAV usage. The cost model shows that internal implementation of UAVs can be economically interesting with just a few uses per year. The findings discussed aspects of implementation from an economic standpoint, highlighting the importance of considering cost-efficiency in UAV deployment strategies.*

**Keywords**: *UAVs, drone, management, cost analysis, implementation process.*

**JEL Classification:** O33, D25, M15.

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## 1. Introduction

Unmanned aerial vehicles (UAVs) have a wide range of uses. The possibility of moving in the air makes them an alternative means of transport or distribution. The low flight level, excellent mobility, user-friendly controls and maneuverability are the basis for their use as visual data acquisition tools. UAVs are one of the names of the machines, similar to the designations drones or Unmanned Aircraft Systems (UAS) or micro aerial vehicles (Sivakumar and Tyj, 2021; Mishra et al., 2024). A wide range of uses of UAVs can already be documented and this is far from fulfilling the potential of their future development (Floreano and Wood, 2015).

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UAV applications have attracted considerable attention from research, especially with regard to technical capabilities, deployment and evaluation of benefits and limitations. However, the future adoption of UAV technology depends not only on technical performance but also on organizations' ability to integrate it into existing processes, which is influenced by organizational, economic, and human factors.

In contrast to technical research, limited attention has been paid to the business application of UAVs. As technology matures, its integration into routine organizational operations becomes increasingly important. This article addresses this gap by linking organizational needs with technical considerations for UAVs. Aligning the business and technical perspectives of UAV deployment is essential to ensure that the technology enhances organizational capability and performance.

The article is conceived as a study in which key aspects of UAV deployment in an organization's operations are identified. A standard cost structure and cost components were modelled for typical situations. The article defines typical deployment scenarios that differ in factors when implementing a UAV. The scenarios are compared, including a comparison with a total or partial outsourcing solution (external service). The services of external suppliers allow for confrontation with the market situation.

The article is divided into the following sections: Section 2 describes the theoretical background of articles dealing with the analysed topic and is followed by Section 3, where methodology and research questions are described. In Section 4 there is the concept of the study described, along with a description of the scenarios used in comparison. The following section described cost model and in last section the results are discussed. The article ends with a conclusion section.

## 2. Theoretical background

The use of UAVs enabled comparatively easy access to information in the form of images or videos that were previously difficult to access (or unavailable). In precision agriculture, the UAVs are used to create visualizations (Tsouros, Bibi and Sarigiannidis, 2019). UAVs can also be used for distribution capabilities based on excellent mobility (Mogili and Deepak, 2018). Monitoring for environmental protection to control the spread of specific tree species (Wang et al., 2024), tree inventory (Capecchi, Borghini and Bernetti, 2023), control of afforestation of areas (Vacca and Vecchi, 2024) or (Liu et al., 2023) or identification of karst sites on the surface of the territory (Ferreira et al., 2023). The UAV can be also advantageous for documenting difficult-to-reach places in insurance claim situations (Zulkifli et al., 2024) or monitoring graffiti (Wang et al., 2019). In cities, UAVs are used for traffic noise analysis (Minea and Dumitrescu, 2023), in rural areas for environmental monitoring (Ninkovic, Vukobratovic and Miskovic, 2024).

The marketing sector is an excellent example of how companies have supplemented their portfolio of capabilities with opportunities arising from UAV technology. Drones and their usage are provided like standard marketing tools as early as 2019 (Grewal et al., 2019). Various usages in marketing can be visible in the case study where the UAV is used as a sustainable method of heritage presentation and propagation of cultural tourism (Mubin, Perumal and Seelan, 2024). Beninger and Robson (2020) outlines the broader context of drone applications and related marketing issues. The application of UAV goes beyond the technical or economic area. The real estate market is another field of business that can illustrate the boom in drone services, with an increase of 18 percent between 2024 and 2025 (TBRC, 2025). Typical uses are in the areas of photo or video processing, mapping and positioning, or the creation of 3D models. However, there is also a discussion of the side effects of this method of acquiring image material, especially in a legal context (Stępień-Załucka, 2022).

In UAV applications, advantages such as accurate data, aerial data (different perspectives of view), safety in achieving data, time and money savings and speed of data achieving are emphasized (Apostolopoulos and Nikolakopoulos, 2021). However, there are few publications that actually document these advantages on the economic characteristics of UAV deployment.

With the increasing number of UAV implementations, the topic of operational economics will become increasingly relevant. Schöttker et al. (2023) analysed the costs of monitoring areas in the field of biodiversity conservation. The analysis was based on a comparison of standard procedures versus a scenario involving UAVs.

From a managerial perspective, this opens up further questions regarding the economic characteristics of use. For a holistic assessment of implementation, it is appropriate to include economic factors in the comparison. The economics of the use of drones by law enforcement are discussed (Tsiamis, Efthymiou and Tsagarakis, 2023) with the aim of optimizing the choice of UAV for the type of task. (Filiopoulou et al., 2025) analyses the economic return on the use of UAVs compared to traditional methods for last-mile delivery. Preview of the potential benefit and lower financial costs can be seen in the (Mondino and Gajetti, 2017), where the whole concept is demonstrated on the Italian viticulture market.

