A Methods Note on Remote Sensing Platforms and Large-Scale Archeological Impact Assessments (AIA) in the Philippines

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Abstract

This short methods note attempts to illustrate how various aerial remote sensing platforms can be utilized in carrying out archeological impact assessments (AIA) on spread-out or large-scale project sites. Cascading remote sensing platforms providing multiscalar (macro, meso, and micro) perspectives are presented in conjunction with the complimentary method of stratified random sampling (SRS). The SRS is informed by a predictive model of where to find archeological sites in the Philippines, even in areas where there are no positive features. This methods note offers the AIA archeologist an efficient and targeted use of limited time and resources following a streamlined workflow process. After carrying out the AIA, further mitigating arrangements can also be undertaken including possible side-by-side monitoring of earthmoving activities by archeologists, and possible recommendation for further revalidations of the initial AIA results.

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Background

Large-scale infrastructure projects (i.e., the construction of highways, expressways, hydroelectric dams, land reclamation, railway systems) in the Philippines are undertaken by the government using taxpayers' money or through the support of foreign aid loans. These projects attempt to comply with the requirement for an AIA at the project sites. The footprint of some of these development projects goes beyond our typical site sizes in research archeology. A railway project, for instance, will cross provincial boundaries, having several hundred kilometers of railway length. An efficient and targeted approach is therefore needed to address such long-span, large-scale projects. Below is a recommendation that capitalizes on the use of remote sensing and geographic information systems (RS-GIS) tradecraft in tandem with stratified random sampling (SRS).

Method

Cascading Multiscalar Platforms

Remote sensing and geographic information systems (RS-GIS) platforms in conjunction with stratified random sampling (SRS) are force multipliers in an AIA due to their ability to access and ability navigate various spatial scales or multiscalar data including the macroscale, mesoscale and micrsoscale data (Figure 1). The macroscale-level data involves the whole project, or the segment/section identified for AIA, and may involve more than one political unit boundary (barangay/municipality/province/county/state). The mesoscale-level data will involve specific sections of the project such as a road segment or railway segment. The microscale will involve the targeted area for test pit excavation, or even a positive feature such as a historical feature within the vicinity of the project.

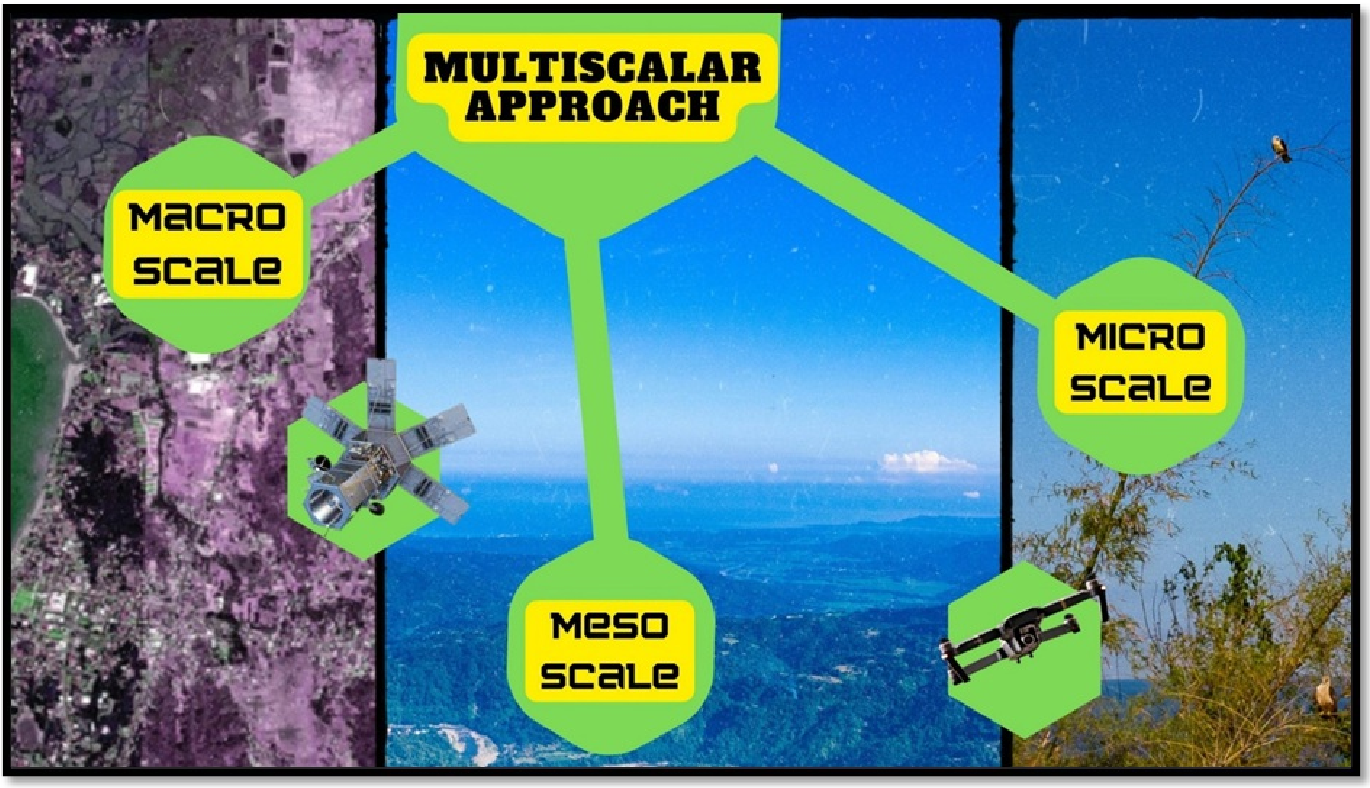

Figure 1. Multiscalar approach integrating aerial platforms including high-resolution multispectral satellites and remotely piloted aircraft systems (RPAS)

