AEN-160

Cooperative Extension Service

Decision Aid for Estimating the Cost of Using a Drone in Production Agriculture

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Unmanned aircraft systems (UAS), commonly known as drones, play an increasingly important role in production agriculture. UAS are already widely used in agriculture for monitoring livestock, inspecting fence lines (see AEN-159 Using Drones to Monitor Fence Lines), and evaluating crops and pastures (e.g., yield, quality, nutrients, water stress, pest pressure, disease impact). The cost of using a UAS will depend on a variety of factors, including platform-based capabilities, maintenance, and insurance. As with any investment, the economic benefit derived from using a UAS should be determined prior to purchase. The accompanying decision aid, applicable for UAS involved in remote sensing, has been developed to estimate the initial, annual, per flight, and per acre cost of utilizing a UAS on the farm. The following document serves as a guide to using the UAS cost estimation decision aid, which is available online at https://www.engr.uky.edu/directory/jackson-joshua.

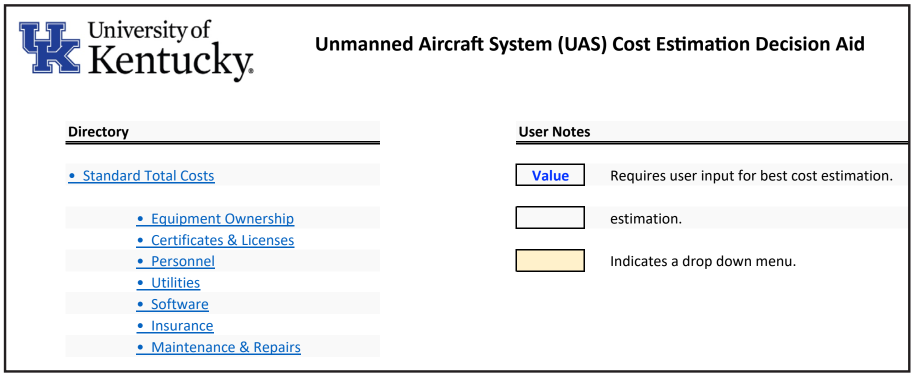

Figure 1. Directory with hyperlinks to cost estimation tabs.

Using the Tool

Directory Tab

Open the UAS Cost Summary in Excel and select the directory tab. The directory includes hyperlinks to the associated tabs (Figure 1.). A notes section specifies that a cell with blue text will indicate user-defined values and cells with yellow backgrounds indicate drop-down lists. All other cells will be prepopulated estimations or calculated values that are dependent on the user-defined values.

Total Cost Tab

A UAS is an investment that must be considered carefully. The returns on investment for a UAS purchase will be based on the data collected and the collected data's management decisions (Figure 2). For monitoring livestock or fence lines, the UAS **cost per flight** would be used to ascertain if the flight is justified. For crop and pasture evaluation, the cost per flight remains vital, but the number of acres covered per flight is also an important factor to consider. Most aspects of the farm are measured on a cost per acre basis. Thus, the area covered by the UAS flight is a critical estimation as it determines the **cost per acre**. The desired spatial resolution will determine the acres covered per flight. UAS costs per flight and cost per acre will help determine if the flight parameters need to be modified and if the flight is worth conducting.

Spatial Resolution

The area covered and spatial resolution of the video or images collected will be determined by **camera specifications, UAS altitude above ground level (AGL), speed, and desired image overlap**. The higher the

Parameters	
Number of Flights Conducted Yearly	52
Average Number of Flights Conducted Weekly	1.0
Interest Rate	6%
Average Number of Acres Covered per Flight	50

Expenditures	Initial Cost	Annual Cost	Cost Per Flight
Capital Expenditure			
Equipment Ownership	$ 2,616	$ 413.20	$ 7.95
Interest (Opportunity Cost)		$ 87.03	$ 1.67
Operational Expenditure			
Certificates & Licenses	$ 175	$ 96.67	$ 1.86
Personnel		$ 407.33	$ 7.83
Utilities		$ 1.04	$ 0.02
Software	$ 1,000	$ 1,000.00	$ 19.23
Insurance	$ 600	$ 600.00	$ 11.54
Maintenance & Repair		$ 80.00	$ 1.54
Total Cost	**$ 4,391**	**$ 2,685.27**	**$ 51.64**
Total Cost/Acre			**$ 1.03**

Figure 2. Total cost tab.

flight altitude, the greater the area that can be covered on the ground (Figure 3). Additionally, as the altitude increases, the spatial resolution, number of images required per unit area, and post-processing time will decrease. Increased area covered, fewer images, and faster post-processing times are all desirable. However, an inherent tradeoff of these benefits is a lower resolution of the final product. This lower resolution could impair or skew decision-making capabilities. While increasing the speed of the aircraft will also result in a larger area that can be covered per flight, the speed of the UAS is limited by the ability of the camera frame rate to maintain the desired spatial resolution and coverage at the increased speed.