## 3. Methodology and Research Questions

The article is comparative in nature and is based on an explanation of aspects that are relevant to the given area of interest. A description in the form of scenarios and their parameters will allow comparison and insight into different combinations. The scenarios are based on typical, probable situations. The steps are as follows:

- Theoretical background and state-of-the-art, practical implementation limits.
- Formulation of research questions.
- Formulation of scenarios and subsequent development of an economic model.
- Scenarios analyses on the created model.
- Explanation of selected factors according to research questions.

The scenarios and research questions are oriented to respond to basic considerations that are relevant in connection with the implementation of UAVs as another tool supporting the organization's business.

Organizations introducing UAV technology must address two principal questions: the specification of required outputs (e.g. quantity and quality) and the choice between internal implementation or outsourcing to external providers. This second decision is inherently related to determining how the overall UAV deployment process will be executed. As with other organizational functions, the choice involves either relying on market based services or developing in house capabilities to support UAV operations. Both approaches presuppose a clear definition of output requirements; however, an internal solution additionally requires a comprehensive understanding of the entire UAV workflow, as all operational steps must be managed within the organization.

The technical specifications of UAV platforms fall outside the scope of this article; however, several foundational considerations must be outlined to clarify the logic of the study, research question and scenario design.

The process begins with defining the required image outputs of the organization. This is followed by evaluating feasible methods for achieving them. Output characteristics directly influence implementation approaches and associated resource needs, including hardware, software, and operational expertise. Therefore, the initial assessment should integrate key technical and economic factors to support an informed decision. The process of using a UAV can be roughly divided into two main phases: 1) UAV data scanning (UAV field operation and control and piloting) and 2) the post-production phase ensures the preparation of UAV data for business use (data processing of acquired image material (from simple and common adjustments to processing in specialized software, where an orthomosaic of the required quality is created).

For orientation, let us further list two aspects that will influence these phases and are used in the study: the complexity of data scanning and the quality of data (image material). Both aspects influence the choice of UAV, the work process, the choice of software, and the level of know-how.

### *The complexity of UAV data scanning consequences*

The complexity of data scanning is determined by the area and the requirements for performing the imaging, which are based on the requirements for the quality of the image material. Relevant factors may be as follows: size of the area; the shape and structure of the chosen area will be reflected in the flight path, flight time, energy consumption; data scanning parameters, i.e. flight altitude, image overlap, etc., which depend on the required quality of the acquired data. The factors mentioned are mainly reflected in the choice of UAV (required parameters).

### *Quality of image material consequences*

The quality of the image material must be reflected both during the imaging (data scanning) and during the subsequent data processing phase.

When scanning image data, the quality of the captured data is influenced also by the flight parameters of the UAV. Thus, the required visual outputs influence UAV flight with respect to:

- The ability of the UAV to capture image data in the required image quality (resolution, image distortion across, data storage etc.).
- The ability to perform a UAV flight within the required specifications, given, for example, by flight altitude, flight planning with regard to overlaps, the possibility of more accurate positioning thanks to GNSS RTK technologies or positioning using GPS coordinates of fixed points. These and other factors are reflected in the quality level of the graphic output, with a recommended minimum acceptable resolution of 1 pixel per 5 cm. Higher-resolution outputs are typically used for specialized applications.

Consequently, the quality of UAV output depends on the level of preparedness of an organization, including resource availability, the capability to manage processing complexity, and employee expertise.

It is obvious that business people do not need to have adequate knowledge regarding the above aspects, but they should have a clear idea of their requirements for the result. In short, there are interrelated factors with an impact on quality. These can be listed as: 1) the UAV and its parameters, 2) the imaging method, and 3) image data processing.

The application of UAVs to obtain visual outputs is a complex issue, and although any model situation will be more or less simplified, the mutual influences of individual factors still apply. With regard to the number of factors and their interdependence, which make simple yes/no answers difficult, an approach based on a research question was applied, which allows the results to be discussed and individual influences and impacts to be pointed out.

Based on the above situation, the following research questions were defined:

**Research question 1** What will be the economic differences between internal form of operation and outsourced services in terms of costs over a given time horizon?

**Research question 2** What is the impact of using paid software versus using free software?

**Research question 3** What is the role of output quality factor?

## 4. Study concept and scenario definition

This study is based on the practical context of the deployment of UAVs observed in the above-mentioned project, aiming to reflect typical conditions in organizations where UAVs enhance existing products or services but are not central to the core business. In such settings, UAVs function as complementary tools that improve process quality. This assumption is reflected in the expected frequency of UAV use, typically 1 to 12 deployments per year. At higher usage levels, UAV operations become integrated into routine workflows, prompting more professionalized management and potentially altering implementation considerations, including the assignment of responsible personnel.

These considerations form the basis for defining the implementation parameters. The study adopts a **four-year evaluation period** for both managerial and technical reasons. From a managerial perspective, the establishment of the capability of UAVs constitutes a long-term strategic investment -; organizations are unlikely to introduce UAVs without clear plans, expected benefits, and sustained objectives. Technically, a multi-year horizon accounts for equipment durability (including battery lifespan), evolving national and EU regulations, and ongoing technological advances that may alter operational conditions.