The targeting of areas for test pit excavation will be based on the output of a stratified random sampling that is based on a predictive model for archeological sites. Archeological materials that may be recovered from these targeted locations may then be subject to further analysis. The full work process is illustrated in Figure 2. Working parallel to the RS GIS approach is a historical approach that will identify sites that will be subjected to positive feature-based excavation or test pit excavation.

The use of archived and tasked high-resolution imagery satellite data is recommended in order to fill in the requirement for macroscale data. The minimum spatial resolution that allows for the remote sensing of features is a < 2-meter resolution. A sub-meter spatial resolution; however, is highly recommended since this may provide a complementary perspective of the microscale level data that can then be easily compared with remotely piloted aircraft systems (RPAS) data. The mesoscale level data will rely heavily on real-time, immersive use of RPAS. The **best-case scenario** (author's emphasis) is to utilize a suite of RPAS payloads including multispectral sensors, infrared sensors, thermal imaging, and light detection and ranging (LiDAR). If unavailable, the minimum requirement can be easily filled in by a high-resolution, imaging consumer off-the-shelf RPAS (COTS-RPAS). The COTS-RPAS can also provide multiple perspectives at the microscale level depending on flight conditions during AIA operations. In fact, the COTS-RPAS is to be used extensively since this provides higher vantage points that help inform a decision on whether to employ test pit excavations in some localities. The COTS-RPAS serves as the archeologists' putative eyes in carrying out the archeological survey/reconnaissance of the area.