For field mapping applications, front and side image overlapping is required to generate a single orthomosaic from the collected images (Figure 4). The minimum required overlap of images needed for map creation depends on the crop, software, and spatial resolution desired. Increasing the image overlap will result in prolonged flight time and a reduction in the overall area covered per flight (Figure 5). Nonetheless, increased image overlap improves the map precision, or model, which can thereby enhance the map analysis outcomes.

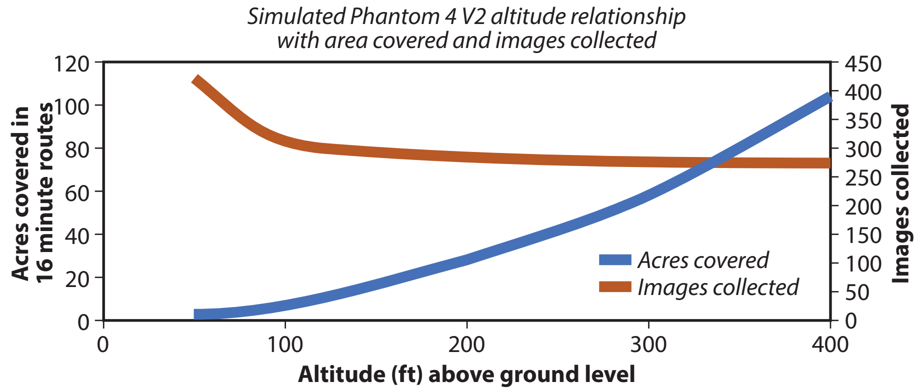

Figure 3. Approximate area that can be mapped with a Phantom 4 V2 with 20 MP camera and the number of images collected during the respective flights. Assumes 75 percent front overlap and 70 percent side overlap.

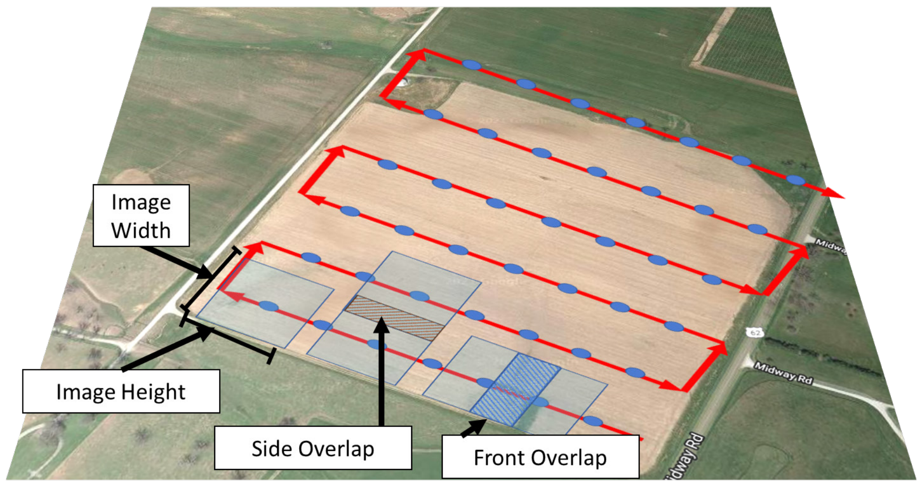

Figure 4. Front ( ) overlap occurs in the direction of travel for the UAS. Side overlap ( ) occurs with adjacent images from along the flight path. Direction of travel for the UAS is indicated by the red arrow. Blue dots and squares represent the location of the images and the image area, respectively.