In contrast, the annual **frequency of UAV imaging** is treated as a variable, as it reflects the actual organization's need for UAV output. Determining whether imaging represents a one-time requirement or a recurring activity is essential for evaluating cost-effectiveness. The study therefore compares scenarios with different imaging frequencies over four years. For rare or exceptional use, outsourcing to external providers represents a reasonable alternative and serves as a benchmark for comparing financial demands against implementation in-house.

In a situation in which the repeated deployment of UAVs is expected to meet the needs of the organization, it is appropriate to define the essential aspects of implementation, perform quantification and subsequent comparison. The result of the comparison should be comparable, therefore the study uses a conversion to a single characteristic - price (de facto expresses the cost), which allows for economic comparison.

The **technical complexity of UAV operations** and the corresponding platform selection are decisive in producing usable output. Organizational needs can be viewed in terms of acquiring standard RGB imagery versus data from specialized sensors (e.g. thermal cameras). Although RGB capable UAVs are widely available and relatively inexpensive, platforms equipped with specialized sensors involve substantially higher acquisition and operational costs, rendering them uneconomical for infrequent use. Study does not consider such systems, as its primary focus is on the deployment of UAV in organizations with standard imaging requirements.

For the purposes of this study, UAVs are categorized into two groups: mini UAVs and standard UAVs. Mini UAVs are lightweight platforms designed for the rapid acquisition of basic images, where high precision data is not required; their limited battery capacity, non-replaceable power sources, and reduced flight endurance restrict their use in demanding terrain. In contrast, standard UAVs provide image quality suitable for advanced processing, typically achieving resolutions of 1 px per ≤ 5 cm with at least 80% overlap, and support larger, replaceable batteries enabling flights of several tens of minutes. Their technical parameters allow for complex mission planning, extended flight durations, higher capture frequencies, and increased data storage requirements.

UAV variants are directly related to the following aspects that comes after the fieldwork phase.

Data processing, hardware and software equipment influence post-production phase. **Data processing** is another important aspect of the decision-making process. Images from UAVs can be used without further editing, or only with the editing currently routinely performed (crop, size, etc.). If an organization needs more advanced image outputs, the creation of orthomosaics is typical, e.g. always created in the case of imaging a larger area, when it is not possible to capture the area in one image, but consists of multiple images that must be mathematically and photogrammetrically combined into one output so as to avoid distortion and other phenomena.

This aspect is significant because it is related to both the quality of the imaging equipment itself – UAV (see above), and to data processing, which is influenced by: 1) technical equipment, hardware; 2) software equipment for data processing; 3) knowledge and skills to process data in software, know-how.

The selection of **technical equipment** was guided by fundamental economic considerations. The study assumes the use of commonly available hardware, as the defined scenarios can be processed effectively with standard systems (e.g., an i5 class processor and integrated graphics). This hardware is sufficient for tasks but computations fully occupy the workstation performance.

The required **software** depends on how much processing is required for the captured material. Common photo or video adjustments can be done with basic, low cost tools. More advanced tasks, such as creating orthomosaics, require specialized software. This study considers both free and paid options to reflect typical organizational needs. Free tools reduce initial costs, but require more user skill and time, while paid software offers easier and more intuitive workflows.

### *4.1 Activities related to the introduction of UAVs*

The above aspects belong to the decision-making group, where it is necessary to decide between defined options. In addition, there are activities necessary to create the organization's ability to operate UAVs and further use the obtained material, which complement the choice of scenarios and the calculation of comparison.

The study considers the following activities, which are divided according to the nature of the costs.

One-time activities that will change the capabilities of the organization (costs that occur only once a year and are not related to the number of UAV operations were also included here). One-time, fixed costs: introductory information on the issue of UAVs; purchase of UAV; purchase of software; pilot's license; insurance for UAV operation; pilot training; software learning.

Key considerations include assessment of UAV applicability to organizational activities, understanding of UAV technology, relevant legal frameworks, and organizational feasibility. These activities may be affected by the legislation of each country.

Costs associated with the frequency of UAV operations. Variable costs: pre-flight activities; transportation costs; UAV flight; post-production.

Pre-flight preparation must be addressed for each individual UAV use project and includes, for example, planning the date – see possible weather effects; analysis of the possibility of conducting a UAV flight and others. Post-production includes all tasks related to already captured image material.

### *4.2 Other Aspects of UAV Operation*

The deployment of UAV also involves situations that cannot be influenced or predicted in advance. These factors can be taken into account or eliminated by appropriate preflight preparation. From a broader perspective, they should be part of the general awareness and possibilities of UAV use. Let us list the following:

- The impact of weather on the planned UAV.
- No-fly zones or zones where the use of UAVs is limited.