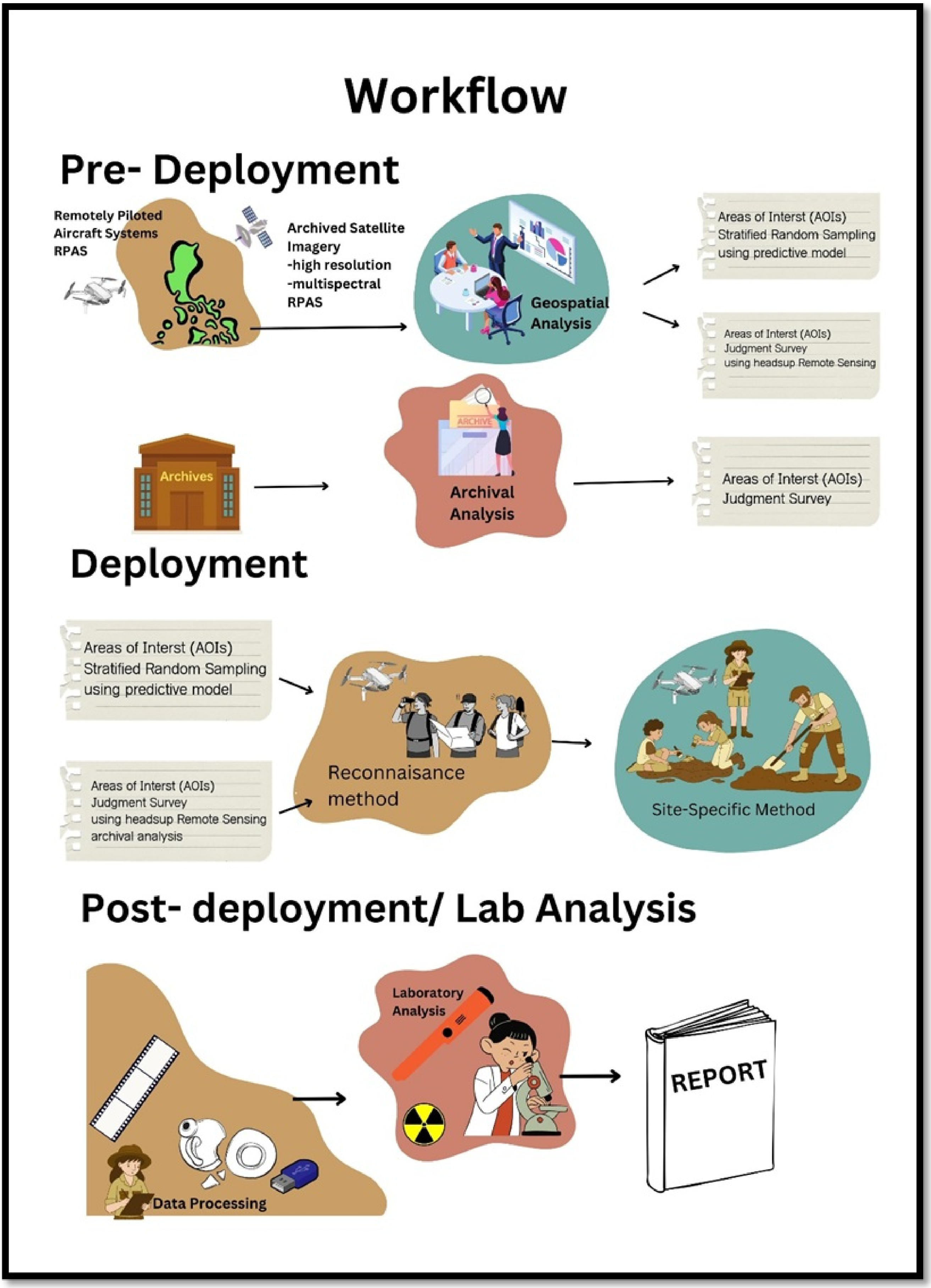

Figure 2. Proposed overall workflow.

Stratified Random Sampling the Predictive Model

The AIA operation should aim to sample the whole universe of archeological sites within the project's spread-out footprint, including known and unknown sites both in the historical and the prehistoric period (see Figure 3). There is also the possibility that known sites are composite sites that must be further investigated. Unknown sites that exist as composite sites can benefit from revalidation AIA to re-assess the period of occupancy of the site. Here I propose to use as a predictive model for archeological sites the generalized model proposed by Bronson (1977) (Figure 4). The model was further elaborated by Junker (2013, 1999) in her work at Tanjay Negros Oriental. The model can also be supplemented by archeological remote sensing works in the Philippines (see Canilao Sarmiento Hilario Rufino 2021, Canilao 2020, Canilao 2018).

In setting up the variables for the predictive model, the first step is to process a digital elevation model DEM of the area to delineate the major rivers and their corresponding drainage basins. The next step is to identify the probability zones for archeological sites within the river dendritic structure, following Bronson (1977). The high probability zone is the river delta estuarine area, the medium probability zone will be slightly upriver, and the low probability zone will coincide with branches further upriver of the river. A shapefile delineating the project footprint is then overlaid on the predictive model, and the resultant intersectional predictive model map (IPMM) is then subjected to a systematic random sampling (SRS) procedure. Constraints in time and resources behoove the AIA archeologist to set a percentage of SRS to be undertaken in the IPMM.