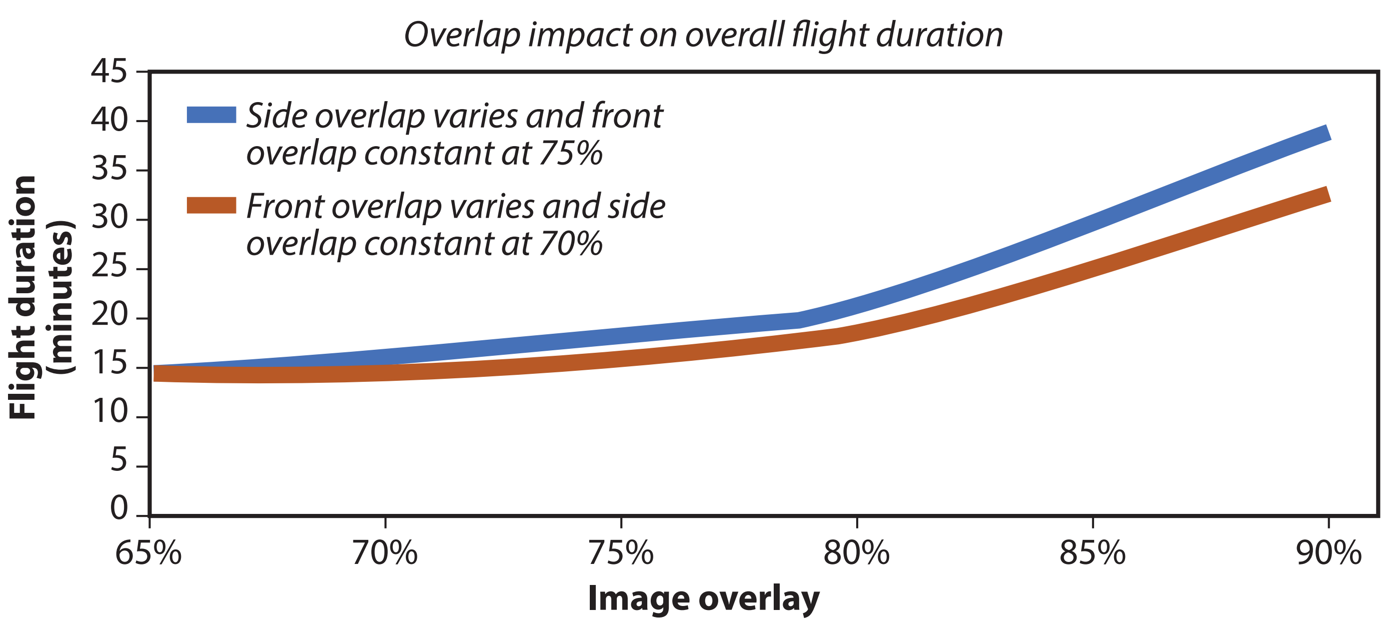

Figure 5. Impact of image overlap on the overall flight duration. Increasing the side or front overlap for image collection results in an increased flight duration. Assumptions were Phantom 4 V2 at 400 feet AGL viewing approximately 106 acres.

The total costs tab presents the initial cost, annual cost, cost per flight, and cost per acre. The user will define the total number of flights conducted annually. Prior to purchasing a UAS, the average number of flights per year needs to be considered carefully as there is an inverse relationship between the number of flights per year and costs per flight (Figure 6). As the number of flights per year increases, the cost per flight decreases due to the input costs being spread out over more flights. However, it should be noted that as the number of flights increases per year, so will the total costs. Additionally, the interest rate defined by the user will be used to determine the opportunity cost of having a UAS.

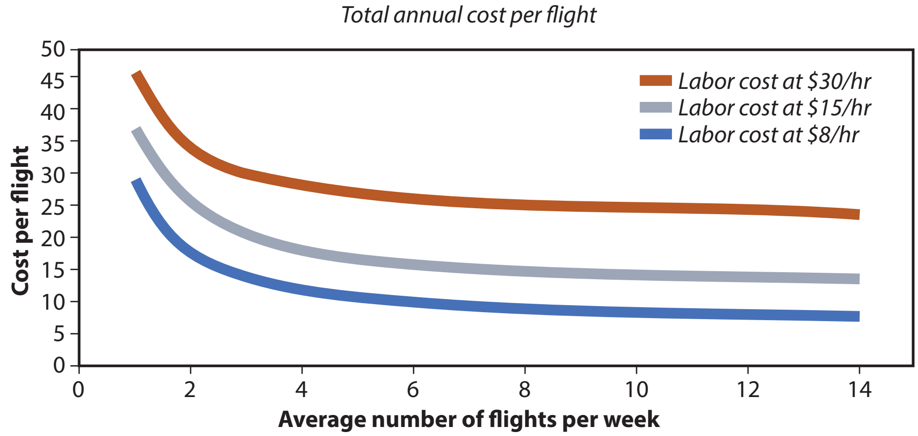

Figure 6. Total annual cost per flight with three different labor costs (i.e., personnel wages) that would most likely vary between producers. The cost per flight decreases with an increasing number of flights as the input costs are spread out over more flights.

Equipment Ownership Tab

Under this tab, the user will define the equipment parameters of the number of units, purchase price per unit, years of economic life, and salvage value (Figure 7). Changing the number of units to zero will deactivate the row, excluding it from the calculations; changing the number of units to one or greater will activate the row. For most remote sensing work, there are certain aspects which are typically

