# Efficacy of Mobile Mapping Technology for the June Area Survey

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**Abstract**

Each year, the National Agricultural Statistics Service (NASS) conducts the June Area Survey (JAS). The JAS, one of the largest annual surveys NASS conducts, collects detailed information on farms and ranches within the United States. The JAS is based on an area sampling frame, consisting of all land in the continental United States, stratified by state and land use. The sampling unit is a segment of land (about one square mile). Within the segment, basic data are collected for each unique land operating arrangement, which is called a tract. For agricultural tracts, detailed data are collected for every field within the tract. Currently, field enumerators use a 24" x 24" aerial photograph to outline all tracts and fields in the segment, collect the basic data via a paper questionnaire, and then collect the detailed data for all agricultural tracts via another paper questionnaire. Since NASS is collecting questionnaire data for many surveys using Computer Assisted Personal Interviewing (CAPI) via an iPad, the agency started exploring how to fully integrate the JAS with this technology. Working with Iowa State University, NASS developed a prototype mobile mapping instrument that would replace the aerial photograph and the field-level questions on the detailed paper questionnaire. This prototype was tested in the field for several years; enhancements were made based on feedback from the field enumerators and the need to reduce the time it took to outline tracts and fields on the map. This paper provides an assessment of the mobile mapping instrument's use in the JAS.

**Keywords:** agriculture; area frame; mobile mapping; iPad.

## 1. Introduction

The National Agricultural Statistics Service (NASS) is a statistical agency within the United States Department of Agriculture (USDA). NASS's mission is to provide timely, accurate, and useful statistics in service to United States (U.S.) agriculture. To successfully accomplish the agency's mission, NASS conducts hundreds of surveys every year and publishes numerous reports covering virtually every aspect of U.S. agriculture. Some examples of areas covered in NASS's reports are production and supplies of food and fiber, prices paid and received by farmers, farm labor and wages, farm income and finances, chemical use, and demographics of producers.

One of the largest annual surveys conducted by NASS is the June Area Survey (JAS), which collects detailed information on farms and ranches within the U.S. The JAS is based on an area sampling frame, consisting of all land in the continental U.S., stratified by state and land use. This survey is different from other NASS surveys because the field enumerators collect field-level data using a 24" x 24" aerial photograph in addition to a paper questionnaire. The enumerators outline the unique land operating arrangements and all fields on the aerial photograph and collect the field-level data via a questionnaire.

After three years of development, in 2012, NASS augmented their data collection strategy with Computer Assisted Personal Interviewing (CAPI). The implemented CAPI system leveraged private cloud technology, broadband transmission, and the use of Apple iPads for data entry (without storing data on the hard drive to protect the respondents' data). NASS equipped the field enumerators with

Apple iPads and trained them on how to use this technology. The electronic questionnaires were phased-in over time, and CAPI data collection is now available for most surveys.

In 2012, NASS partnered with Iowa State University's Center for Survey Statistics and Methodology to develop a prototype mobile mapping instrument for the JAS (Gerling et. al, 2015). The goal of the instrument was to convert the 24" x 24" aerial photograph and field-level paper questionnaire to electronic format. The prototype was tested in the field for several years by well-trained enumerators; enhancements were made based on feedback from the field enumerators as well as the need to reduce the time spent outlining the unique land operating arrangements and fields. This paper provides an assessment of the mobile mapping instrument's use in the JAS.

## 2. NASS's Area Sampling Frame

NASS maintains an area sampling frame, which consists of all land in the continental U.S. The U.S. is divided into 50 administrative areas called states and a state is further divided into administrative areas called counties; the number of counties within a state varies from three to 254. Within a state, NASS cartographers use satellite imagery, aerial photography, crop-specific land cover data, county highway maps, etc. to categorize all land into strata defined by the percentage of cultivated land (see Table 1). Within a state, stratum, and county (when possible), they electronically identify (i.e., digitize) the primary sampling units (PSUs) using physical boundaries and other features on the ground such as roads, rivers, railroads, etc. After the sample PSUs are selected, they are subdivided into similar-sized segments of about one square mile (or 640 acres). These segment boundaries also follow physical or natural boundaries such as roads, creeks, ditches, edges of fields, tree lines, etc. A segment is randomly chosen from within each sampled PSU (see Figure 1). Note that this process does not divide non-selected PSUs into segments, thereby saving money and staff resources. Within a state, a new area frame is developed about every fifteen years.