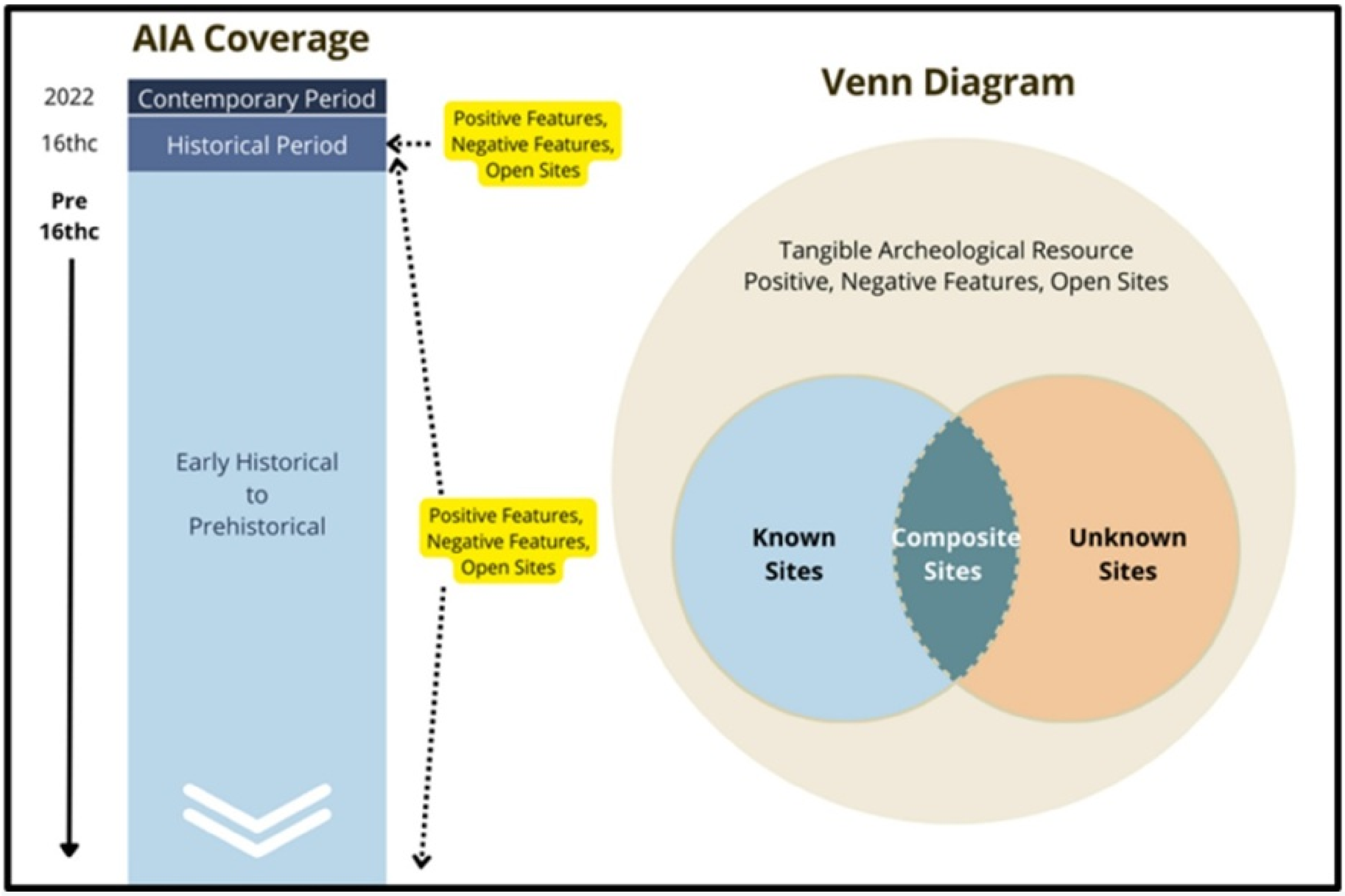

Figure 3. the purported universe of archeological materials in the Philippines

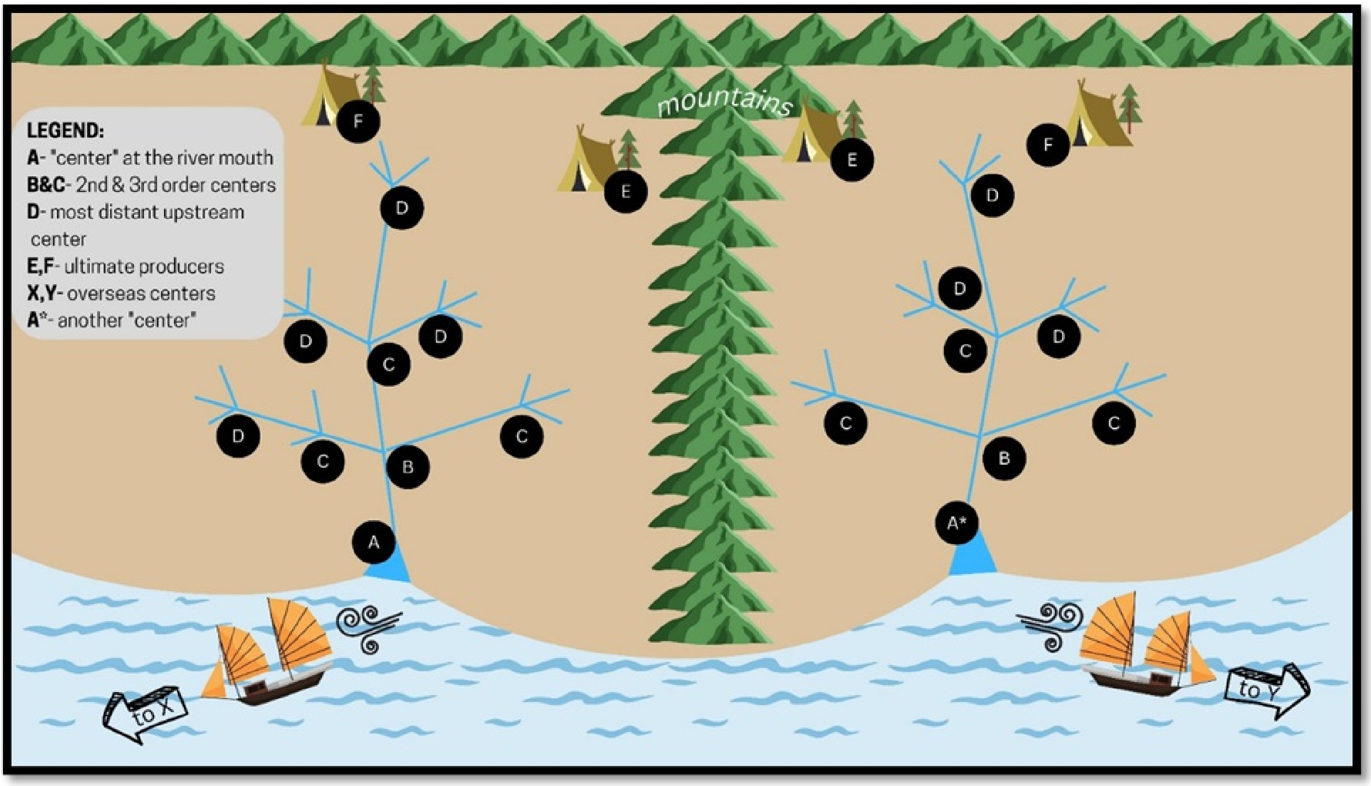

Figure 4. After Bronson's (1977) model of settlement sites. The proposed core model to be used in the AIA predictive modeling

The IPMM final output is principally a map of target locations that will then be the guide to undertaking the archeological aerial survey which then informs possible test pit excavation. Depending on the scope of work of the AIA contract, site discoveries may be subjected to subsequent focused excavations or earmarked for follow-up salvage archeology at a later time.