Equipment Information	Number of Units	Purchase Price Per Unit	Years of Economic Life	Salvage Value	Initial Cost	Annual Depreciation	Cost Per Flight	Annual Interest	Interest Cost Per Flight
Required									
UAV & Controller Station Package	1	$ 1,600	5	$ 500	$ 1,600	$ 220	$ 4.23	$ 63.00	$ 1.21
Battery Charger	0	$ 109	5	$ -	$ -	$ -	$ -	$ -	$ -
Tablet or Mobile Device	1	$ 500	5	$ 50	$ 500	$ 90	$ 1.73	$ 16.50	$ 0.32
64 GB Micro SD Card (x4)	5	$ 20	5	$ -	$ 100	$ 20	$ 0.38	$ 0.60	$ 0.01
Micro SD Card Reader	1	$ 15	5	$ -	$ 15	$ 3	$ 0.06	$ 0.45	$ 0.01
Spare Batteries	2	$ 185	5	$ -	$ 370	$ 74	$ 1.42	$ 5.55	$ 0.11
Landing Pad	1	$ 20	5	$ -	$ 20	$ 4	$ 0.08	$ 0.60	$ 0.01
Spare Propellers	1	$ 11	5	$ -	$ 11	$ 2	$ 0.04	$ 0.33	$ 0.01
Optional									
Wifi Hotspot	0	$ 200	5	$ 20	$ -	$ -	$ -	$ -	$ -
HDMI Cables	0	$ 15	5	$ -	$ -	$ -	$ -	$ -	$ -
Lidar	0	$ 8,000	5	$ 3,000	$ -	$ -	$ -	$ -	$ -
Multispec Camera	0	$ 2,000	5	$ 500	$ -	$ -	$ -	$ -	$ -
Thermal Camera	0	$ 2,000	5	$ -	$ -	$ -	$ -	$ -	$ -
Other camera	0	$ 1,000	5	$ -	$ -	$ -	$ -	$ -	$ -
Mounts	1	$ 50	5	$ -	$ 50	$ 10.00	$ 0.19	$ 1.50	$ 0.03
Tank	0	$ 500	5	$ -	$ -	$ -	$ -	$ -	$ -
RTK Equipment	0	$ 5,000	10	$ 2,500	$ -	$ -	$ -	$ -	$ -
Command Center Options									
Chair	0	$ 50	5	$ -	$ -	$ -	$ -	$ -	$ -
Table	0	$ 100	10	$ -	$ -	$ -	$ -	$ -	$ -
Laptop	0	$ 1,500	5	$ -	$ -	$ -	$ -	$ -	$ -
Large Screen TV	0	$ 500	5	$ -				$ -	
Generator	0	$ 1,000	20	$ 600	$ -	$ -	$ -	$ -	$ -
Power Converter	0	$ 5	4.5	$ -	$ -	$ -	$ -	$ -	$ -
Mounts	0	$ 75	4.5	$ -	$ -	$ -	$ -	$ -	$ -
Tent	0	$ 200	3	$ -	$ -	$ -		$ -	
Miscellaneous	0	$ 5	4.5	$ -	$ -	$ -	$ -	$ -	$ -
Total Investment Cost					**$ 2,666**	**$ 423**	**$ 8.14**	**$ 88.53**	**$ 1.70**

Figure 7. Equipment ownership tab.

required: a UAS and controller station package which will generally come with a UAS battery and charger, display screen (Android or iOS-based tablet or smartphone; Windows tablets will not work with most consumer drones), SD card, SD card reader, spare batteries, and spare propellers. It is important to keep in mind that some UAS controller stations will include a display screen, while others will not. Any additional UAS related accessories such as HDMI cables, cellular hotspots for internet connectivity, or other UAS related equipment will need to be included in the analysis if purchased.

The purchase price for the UAS related equipment can typically be found on a retailer's website, while the years of economic life would relate to how long the equipment is expected to last under normal conditions. Assuming a UAS lifespan is similar to that of business computers, the drone would be replaced every three to five years to keep pace with technological improvements. If cared for properly, the UAS should be functional for more than five years, but five years of economic life would provide a reasonable estimate for most UAS-related equipment. Lastly, the salvage value would be the assumed worth of a product if it were sold at the end of its economic life. It should also be noted that the interest rate is calculated and displayed in this tab, which can be altered in the total cost tab.

Certificates & Licenses	Years Valid	Purchase Price	Annual Cost	Cost Per Flight
Required				
FAA Remote Pilot Certificate Knowledge Ex	2	$ 150	$ 75.00	$ 1.44
FAA UAS Registration	3	$ 5	$ 1.67	$ 0.03
Optional				
FAA Study Material for Remote Pilot Test	1	$ 20	$ 20.00	$ 0.38
Total Cost		**$ 175**	**$ 96.67**	**$ 1.86**

Figure 8. Certificates and licenses tab.

Personnel Responsibilities	Duration of Time Allocated Per Flight	Labor Cost ($/hr)	Annual Cost	Cost Per Flight
Flight Planning	2	10	$ 17.33	$ 0.33
Launching & Landing Preparatic	5	10	$ 43.33	$ 0.83
Actual UAS Flying Time	20	10	$ 173.33	$ 3.33
Post-Processing	20	10	$ 173.33	$ 3.33
Visual Observer	0	8	$ -	$ -
Other	1	8	$ 6.93	$ 0.13
Total Cost			**$ 414.27**	**$ 7.97**

Figure 9. Personnel cost tab.

Certificates and Licenses Tab

This tab lists the details of required and optional certificates and licenses (Figure 8). All commercial operations of a drone (under 55 lb) must follow the Federal Aviation Administration (FAA) Part 107 rules and regulations. Operating a UAS for commercial purposes requires that individuals take and pass the FAA Remote Pilot Certification Knowledge Exam. The exam is $150 and requires a 70 percent or greater to pass.

