Requirements

1. Cost Efficiency (Tab)

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| Requirement | Criteria | Metric | Constraint |
| Cost Efficiency, Affordability | Lower price is preferred | South African Rand  (R1 ≈ 0.084 CAD) | Must not exceed R57000/yr or R380/sheep/yr |
| Should not exceed R9000/yr or R60/sheep/yr |

1. Functionality

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| Requirement | Criteria | Metric | Constraint |
| Identify when sheep are lost (notification system)  [1] | Synchronization of notification creation | Time used (mins) for data entry/extraction | Must be less than 10 mins [2]  Should be below 7 mins, according to US EMS notification time in rural area |
| Reliability of the notification communication | Lower percentage error of false alert. Percentage error = number of false alerts/total number of alerts. | NA |
| Notification documentation history [3] | Should allow notification documentation, record all the history notifications |
| Be able to create and send notifications on open field, in ditches, in water, from homesteads, around on land obstacles. Work is more scenarios is better. | NA |
| Traffic analysis  1. Identify when a sheep wanders off by themselves  2. Identify when two groups of sheep meet (Warning)  3. Identify when a sheep is lost due to | NA |
|  |  | Allow multilevel alert [3], warning (no sheep lost but the risk is high), alert (a sheep is lost). | NA |
| Locate the lost sheep (finding system) | Tracking range in kilometers. | Farther is better. | Should be no less than 5km, unless preventing sheep from mixing up with other owner’s sheep groups.  Must be no less than 2km. |
| Location Accuracy, closeness of a measured location to the real location of the device at the time of measurement [5] | More accurate is better. GPS level accuracy, within 4.9m[6]. | Must not exceed 20m. [after testing, 20 m radius searching area requires efforts and energy makes a person feel tired] |
| Signal persistence. | Longer pulse duration (s) and more frequent the pulse (time/seconds) is better [7]. | Must not be interrupted completely. |
| Signal strength. | Easily perceptible to human.  Not blocked by obstacles.  Not interfering with other signals. | NA |
| Differentiate between sheep that belongs to different owners (finding system) | Identification must be unique to each sheep | NA | Must be able to differentiate each individual sheep, not just two groups of sheep.  Must be able to correctly find the lost sheep among a group of sheep. |

[1] <https://en.wikipedia.org/wiki/Notification_system>

[4] Akella MR, Bang C, Beutner R, Delmelle EM, Batta R, Blatt A, Rogerson PA, Wilson G. Evaluating the reliability of automated collision notification systems. Accid Anal Prev. 2003 May;35(3):349-60. doi: 10.1016/s0001-4575(02)00010-6. PMID: 12643952.

[2] Lahausse, J. A., Fildes, B. N., Page, Y., & Fitzharris, M. P. (2008). The potential for automatic crash notification systems to reduce road fatalities. *Annals of advances in automotive medicine. Association for the Advancement of Automotive Medicine. Annual Scientific Conference*, *52*, 85–92.

[3] Lacson, R., O'Connor, S. D., Andriole, K. P., Prevedello, L. M., & Khorasani, R. (2014). Automated critical test result notification system: architecture, design, and assessment of provider satisfaction. *AJR. American journal of roentgenology*, *203*(5), W491–W496. <https://doi.org/10.2214/AJR.14.13063>

[5] <https://www.mmaglobal.com/files/documents/location-data-accuracy-v3.pdf>

[6] <https://www.gps.gov/systems/gps/performance/accuracy/>

<https://royalsocietypublishing.org/doi/10.1098/rsos.181641>

1. Accessibility
2. Sustainability
   1. Durability

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| Requirement | Durability |
| Metric | Lifetime of design to be 5 to 6 years [1]  Higher performance during tests is preferred |
| Criteria | Device needs to work for a long period without errors and mistakes.  Device needs to use for a long time without broken  Device can work against water and dust |
| Constraint | Past waterproof and dustproof test from IP5 to IP6[2] Past drop test for ANSI/ISEA 121-2018 [3] Working at least two weeks without charging [4] |
| Source | [1] <https://www.iconcox.com/blog/how-long-does-the-gps-tracker-last.html>  [2] <https://atslab.com/environmental-testing/waterproof-testing/>  [3] <https://www.element.com/product-qualification-testing-services/dropped-objects-testing>  [4] <https://www.brickhousesecurity.com/gps-trackers/device-guide/> |

* 1. UNSDG, green materials

1. Safety

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| Requirement | Safety |
| Criteria | Device needs to be safe to use around people and sheep |
| Metric 1  Metric 2 | Noise emitted in use (dB/frequency range)  A smaller stowaway volume is preferred (size) |
| Constraint | The typical hearing range of sheep is from 125 Hz to 40 kHz. Most sensitive at 7 kHz. The device must not operate in those frequencies [1].  Sheep can adapt to noise between 60-90dB. Device should not operate over 90dB [1]. |
| Source | [1] <http://www.cvzv.sk/slju/14_2/8_Broucek.pdf> |
| Requirement | Electrical Safety |
| Criteria | Device cannot cause harm through electrical discharge around people and sheep |
| Metric 1 | Operational voltage |
| Constraint | The operational voltage must not exceed 60V dc or 42.4 V\_peak ac. [1]. This comes from an international standard regarding the safety of handheld electronic devices. |
| Source | [1] <https://webstore.iec.ch/preview/info_iec60950-1%7Bed2.0%7Den_d.pdf> |

1. Portability

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| Requirement | Portability |
| Criteria | Device needs to be easy to move around, and shepherds must be able to use the device over the range of the grazing area (~5km through hilly terrain and villages). |
| Metric 1  Metric 2 | A lighter device is preferred (weight in pounds)  A smaller stowaway volume is preferred (size of dimensions in mm) |
| Constraint | Widget should be under 5.1 pounds if handheld.  Widget should stow away to under 100x125x255mm in size.  Both constraints come from the 2005 US human factors guide for the design of handheld devices. |
| Source | [1]<https://hf.tc.faa.gov/publications/2005-human-factors-guidance-for-the-use-of-handheld/full_text.pdf> |