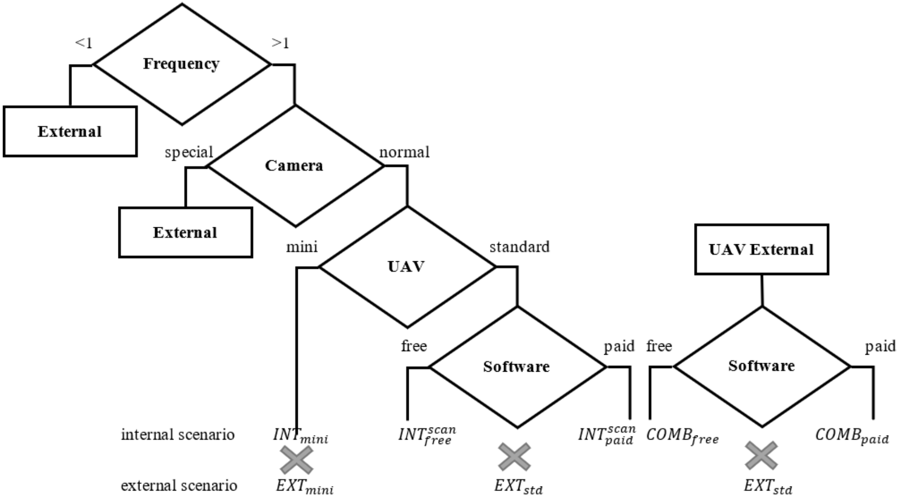

**Figure 1. Overview of scenarios**

*Source*: Authors' own creation.

A visual overview of the scenarios is shown in Figure 1. The study works with the following scenarios:

**Scenario** $INT_{mini}$ Internal, in-house mini UAV imaging, no additional image processing requirements, small-scale imaging.

**Scenario** $INT^{scan}_{free}$ Internal, in-house standard UAV imaging, data processed in free software.

**Scenario** $INT^{scan}_{paid}$ Internal, in-house standard UAV imaging, data processed in paid software.

**Scenario** $COMB_{free}$ UAV imaging by an external service, data processed internally in free software.

**Scenario** $COMB_{paid}$ UAV imaging by an external service, data processed internally in paid software.

**Scenario** $EXT_{mini}$ Service from an external company, demand corresponds to scenario $INT_{mini}$, after initial consideration of internal processing.

**Scenario** $EXT^{INT}_{std}$ UAV imaging and RGB data processing by an external service, after initial consideration of internal processing.

**Scenario** $EXT^{COMB}_{std}$ UAV imaging and RBG data processing by an external service, after initial consideration of internal processing.

Scenarios $INT_{mini}$, $INT_{free}^{scan}$ and $INT_{paid}^{scan}$ are internal forms of implementing UAV use and combine the main aspects influencing the implementation of the use.

Scenarios $COMB_{free}$ and $COMB_{paid}$ are based on the participation of an external company. The external supplier will deliver the image material in the form of a service. Post-production would already be provided by the organization internally. Therefore, this is a combination of internal and external forms for the two main phases of UAV use.

For economic evaluation, three scenarios are analysed in which the complete service, including final output, is provided by external suppliers. Service prices were determined through consultations with UAV service providers in the Czech Republic. It is worth to note that there are relatively large differences in the range of outputs and prices. The price is also influenced by the distance from the customer. Consequently, transportation costs were considered within a range of 0 to 100 km, reflecting typical service areas of the supplier.

## 5. Cost model and description of parameters

A period of four years was chosen for the calculation. This period is intentionally fixed in the calculations. The study emphasizes monitoring the influence of the frequency of UAV use as one of the key variables.

### *5.1 Model*

The total cost for the four-year period under study ($TC$) can be expressed as the sum of labour costs to obtain more detailed information on the issue ($LC_{intro}$), the total costs associated with the internal implementation of UAV scanning ($TC_{scan}$), the total cost of internal processing the obtained material ($TC_{proc}$), and the total cost of external services ($TC_{ext}$). The costs associated with the actual scanning, processing of the material obtained, and using external services vary depending on the number of repetitions of this activity during a year. Denoting the number of requests within year $n_y$, the total cost can be expressed by the following model:

$$TC(n_y) = LC_{intro} + TC_{scan}(n_y) + TC_{proc}(n_y) + TC_{ext}(n_y)$$

All four components of the total cost, $LC_{intro}$, $TC_{scan}$, $TC_{proc}$ and $TC_{ext}$, will then vary depending on the chosen scenario.

In our calculations, two different hourly wages are considered, $HW$ and $HW_{ext}$, the first for the internal worker who will be involved in the individual processes, and the second for the external worker invited to train the internal worker. Given the duration of the study period, the risk associated with the possible need to replace an internal staff member who has already gone through the training process must also be considered. To this end, a variable $rate_{risk}$ is introduced to represent the probability that the internal worker would have to be replaced during the four-year period. This parameter can also be used to model a situation in which the organization would like to train more staff in the processes under consideration.

**Initial labour costs $LC_{intro}$**

It is assumed that each scenario will start with an initial introduction to the possibilities of obtaining the required outputs, studying legislation and reviewing commercial offers. The resulting fixed cost $LC_{intro}$ can be expressed by the hourly allocation for this activity $HA_{intro}$,

$$LC_{intro} = HA_{intro} \cdot HW.$$

This introduction to the issue will be implemented only once, so the incorporation of parameter $rate_{risk}$ is not considered.