Some of the pertinent Part 107 rules:

- UAS must be registered with the FAA ($5 for three years).
- Maximum flight altitude is 400 feet AGL.
- Must maintain visual line of sight.
- UAS must weigh less than 55 pounds.
- Required to perform a preflight inspection (aircraft, airspace, weather conditions, locations of people and property) prior to flight.

Personnel Cost Tab

There is a personnel cost associated with flying UAS (Figure 10). This is the time that could be spent performing other farm-related activities. The estimated labor cost is one factor that would vary the most between farms as differing valuations are placed on time. Again, consider the number of flights conducted annually carefully, as there is a direct relationship between the total annual cost and num-

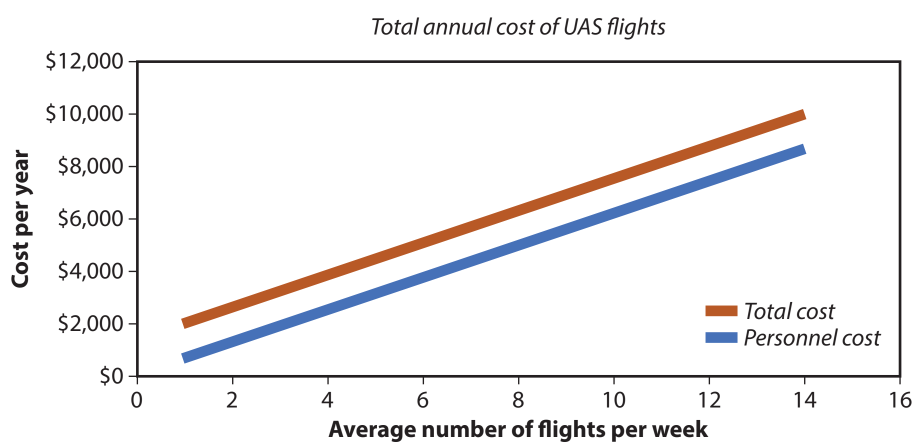

Figure 10. Total annual and personnel costs of operating a Phantom 4 V2 with labor costs at $15 per hour.

ber of flights. As the number of flights conducted per year increases, the total annual cost increases, and this increase in total cost is controlled primarily by personnel cost (Figure 10). For UAS flights, personnel time is allocated among flight planning, launching and landing preparations, actual flight time over the area of interest, post-processing of videos and images, a visual observer's time (if one is used), and other related costs.

To ensure successful and efficient flights, proper planning and preparation is critical. Flight planning is typically performed by selecting the area of interest on a digital map. Since rendering the digital maps typically requires a decent internet connection (WiFi or cellular/mobile), performing flight planning prior to entering the fields is suggested as connections in fields may be limited. Nonetheless, some flight plans may require more dynamic planning capabilities, and the associated flight planning can be updated at the field edge. Once most flight patterns have been established for a farm, the time allocated to planning should decrease accordingly. For the cost estimation, use the average time needed for each personnel responsibility.

Launching and landing preparations will require a time input from personnel as well. At launch, propellers will need to be installed or folded out into flying positions. Equipment protecting instruments and cameras during transport will also need to be removed from the UAS prior to flight. Deployment of a foldable launchpad is typically advisable for multirotor UAS. This will prevent tall grass from becoming entangled in the propellers, and alert nearby low altitude manned aircraft that there is a UAS within the vicinity. Additionally, as per Part 107 regulations, a preflight inspection needs to be performed. If there are subsequent flights, preparation regarding batteries and recharging would also need to be considered. Time must be allocated for transport or storage procedures after flights. Flight time may vary depending on the mission objectives, but the average time of flight and associated cost per hour should be entered.

Furthermore, the time associated with the post-processing of the videos and images would need to be considered. For most analyses, we assume there will be a one-to-one relationship between flight time and post-processing; however, there may be instances where this is not the case. Depending on the complexity, post-processing procedures can at times take two to four hours and sometimes more. Some aspects of post-processing can be initiated and other pertinent tasks performed while the post-processing software is being executed. However, for this decision aid, consider only the actual time of human engagement with the program: uploading the images, setting up the analysis, reviewing the information, and making data-driven decisions.

If a visual observer is used, include the duration of time in which they were available to assist in flight monitoring and the associated labor cost. Other personnel-related costs such as travel time to launch sites and fields, evaluation time for weather reports, or development of standard operating procedures need to be included in the cost estimate as well.

Equipment Information	Number of Charged Batteries Per Flight	Charger Power Requirements (Watts)	Duration of Charge Per Hour	Cost Per kWh	Annual Cost	Cost Per Flight
UAS Battery	1	100	1	$ 0.10	$ 0.52	$ 0.01
Tablet or Mobile Device	1	100	1	$ 0.10	$ 0.52	$ 0.01
Laptop	0	100	1	$ 0.10	$ -	$ -
Total Cost					$ 1.04	$ 0.02

Figure 11. Utilities tab.