Heads-up Remote Sensing of the High-Resolution Maps

The high-resolution satellite imagery available in the AIA project will also be analyzed using heads-up remote sensing. In such a procedure, possible archeological features are identified based on some of the remote sensing indicators seen in previous works (see Canilao Sarmiento Hilario Rufino 2021, Canilao 2020, Canilao 2018). These works are specific to remote sensing of *ijang* (fort) locations and archeological trails in smaller island contexts.

Systematic Archeological Aerial Survey

It should be stated at the outset that formal training in RPAS operation with corresponding accumulated flight hours is required in implementing this method. Local RPAS laws should also be consulted by the AIA archeologist. The objective of the systematic archaeological aerial survey (SAAS) is documentation of the meso- and micro-scale context of the target location. The RPAS will undertake both orthogonal documentation (Figure 5) and side-looking documentation with perspectives following the different cardinal directions (Figure 6). The imaging drone will be used to take not only aerial photographs but also aerial videos of the site. The latter will involve two additional flight patterns: the expanding spiral/helix flight pattern (Figure 7); as well as the full-length/full coverage flight over the target location (Figure 8).

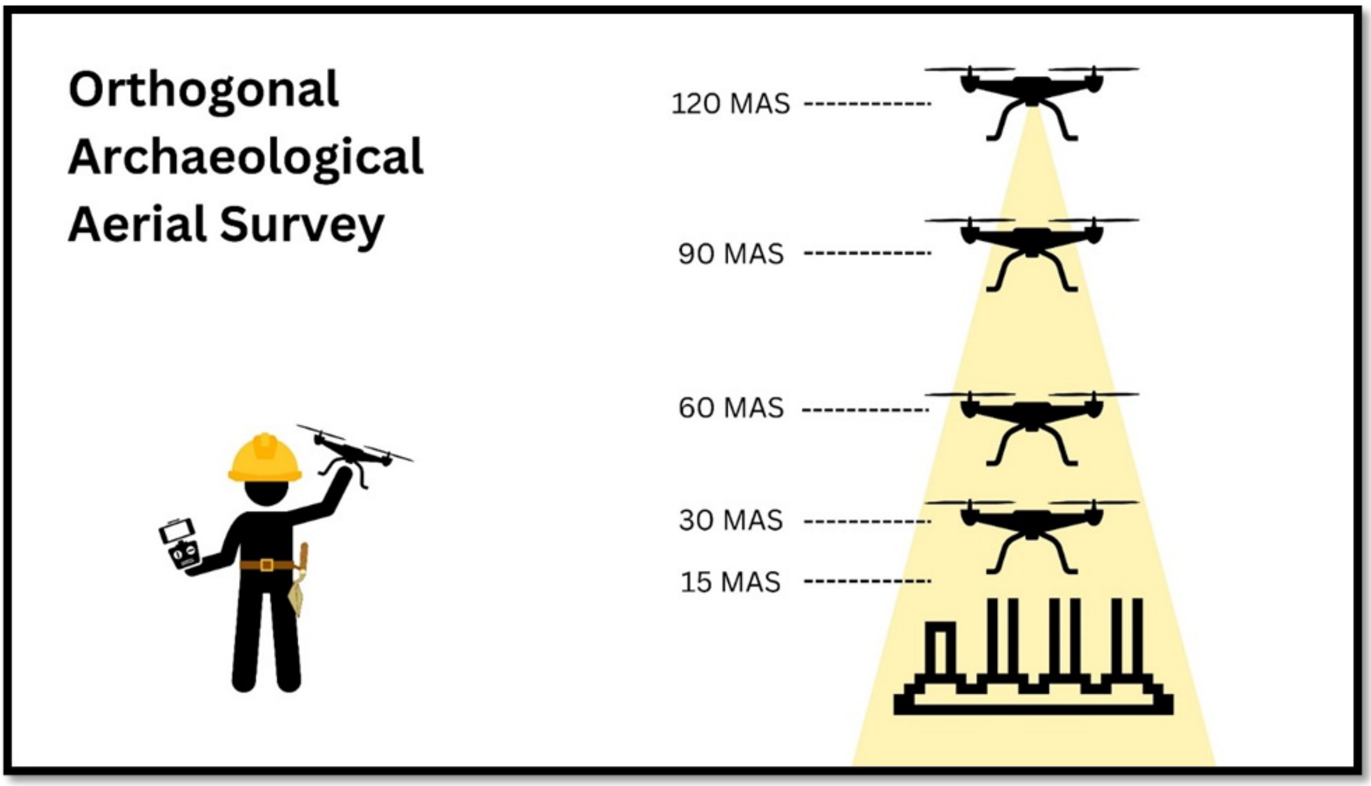

Figure 5. Orthogonal documentation at decreasing altitudes in meters above surface MAS