**Total cost of scanning $TC_{scan}(n_y)$**

The total cost of scanning includes both the fixed cost, $C^0_{scan}$, and the variable cost of repeated scanning, $C_{scan}(n_y)$, provided internally by the organization,

$$TC_{scan}(n_y) = C^0_{scan} + C_{scan}(n_y).$$

**Fixed costs** $C^0_{scan}$ includes the cost of UAV purchase $C_{drone}$, UAV insurance $C_{ins}$, labour costs associated with UAV pilot training $LC_{pilot}$, and the acquisition of a UAV license $LC_{lic}$,

$$C^0_{scan} = C_{drone} + C_{ins} + \left(LC_{pilot} + LC_{lic}\right) \cdot (1 + rate_{risk}).$$

The labour costs are calculated as

$$LC_{pilot} = HA_{pilot} \cdot (HW + HW_{ext})$$

and

$$LC_{lic} = HA_{lic} \cdot HW,$$

where $HA_{pilot}$ is the hourly allocation for UAV control training and $HA_{lic}$ for pilot test preparation.

**Variable costs** $C_{scan}(n_y)$ include labour costs associated with the planning of individual scanning, $LC_{plan}$, travelling to the scanning location, $LC_{trans}$, its subsequent realization $LC_{scan}$, and transport overhead costs $C_{trans}$,

$$C_{scan}(n_y) = 4n_y \cdot \left(LC_{plan} + LC_{trans} + LC_{scan} + C_{trans}\right).$$

The role of the $C_{trans}$ variable can be much broader. Basically, it combines any non-labour costs associated with a single event. The labour costs are calculated as

$$LC_{plan} = HA_{plan} \cdot HW,$$
$$LC_{trans} = HA_{trans} \cdot HW,$$

and

$$LC_{scan} = HA_{scan} \cdot HW,$$

where $HA_{plan}$, $HA_{trans}$, and $HA_{scan}$ are the hourly allocations for one individual planning, transfer, and scanning respectively.

**Total cost of image data processing $TC_{proc}(n_y)$**

The total processing cost includes both the fixed cost, $C^0_{proc}$, and the variable cost of repeated processing, $C_{proc}(n_y)$, provided internally by the organization,

$$TC_{proc}(n_y) = C^0_{proc} + C_{proc}(n_y).$$

**Fixed costs** $C_{proc}^{0}$ includes the possible cost of software $C_{SW}$ and labour costs related to software acquisition $LC_{SW}$.

$$C_{proc}^{0} = C_{SW} + LC_{SW} \cdot (1 + rate_{risk})$$

The labour costs are calculated as

$$LC_{SW} = HA_{SW} \cdot HW,$$

where $HA_{SW}$ is the hourly allocation for software training.

**Variable costs** $proc(n_y)$ includes only labour costs for the processing $LC_{proc}$,

$$C_{proc}(n_y) = 4n_y \cdot LC_{proc}.$$

The labour costs are calculated as

$$LC_{proc} = HA_{proc} \cdot HW,$$

where $HA_{proc}$ is the hourly allocation for one individual processing.

**Total cost of external services $TC_{ext}(n_y)$**

This component includes the cost of the service demanded and supplied by an external company. It may be either the total service, i.e. scanning and processing, or part of it,

$$TC_{ext}(n_y) = 4n_y \cdot C_{ext}.$$

where $C_{ext}$ is the cost of processing one request under consideration by an external company.

### *5.2 Settings for individual scenarios in our conditions*

First of all, all settings for total cost, $TC_{scan}(n_y)$, apply only to INT scenarios, while $TC_{proc}(n_y)$ apply to both INT and COMB scenarios. On the other hand, the cost of external services, $TC_{ext}(n_y)$ , refers to COMB and EXT scenarios.

The setting of non-labour costs considered in the model is as follows:

– $C_{drone}$: The price of the mini UAV from scenario $INT_{mini}$ is set to 2.000 CZK, the price of the standard UAV, scenarios $INT_{free}^{scan}$ and $INT_{paid}^{scan}$, is set to 40.000 CZK.

– $C_{ins}$: As the cost of insurance changes over time, an amount of 5 690 CZK is assumed for the first two years and the expected increase is modeled by a one-time increase of this amount by 10% after two years for all INT scenarios:

$$C_{ins} = 2 \cdot 5.690 + 2 \cdot 5.690 \cdot (1 + 10\%)$$

– $C_{SW}$ : Scenarios $INT_{mini}$ , $INT_{free}^{scan}$ and $COMB_{free}$ do not require any investment in special software, only for scenarios $INT_{paid}^{scan}$ and $COMB_{paid}$ the software is considered at a value of \$179. Using the current exchange rate of 23,08 it gives $C_{SW} = 4.132{,}32$ CZK.

– $C_{trans}$: This cost was quantified ad 720 CZK. Our study assumes a location 50 km away. The amount was derived from the expected cost per km driven.

The labour costs correspond to the current private sector labour market value. The $HW$ price is derived by converting the total annual cost of an employee (including compulsory contributions) per hour (total annual labour pool at eight hours/day). For the initial comparison, the average wage for the 4th quartal of 2024 in the Czech Republic according to the Czech Statistical Office was used, i.e. 49.229 CZK. The hourly wage cost is set as $HW = 400$ CZK which slightly exceeds the average wage, namely 50.024 CZK. The price of $HW_{ext} = 1.000$ CZK was derived from market prices of the training offers.