Software	Years Valid	Initial Cost	Annual Cost	Cost Per Flight
Flight Software	0	$ -	$ -	$ -
Post-Processing Software	1	$ 1,000	$ 1,000.00	$ 19.23
Total Cost		**$1,000**	**$ 1,000.00**	**$19.23**

Figure 12. Software tab.

Utilities Tab

The utilities tab addresses the cost associated with recharging batteries for equipment such as the UAS, tablet, or laptop (if one is used during flight or post-processing) (Figure 11). For the analysis, the number of batteries charged per flight would typically be specified as "1" for most UAS quadcopters since one battery would be used per flight. Nonetheless, some of the larger UAS use multiple batteries per flight, and this value would need to be adjusted accordingly. The inputs relating to charger power requirement and duration of charge can be found in the product literature or manufacturer's website. If unavailable, a power analyzer could be used to determine the power requirements of the battery charger. Lastly, the electricity costs, in cost per kWh, can be found in recent electrical utility bills.

For example, the charger for a Phantom 4 V2 with a 5,870 mAh battery possesses a maximum charging power requirement of 100 watts and a duration of charge of approximately 1 hour. The US Energy Information Administration (EIA) states that the average retail price for electricity in Kentucky is approximately $0.09 cents per kWh. For the Phantom 4 V2, that is $0.09 cents for 10 flights or $0.90 for 100 flights. Thus, utilities cost is generally negligible for UAS with small payloads such as the Phantom 4 V2. If a UAS were large enough that energy costs more than a few dollars per 100 flights, the UAS is most likely expensive enough that the energy cost is still a rounding error of the overall cost annually.

Software Tab

This tab addresses the cost of software used (Figure 12). Flight patterns will typically vary according to the desired task, but grid, circular, or waypoint flight patterns are the most common for farm applications. The grid pattern flight is used primarily for mapping operations, where the collected images are used to create orthomosiac images, 3-D surfaces, elevation contours, and vegetative indices (Figure 13). Video recordings of pastures can also be used to create field maps; though this option exists, maps created from still images are of higher quality

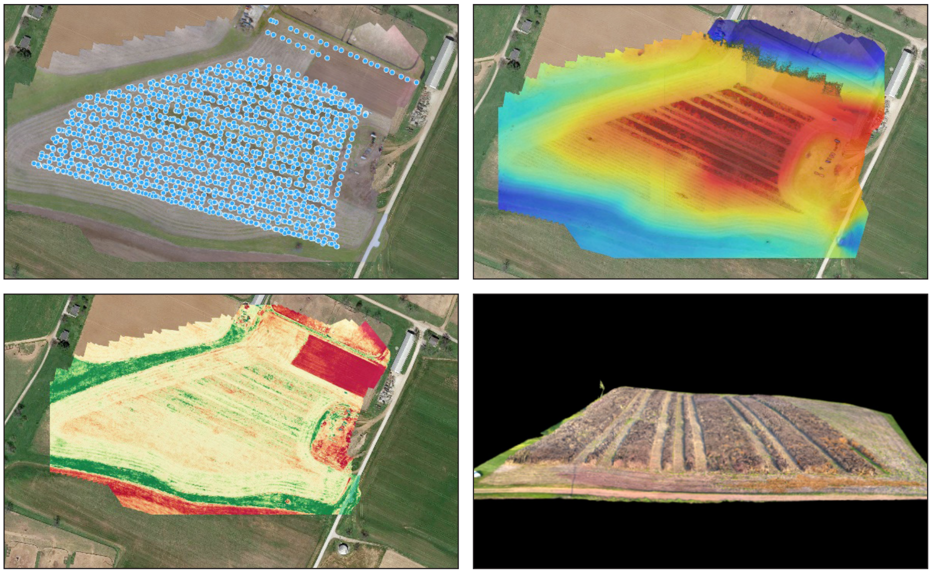

Figure 13. Top left: location of images taken. Top right: elevation profile created. Bottom left: normalized difference vegetation index developed. Bottom right: 3-D representation of field.

than those created from videos. On the other hand, circular pattern flights are ideal for inspecting structures and monitoring livestock; while GPS waypoint flight patterns are best used for inspecting fence lines, waterers, livestock feeders, and water crossings. Most flight planning apps for image and video collection are free. However, most post-processing programs related to image processing and utilization require an annual or monthly subscription.

If the flight software is free, input 0 as the value for the initial cost. For post-processing costs, enter the appropriate number for years the software is valid and input cost. Please note that if there is a one-time fee and perpetual license, enter 40 as the number of years valid and the associated input cost.

Insurance Tab

Drone insurance is essential, as accidents will occur, and insurance allows for commercial agricultural operators to protect themselves from financial ruin due to claims caused by a UAS accident. Some homeowner's insurance policies cover drone activities. However, check the homeowner's policy as drone coverage for commercial activities may be excluded. A separate policy is most likely needed for various aspects to be covered (Figure 14).