**Table 1: Strata definitions for the state of Pennsylvania**

| Stratum Number | Stratum Definition |
|---|---|
| 13 | ≥ 50% cultivated land |
| 20 | ≥ 15% and < 50% cultivated land |
| 31 | Urban: 100+ homes per square mile |
| 32 | Commercial: 100+ homes per square mile |
| 40 | > 0% and <15% cultivated land |
| 50 | Non-agricultural |

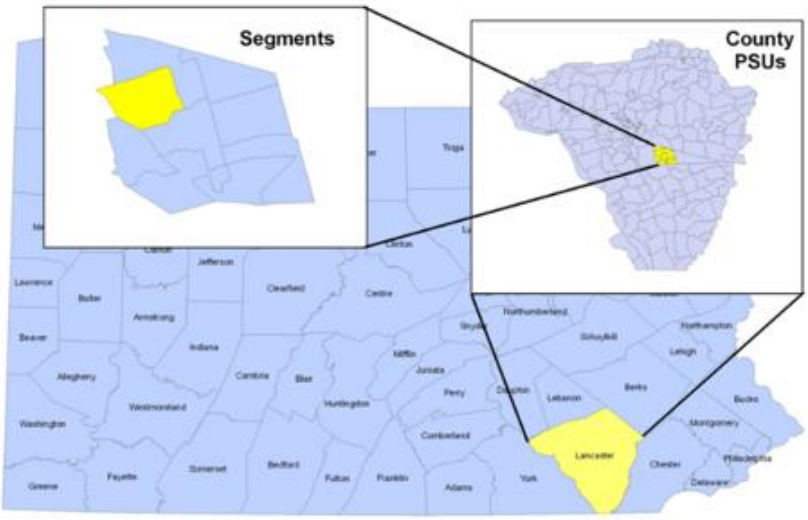


**Figure 1: Example of the area sampling frame in the state of Pennsylvania**

## 3. NASS's June Area Survey (JAS)

The JAS sample is selected from NASS's area sampling frame, and the sampling unit is a segment of about one square mile. In the JAS sample design, segments are typically in the sample for five years, and approximately 20% of the segments are replaced with new ones each year. This sample design avoids the extra expense of selecting a completely new area frame sample each year. In addition, the rotation scheme provides a reliable measure of change in the production of agricultural commodities from year-to-year while attempting to reduce respondent burden.

Prior to data collection, the field enumerators are provided with a 24" x 24" aerial photograph of the sampled segment (outlined in red in Figure 2). They use a blue grease pencil to outline each unique operating arrangement, which is referred to as a tract, and each tract is assigned a letter (see Figure 2). Basic data are collected via a paper questionnaire and the tracts are classified as either agricultural or non-agricultural. For agricultural tracts, the field enumerators use a red grease pencil to outline all fields within the tract and each field is assigned a number (see Figure 3). Detailed data are collected via a paper questionnaire for every field within the tract.

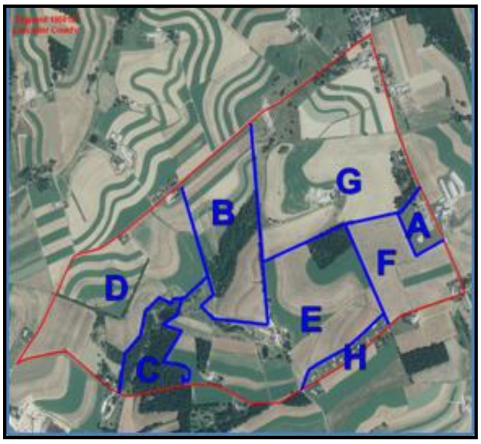


**Figure 2: Within the segment, eight tracts are outlined in blue and labeled with letters.**


**Figure 3: Within agricultural tract F, four fields are outlined in red and labeled with numbers.**

## 4. Prototype Mobile Mapping Instrument

As stated earlier, NASS partnered with Iowa State University's Center for Survey Statistics and Methodology to develop a prototype mobile mapping instrument for the JAS. The goal of the prototype was to convert the 24" x 24" aerial photograph and field-level paper questionnaire to electronic format. Some potential benefits include elimination of printing and mailing costs for the aerial photographs and survey questionnaires, improved data quality with automated edit checks, and more time to collect the JAS data (i.e., the field enumerators can electronically submit the materials rather than mailing them to the data processing center).

The prototype mobile mapping instrument is a web application designed to run within the Safari browser on an iPad without an Internet service provider (ISP). It is essential that the instrument operate without an Internet connection because rural agricultural areas tend to have intermittent or no signal. This means the field enumerators are required to run a cache routine when they have a wireless broadband connection so the required imagery is downloaded into the iPad's memory. During data collection, if wireless broadband is available, the instrument transmits the data to the web server as it is entered or modified by the field enumerator. If a connection is not available, the data are stored in the iPad's memory until a wireless broadband connection becomes available. Different colors are used to indicate whether the data have been stored locally on the iPad, saved to the web server, or both.

The prototype mobile mapping instrument has two main parts (see Figure 4): the digital aerial imagery is displayed on the left side of the screen, and the field-level electronic questionnaire for each tract is displayed on the right side of the screen. The instrument has the option of enlarging the digital aerial imagery to full screen mode. During data collection, the field enumerators identify the tract and field boundaries in the digital aerial imagery (rather than on a 24” x 24” aerial photograph) and enter the field-level data into the instrument (rather than on a paper questionnaire). The field boundaries are captured as polygons with the field-level data linked as attributes; the instrument also calculates and stores a GIS acreage for each polygon.