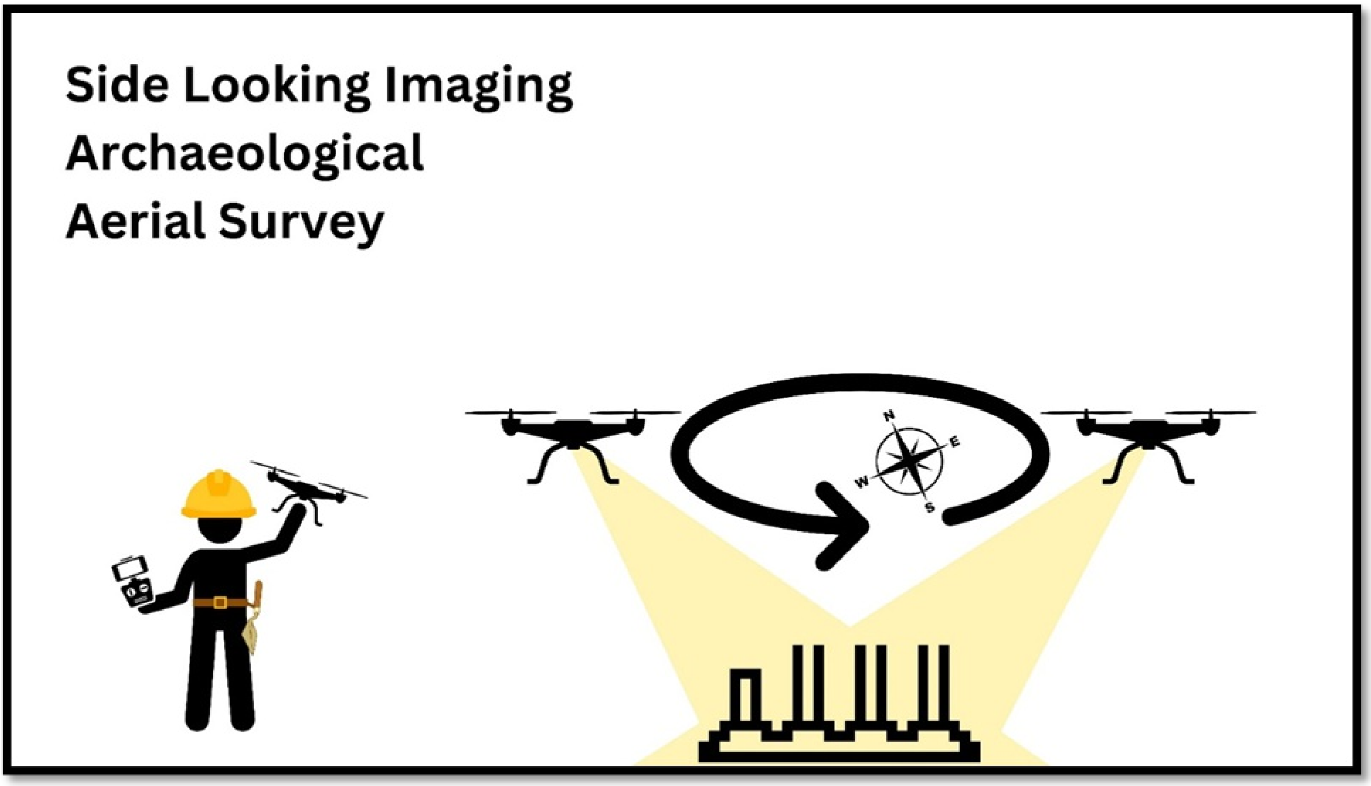

Figure 6. Side-looking imaging following cardinal directions.

Depending on the project footprint, there may also be a need to fly the entire length of the project segment or even close-up documentation of features located in inaccessible areas.

The RPAS display size may allow on-the-spot analysis or there may be a need to immediately export data to be viewed on a good-sized monitor to analyze the aerial photos and videos. This data will then be used to inform decisions on whether carrying out a test pit. Archeological plan and if possible archeological profile drafting of sites can already be undertaken with the RPAS. The use of control points (See Figure 9) is recommended to be able to eoreferenced the resulting RPAS plates and overlay them on the macroscale satellite imageries.

Discussion

The method outlined above has presented a possible approach for undertaking AIA on spread-out, large-scale infrastructure projects. This is a bare minimum, although the scope of work in the contract may be negotiated to include further sampling runs, revalidations, or even on-the-spot monitoring of the actual earth-moving activities. At the very least, this method would guarantee a dipstick into the plethora of archeological sites that may be impacted by the project (the known and the unknown; pre-contact and contact sites). Total excavation, which entails completely peeling off the stratigraphic layers that may contain archeological materials up to the putative bedrock is a utopian endeavor. Instead, we should aim for a sound sampling procedure that is guided by a predictive model and further supplemented by RS-GIS methods.