For instance, hull insurance, or physical damage insurance, is required to cover the UAS itself, sensors, or water damage. If the UAS is carrying an especially valuable payload such as a hyperspectral camera, LiDAR, or another type of sensor, consider adding the payload to its own policy or combining it with the hull insurance. The rate of depreciation for the payload may differ from that of the drone. Suppose the payload and the drone are considered separately. In that case, it may allow for potential cost savings on the insurance policy due to the difference in the insurance rate for the differing depreciations. Some hull insurance requires that the crashed drone be provided to the insurance company to receive a replacement. In this case, flight planning to ensure that the UAS is recoverable is a must. Other policies may cover the loss or theft of a UAS. Thus, be sure to understand what each policy covers.

Liability insurance is required to cover bodily injury, property damage, and personal injury claims. Bodily injury would apply to the medical expenses of people injured by a UAS crash. In contrast, property damage would cover a UAS accident resulting in the damaged property of others, such as hitting a roof or vehicle. Personal injury coverage applies to libel, slander, invasion of privacy, or other psychological-based claims. With the prevalence of social media and the litigious mindset of some individuals, personal injury coverage may be more relevant than ever.

Insurance Information	Years Valid	Intial Cost	Annual Cost	Cost Per Flight
Hull Insurance	1	$ 250	$ 250.00	$ 4.81
Water Damage				
Sensors				
Liability Insurance	1	$ 250	$ 250.00	$ 4.81
Public Liability				
Chemical Liability				
Additional Insurance	1	$ 100	$ 100.00	$ 1.92
Payload Coverage				
Ground Station Coverage				
Non Owned Coverage				
Personal Injury Coverage				
Total Cost		**$ 600**	**$ 600.00**	**$ 11.54**

Flight Parameters	
Average Flight Hours Per Montl	12
Months Flying Per Year	6

* Taking into account weather conditions of flight location

Insurance Packages	Insurance Quote	Comparison of Cost Per Year
Hourly Cost	$ 15	$ 1,080.00
Monthly Cost	$ 65	$ 390.00
Annual Cost	$ 600	$ 600.00

* Home Owners insurance does not always provide UAS coverage and some exclude coverage for business activities.

Figure 14. Insurance tab.

Thinking you are invulnerable, or that accidents will not happen to you, is a dangerous mentality that can lead to critical mistakes. Remote pilots need to manage hazardous attitudes in themselves and others who are working for them. As adrenaline and stress are likely to be high when a crash occurs, a standard operating procedure (SOP) for accident response needs to be developed to help ensure a calm and collected mindset during the process. Practicing the SOP accident response ahead of time will help ensure it will be conducted correctly when it matters most.

Some general post-crash recommendations are:

- Seek medical attention for bodily injuries (if required).
- Take images.
- Record any accident details (more is better).
- Acquire witness data.

Timeliness and completeness are vital to ensure an expedited response to an insurance claim.

Insurance for drones is quoted in several different ways. It can be on-demand (hourly or monthly) or more traditional (annually). Modify the flight parameters (months flying per year and average flight hours per month) in the tables to determine which type of policy would be the most cost effective for the number of estimated flights conducted. Values for the insurance quotes for hourly, monthly, and annual can be adjusted depending on the quote provided. The drop-down list allows for the comparison to show the equivalent value for each quote on an hourly, monthly, or annual basis.

Maintenance and Repairs Tab

Part failures, accidents, and natural wear are costs associated with keeping UAS equipment operational (Figure 15).

Equipment Information	Number of Units	Initial Value	Maintenance & Repair	Annual Cost	Cost Per Flight
Maintenance					
UAS Platform	1	$ 1,600	2.5%	$ 40.00	$ 0.77
Mainframe	0	$ 400	2.5%	$ -	$ -
Power Plant	0	$ 400	2.5%	$ -	$ -
Navigation System	0	$ 500	2.5%	$ -	$ -
Electronic System	0	$ 200	2.5%	$ -	$ -
	0	$ -	2.5%	$ -	$ -
Repairs					
UAS Platform	1	$ 1,600	2.5%	$ 40.00	$ 0.77
Mainframe	0	$ 400	2.5%	$ -	$ -
Power Plant	0	$ 400	2.5%	$ -	$ -
Navigation System	0	$ 500	2.5%	$ -	$ -
Electronic System	0	$ 200	2.5%	$ -	$ -
	0	$ -	2.5%	$ -	$ -
Total Cost				**$ 80.00**	**$ 1.54**

* Condition Based Maintenance = Cost Savings + Higher System Reliability + Reduced Liability

* Impact of ineffective maintenance: Replacement cost of a lost UAS, cost of UAS accidents, reduced productivity due to loss of the actual time that the UAS is airborne, cancellation of contracts due to an on-site crash, liability exposure in the case of a crash causing personal injury, environmental damage or equipment damage

Figure 15. Maintenance and repairs tab.