The probability of having to replace the internal employee over a four-year period, rate of risk $rate_{risk}$, is set as $35\%$.

The next step is to set the hourly allocations for each activity expressed in terms of working hours (60 minutes). The allocations common to all INT scenarios are:

- $HA_{pilot} = 5$,
- $HA_{lic} = 4$,
- $HA_{trans} = 2$.

Other allocations vary by scenario. These are summarized in Table 1. Allocation $HA_{intro}$ reflects the impact of the chosen scenario. An organization's decision to process internally will be associated with higher time requirements for the introduction to the issue. On the other hand, it is assumed that the final decision to outsource even part of the process to a firm will be preceded by some familiarization with the topic, selection of the firm and communication about the contract specification. In $INT_{mini}$ scenario, lower allocations can generally be expected. The choice of software will then affect not only the time to learn how to operate it, but also the time spent on the processing itself.

**Table 1. Scenario hourly allocations**

| | $\mathbf{INT_{mini}}$ | $\mathbf{INT^{scan}_{free}}$ | $\mathbf{INT^{scan}_{paid}}$ | $\mathbf{COMB_{free}}$ | $\mathbf{COMB_{paid}}$ | $\mathbf{EXT_{mini}}$ | $\mathbf{EXT^{INT}_{std}}$ | $\mathbf{EXT^{COMB}_{std}}$ |
|---|---|---|---|---|---|---|---|---|
| $HA_{intro}$ | 24 | 40 | 40 | 32 | 32 | 20 | 20 | 32 |
| $HA_{plan}$ | 1 | 3 | 3 | - | - | - | - | - |
| $HA_{scan}$ | 2 | 4 | 4 | - | - | - | - | - |
| $HA_{SW}$ | 1 | 24 | 12 | 24 | 12 | - | - | - |
| $HA_{proc}$ | 2 | 8 | 4 | 8 | 4 | - | - | - |

*Source*: Authors' own creation.

Finally, the expected prices of external services, $C_{ext}$, are presented. Prices were set based on communication with service providers in the Czech Republic. The prices requested for such processed orders were adjusted by the costs that the organization also has in the case of implementation in an external form. In the study, these are the costs related to the initial analysis of the situation $HA_{intro}$.

The prices differ for individual scenarios according to their nature. In EXT scenarios, it is the price for both scanning and data processing. For $EXT_{mini}$ the price is estimated as 8 960 CZK, and for $EXT^{INT}_{std}$ and $EXT^{COMB}_{std}$ as 24.960 CZK. In COMB scenarios it is only the price for scanning - $C_{ext}$ = 15.960 CZK.

## 6. Results and Discussion

Before interpreting the results, let us list some aspects that must also be taken into account when evaluating them. This is a necessary simplification that allowed us to focus on a reasonable number of scenarios.

The work associated with drone operations is expressed in the study, although it is based on the assumption that it is an existing employee. The cost model does not include the risk associated with activities. In the case of implementation in the form of an external contract, the risk is completely nullified, as the service provider is responsible for the contract. In the case of in-house form, the organization itself bears the risk, while de facto each activity is associated with a risk

Table 2 contains the total costs resulting from the scenarios. In the rows, the costs are calculated for the respective number of UAV uses per year. The amounts (in thousands CZK) where the internal form is financially for the first time more advantageous compared to the price for an external service are highlighted in bold. The reported results were use to formulate answers to the research questions discussed.

**Table 2. Total costs $TC_{scan}(n_y)$ in thousands of CZK**

| $\mathbf{n_y}$ | $\mathbf{INT_{mini}}$ | $\mathbf{EXT_{mini}}$ | $\mathbf{INT^{scan}_{free}}$ | $\mathbf{INT^{scan}_{paid}}$ | $\mathbf{EXT^{INT}_{std}}$ | $\mathbf{COMB_{free}}$ | $\mathbf{COMB_{paid}}$ | $\mathbf{EXT^{COMB}_{std}}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 62 | 44 | 135 | 126 | 108 | **102** | **94** | 113 |
| 2 | **76** | 80 | **165** | **149** | 208 | 179 | 164 | 212 |
| 3 | 90 | 116 | 195 | 173 | 308 | 256 | 234 | 312 |
| 4 | 104 | 151 | 225 | 197 | 407 | 332 | 304 | 412 |
| 5 | 118 | 187 | 255 | 221 | 507 | 409 | 375 | 512 |
| 6 | 132 | 223 | 285 | 244 | 607 | 486 | 445 | 612 |
| 7 | 146 | 259 | 315 | 268 | 707 | 562 | 515 | 712 |
| 8 | 160 | 295 | 345 | 292 | 807 | 639 | 585 | 812 |
| 9 | 174 | 331 | 375 | 315 | 907 | 716 | 656 | 911 |
| 10 | 188 | 366 | 405 | 339 | 1.006 | 792 | 726 | 1.011 |
| 11 | 203 | 402 | 435 | 363 | 1.106 | 869 | 796 | 1.111 |
| 12 | 217 | 438 | 465 | 386 | 1.206 | 945 | 866 | 1.211 |

*Source*: Authors' own creation.