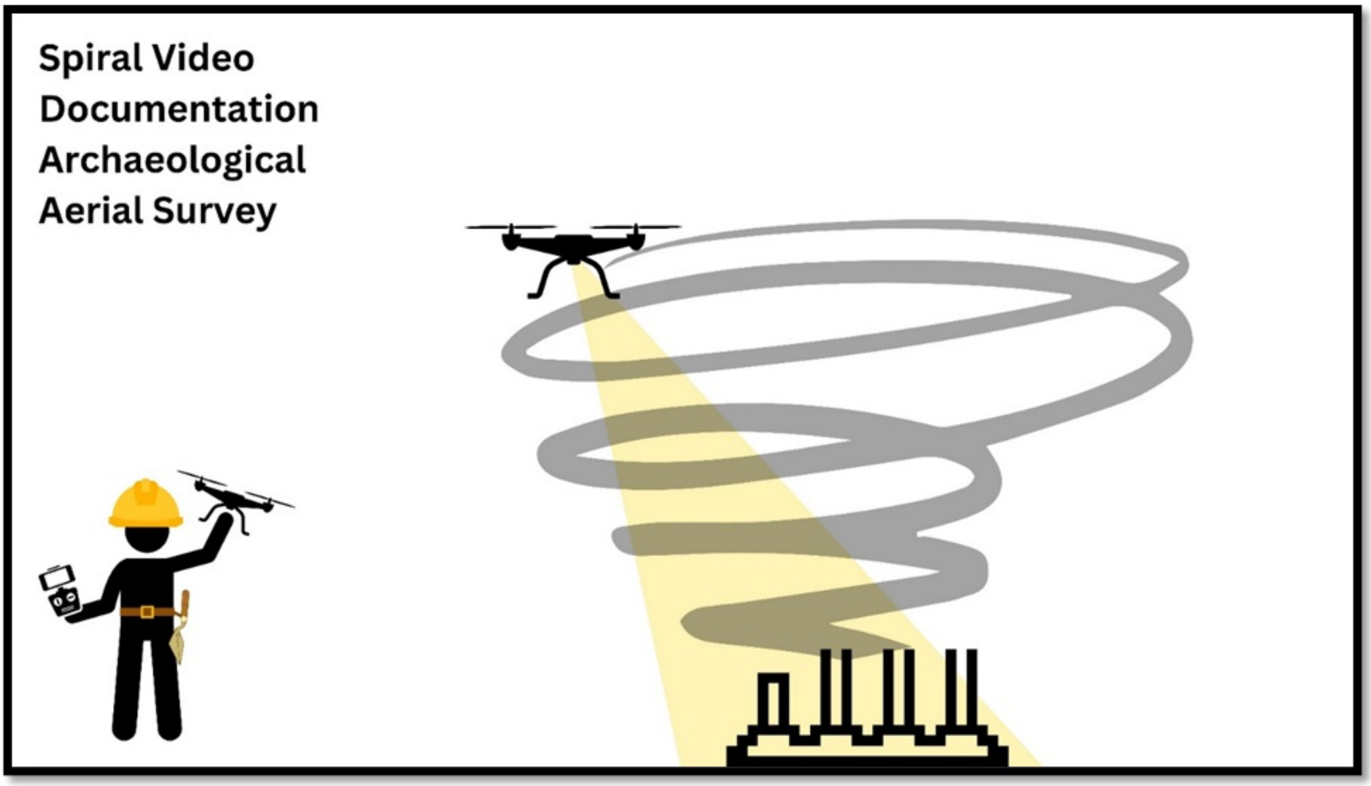

Figure 7. Expanding spiral/helix flight pattern in video documentation.