The cost of repairs is highly variable as different individuals place varying degrees of emphasis on UAS and associated UAS accessory care. The potential difference in UAS manufacturer quality and resilience also introduces variability into the cost of repairs. As a general estimate, plan for approximately 5 to 10 percent of the initial cost of the UAS to be associated with yearly repair and maintenance. Individuals who are attentive to UAS management and maintenance generally have lower repair costs in the long term.

There is an extremely high cost for not following proper maintenance requirements. The lack of repair and maintenance could result in a crash, the destruction or loss of the UAS, unscheduled downtime, and litigation related to damages or injury.

Example Analysis

To evaluate crops and pastures, Farmer John purchases a Phantom 4 V2, which he will fly an average of 52 times throughout the year. John plans to map an average of 50 acres per flight. His equipment costs are shown in Table 1. The knowledge exam, UAS registration, and study guide cost him $175. Regarding his personnel time, he plans to spend an average of two minutes for flight planning, five minutes for launching and landing preparations, and twenty minutes each for flight time and post-processing. For his UAS batteries and tablet, he will assume one hour of charge time with a 100W power requirement at $0.10/kWh. For his software cost, he will purchase a post-processing package that will allow him to stitch his images collected into a single map and cost $1,000 annually. Insurance will be acquired at $600 per year, and the assumed cost of repair and maintenance per year will be 5 percent of the initial cost of the UAS, or $80 ($1,600 * 0.05). All costs, including the initial cost for his UAS, would be approximately $4,400 (Table 2). If his costs were considered on an annual basis instead, he would be spending almost $2,700 per year on his UAS flights. Alternatively, the cost per flight would be $51.64/flight, which would provide him with an average of approximately $1/acre UAS cost. The total cost saving or improved revenue due to alterations in management or strategies would need to match or exceed the costs. Additionally, the cost of this additional mapping would need to be included within the partial or annual budgets that are developed on his farm.

Equipment Information	Number of Units	Purchase Price Per Unit	Years of Economic Life	Salvage Value	Initial Cost	Annual Depreciation	Cost Per Flight	Annual Interest	Interest Cost Per Flight
Required									
UAV & Controller Station Package	1	$ 1,600	5	$ 500	$ 1,600	$ 220	$ 4.23	$ 63.00	$ 1.21
Battery Charger	0	$ 109	5	$ -	$ -	$ -	$ -	$ -	$ -
Tablet or Mobile Device	1	$ 500	5	$ 50	$ 500	$ 90	$ 1.73	$ 16.50	$ 0.32
64 GB Micro SD Card (x4)	5	$ 20	5	$ -	$ 100	$ 20	$ 0.38	$ 0.60	$ 0.01
Micro SD Card Reader	1	$ 15	5	$ -	$ 15	$ 3	$ 0.06	$ 0.45	$ 0.01
Spare Batteries	2	$ 185	5	$ -	$ 370	$ 74	$ 1.42	$ 5.55	$ 0.11
Landing Pad	1	$ 20	5	$ -	$ 20	$ 4	$ 0.08	$ 0.60	$ 0.01
Spare Propellers	1	$ 11	5	$ -	$ 11	$ 2	$ 0.04	$ 0.33	$ 0.01
Total Investment Cost					**$ 2,616**	**$ 413**	**$ 7.95**	**$ 87.03**	**$ 1.67**

Table 1. Equipment ownership cost for UAS example analysis.

Conclusion

The cost of purchasing a UAS is non-negligible and must be considered carefully. The annual UAS cost, cost per flight, or cost per acre would ideally be offset by the cost saving or additional revenue from altered management strategies developed from reviewing the UAS images or video. The UAS costs will vary for each farm, crop, and livestock species monitored, but this decision aid allows for the estimation of this cost. This estimated cost could be input into a partial or annual budget and used to decide if the purchase of a UAS is warranted. Ideally, the purchase of a drone would allow for cost savings, increased revenue, or more effective use of resources. In some cases, even if the purchase of a drone does not increase profits, the purchase may still be justified if it has a little influence on overall farm profitability. Otherwise, non-economic factors (time with family, peace of mind, fun and enjoyment, or other factors) would need to be considered and used to justify the UAS purchase.

Expenditures	Initial Cost	Annual Cost	Cost Per Flight
Capital Expenditure			
Equipment Ownership	$ 2,616	$ 413.20	$ 7.95
Interest (Opportunity Cost)		$ 87.03	$ 1.67
Operational Expenditure			
Certificates & Licenses	$ 175	$ 96.67	$ 1.86
Personnel		$ 407.33	$ 7.83
Utilities		$ 1.04	$ 0.02
Software	$ 1,000	$ 1,000.00	$ 19.23
Insurance	$ 600	$ 600.00	$ 11.54
Maintenance & Repair		$ 80.00	$ 1.54
Total Cost	**$ 4,391**	**$ 2,685.27**	**$ 51.64**
Total Cost/Acre			**$ 1.03**

Table 2. Total cost for UAS example analysis.

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