**Research question 1** What will be the economic differences between internal form of operation and outsourced services in terms of costs over a given time horizon?

Table 2 shows estimated total costs that vary across scenarios and determine main directions of interpretation: 1) overall, general comparison between internal and external implementation; and 2) a comparison of the most significant effects

Ad 1) In general, it has been shown that if an organization uses UAV data more than twice a year, it is appropriate to consider at least some form of internal of application. With a small number of uses, the effect of initial costs - investments in ensuring UAV outputs - is evident. These are reflected in the price. More frequent use dissolves these costs, and these are increasingly nullified by higher supplier prices. Nevertheless, the profitability limit is very low; if only the costs are taken into account, it is around two uses per year.

It must be said that although the internal implementation of obtaining simple outputs represented by $INT_{mini}$ shows a positive effect from two uses per year, the difference is so small that real savings can only be recorded for use at least three times per year. This is primarily due to the high initial costs, where, for example, for one use per, $n_y = 1$, year, the costs of insurance and training of the worker constitute more than 50% of the costs. For $n_y = 3$ uses per year, the costs for the internal form of implementation are 78% compared to the external service, which may be the limit for considering internal implementation.

On the other hand, in combined/hybrid scenarios the initial costs are less pronounced, so the financial savings are visible right from the start, however the advantage of this effect disappears with more frequent use. So is does not provide the potential for increased cost-effectiveness with more usage.

Ad 2) The evaluation of the most significant effects refers to the most significant difference between implementation in the form of an external service (purchase) versus at least partial in-house implementation by internal processes.

Figure 2 shows that from three uses per year, the internal form of deployment appears to be more advantageous, with costs decreasing significantly with each additional use per year. In combined scenarios, costs decrease more slowly with the intensity of use. The high ratio of added value resulting from the employees work and the gradual dissolution of costs translates into significant benefits.

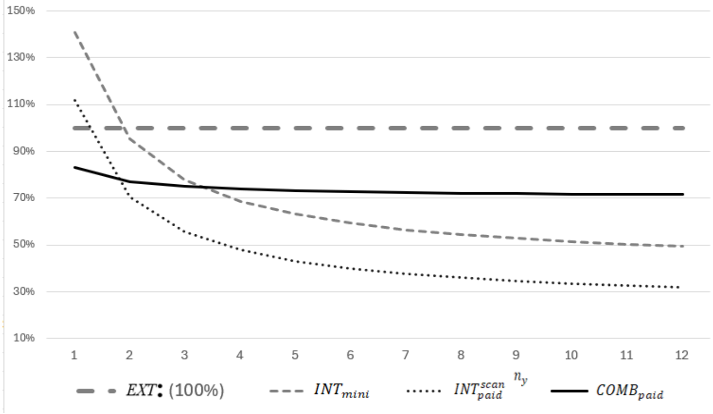

**Figure 2. Decreasing the cost of scenarios compared to an external service (100%)**
*Source*: Authors' own creation.

**Research question 2** What is the impact of using paid software versus using free software?

In short, it can be stated that it is economically worthwhile to invest in paid software. The reason is the connection with labour costs. The price of software has a smaller impact on costs compared to the price formed by the labour costs of using the software. Labour costs are significantly reflected in the calculation and fall largely on the work with the software when processing the UAV outputs. Therefore, the savings that arise from image processing have a large share in the efficiency of the entire process. These were the main reasons why scenarios with paid software always show savings compared to scenarios using freely available software. The more frequent the use, the greater the savings will be from investing in paid software. All this is illustrated by the results in Table 2 in the columns $INT_{free}^{scan}$ versus $INT_{paid}^{scan}$ and in the columns $COMB_{free}$ versus $COMB_{paid}$.

The reasons for the savings are: 1) with paid software, learning to use the software is shorter 2) simpler method of image processing. The use of ready-made functions in specialized software usually brings savings in the range of hours and prebuilt procedures are optimized (automated) in paid software, compared to open-source software. A higher frequency of uses further emphasizes the positive effects of paid software.

**Research question 3** What is the role of output quality factor?

The results confirmed aspects of the final output quality (required visual outputs) will have a significant impact on the results, specifically in the completely different demands on technical and software equipment and on people's knowledge and skills. This makes the issue of the required outputs one of the key issues for implementation.

The quality factor is reflected in $INT_{mini}$ scenario that describes a less demanding outputs and the other scenarios representing higher complexity. The differences are striking when comparing costs in the case of acquisition by an external supplier, as well as when comparing costs in internal scenarios. This makes it more important to observe how technical characteristics relate to higher quality requirements, which helps in the considerations in the initial stages of implementation.

With more frequent use, a certain convergence of the price for one project (one use) is seen (Figure 3, $INT_{mini}$ and $INT_{paid}^{scan}$).