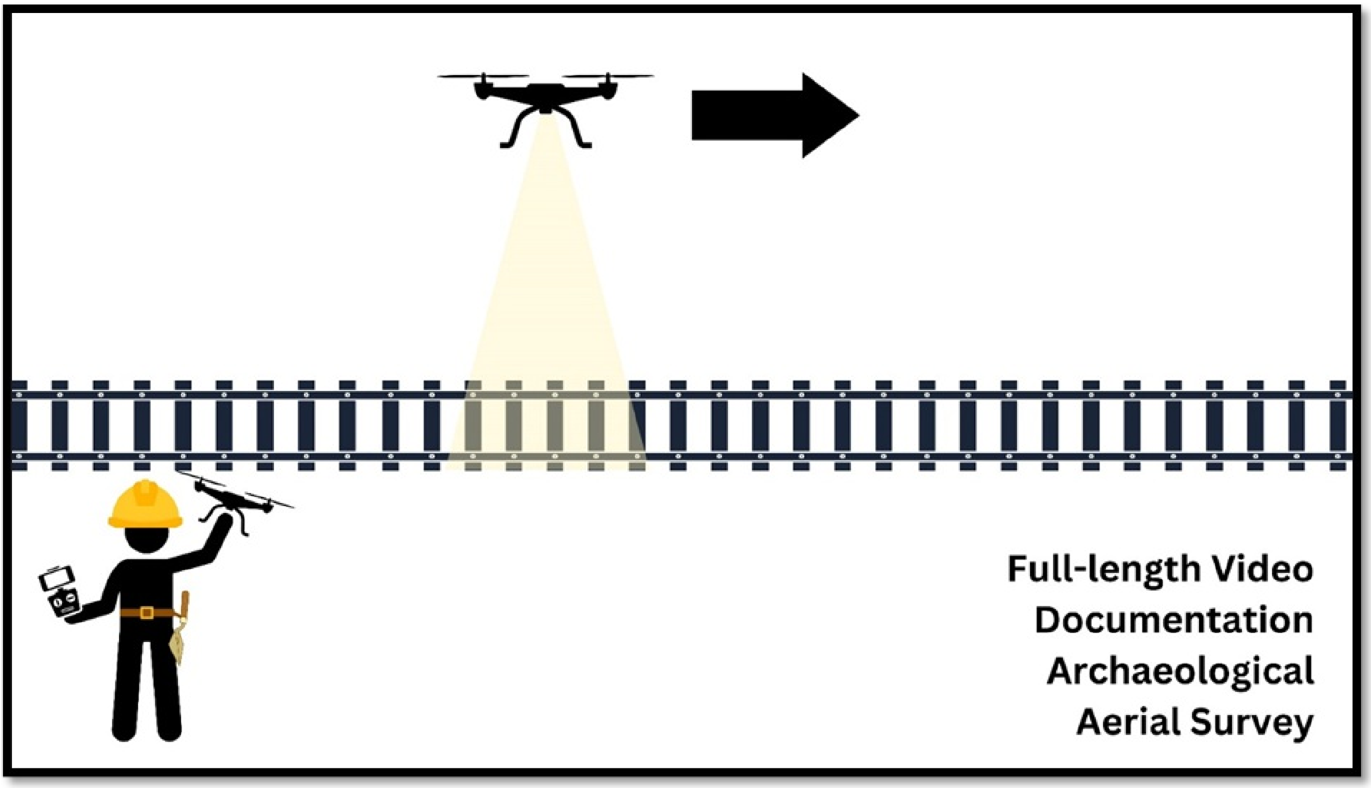

Figure 8. Side-looking imaging following cardinal directions.

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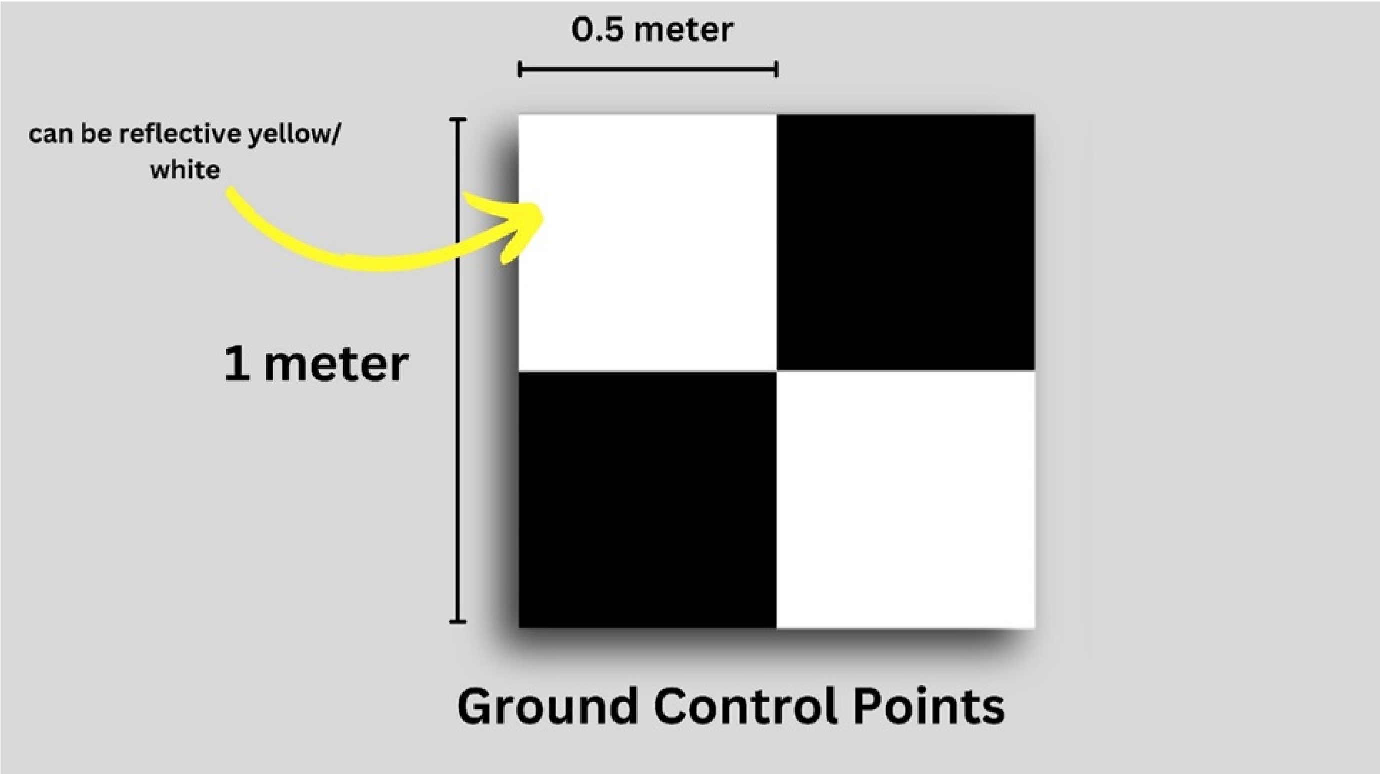

Figure 9. Example of a ground control point (GCP) to use in an archaeological plan and, if possible, profile drafting.

recommendation for archeologists to be present to monitor the actual earthmoving activities should also be made.

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