Figure 3 shows the costs of one scanning project and the total for $INT_{mini}$ scenario, $INT_{paid}^{scan}$ scenario and $COMB_{paid}$ scenario. The graphs illustrate the development of costs with each subsequent scan. A significant decrease per action for scenario $INT_{paid}^{scan}$, whose economic benefit with frequent scanning is clear. Cost reduction for $COMB_{paid}$ scenario gradually fades and also appears to be significantly more expensive compared to $INT_{paid}^{scan}$ scenario, which produces the same results. And the already stated and expected result of lower costs for the outputs of $INT_{mini}$ scenario compared to the higher quality outputs of scenarios $INT_{paid}^{scan}$ and $COMB_{paid}$.

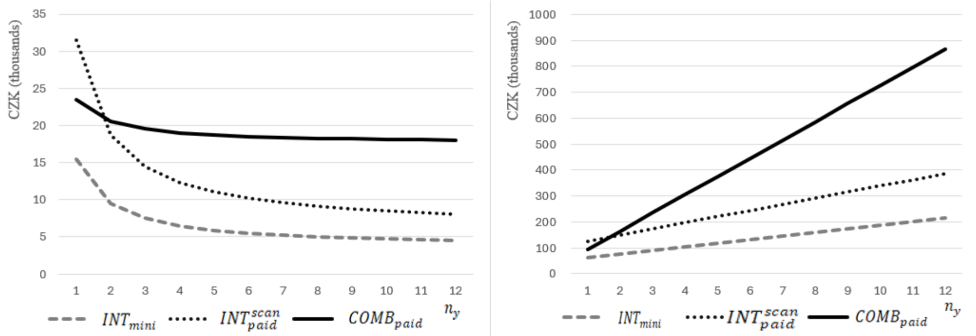

**Figure 3. Cost per one project (left) and in total (right) at CZK**
*Source*: Authors' own creation.

A visual comparison between the internal form of implementation and the external service can be seen in Figure 4. The dynamics of the decrease in costs slows down from $n_y = 5$ uses per year. If prices decrease in the market due to increasing competition, there is a large scope for maintaining the economic advantage of the internal form of implementation in $INT_{paid}^{scan}$ scenario. In $INT_{mini}$ scenario, the differences between the internal and external prices are smaller and a possible decrease in prices from external suppliers could lead to a discussion about whether it is worth doing it internally.

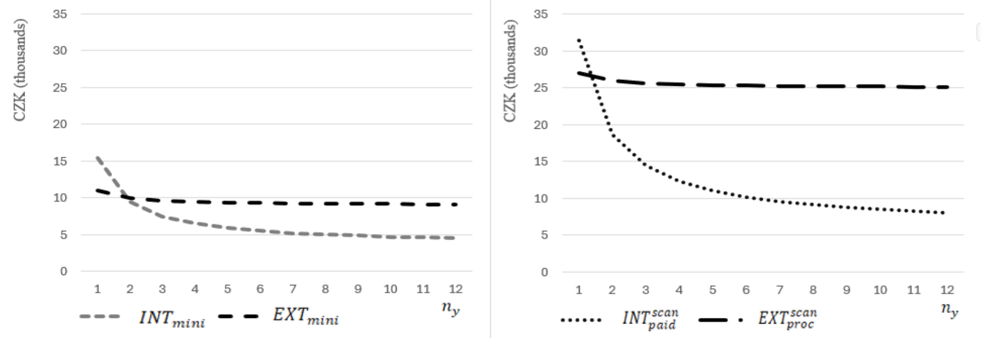

**Figure 4. Costs per one project at CZK**
*Source*: Authors' own creation.

## Limitations of the study

The main limitation of the study lies in the limitations in defining the model situation. Despite the efforts to define scenarios practically, in practice it can be expected that the situation will be much more diverse.

Prices and costs are based on the environment of the Czech Republic. However, all factors and the calculation model are published. Adjustment of individual cost items is possible. There is also the question of how prices will change in the near future with regard to the expected growth of competition on the market.

Given the focus on organizations for which UAV capability is not the core business but is clearly complementary, the study did not pay much attention to the hardware to process the image material.

The study does not assume the use of advanced data processing methods such as deep mapping. These data processing methods are not typical, they are a specific and narrowly profiled area of UAV data processing.

## 7. Conclusions

The article discusses the factors that influence the implementation of UAVs in organizations. The factor of output requirements complexity and related technologies proved to be crucial.

It was found that the cost structure and price level lead to the conclusion that the internal form of provision is economically justified even with an expected use of 2-3 per year. And more frequent use further improves the economy of operation. However, the cost model is rather mathematical calculation. The evaluation of other indirect contributing factors is difficult. Therefore, the article focuses on the entire process of providing UAV image outputs. This comprehensive approach enables to better consider quantitative results in relation to the identified factors.

Beyond the answers to the research question, the results of the study also point to aspects that are critical for decision-making. Strong interdependence of sub-factors that managers should be aware of when considering implementation. Need for flexibility in modifying image output when building internal capacity for image data processing.

It is appropriate to pay attention to the issues of implementation, as this is a little-discussed area compared to the number of publications with technical focus. Due to the dynamics through which UAVs development is going, it is likely that the number of implementations will increase; therefore, it is advisable to pay attention to organizational and economic aspects, so that organizations are generally prepared for the acceptance of this UAV technology and technologies related to the use of UAVs.

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