The prototype mobile mapping instrument contains a wide range of GIS tools and features. It is capable of presenting additional resource material using Web Map Service overlays. This means the digital aerial imagery can be replaced with another layer such as road maps, which is helpful in identifying the tracts and fields in the digital aerial imagery. A geolocation feature was also included to assist the field enumerators in pinpointing the location of the segment (see Figure 5).

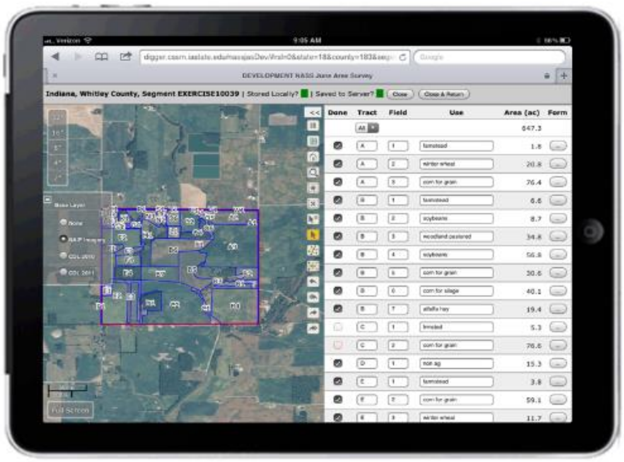


**Figure 4: Mobile mapping instrument**

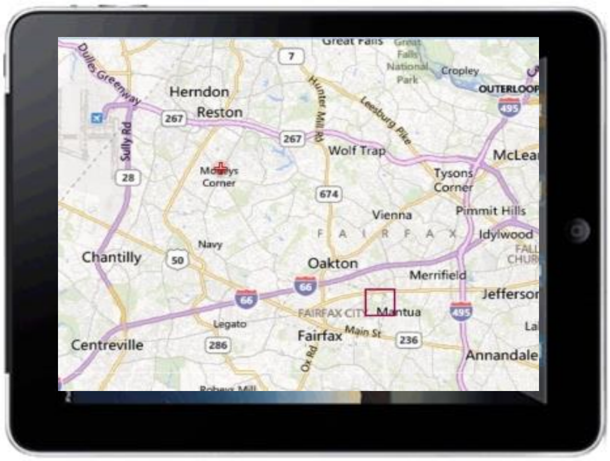


**Figure 5: Geolocation feature**

The various tools within the digital aerial imagery were created with OpenLayers, which is an open-source JavaScript mapping library and provides basic web and GIS functionality. The prototype mobile mapping instrument requires the field enumerator to “split” a segment into tracts and fields, instead of outlining them. Splitting ensures that all land parcels are included within the segment boundary. The split tool was integrated into a toolbar on the OpenLayers map in the instrument. A merge tool was also developed for updating/correcting errors made when splitting. Several additional tools were added to the OpenLayers map, including zoom tools, selection tools, and undo/redo buttons to make it more user-friendly. The mobile mapping instrument has touch screen pinch-to-zoom capabilities and also includes buttons to quickly zoom to preset levels.

## 5. Data Collection Challenges

The field enumerators were already familiar with entering data into an electronic questionnaire via the iPad, but they required training on the functionality of the mobile mapping instrument’s digital aerial imagery. A comprehensive training program needed to be created for the field enumerators and a two-step approach was adopted. The training took a significant amount of time – a total of 32 hours. For the first module, the field enumerators completed an independent training course where they read through a manual, viewed instructional videos, and completed practice exercises designed to teach them the basic fundamentals of the instrument. For the second module, the field enumerators attended a training workshop that included presentations and discussion of more complex functions of the instrument along with practicing mock interviews using the iPad. Since the JAS is only conducted annually, this training, or a condensed version of the training, will be necessary every year and thus increase the survey's "start-up" cost (although this will be negated by other cost savings).

As stated earlier, a geolocation feature was included in the prototype mobile mapping instrument to assist the field enumerators in pinpointing the location of the segment. During testing, several field enumerators reported that this feature timed out and caused the instrument to malfunction. After further research, it was confirmed that the geolocation feature could fail in rural areas with poor cellular coverage so it was removed before performing additional testing of the instrument.

During testing, the field enumerators reported that the iPad touch screen was sometimes unresponsive when working with the digital aerial imagery; in particular, when identifying the tract and field boundaries. After further investigation, it was confirmed that the iPad's touch screen was unresponsive if the user's finger wiggled when pressing a button. This problem was not detected prior to testing because the instrument was assessed while the iPad was on a stable surface (e.g., table) and not while the iPad was being held. The instrument's sensitivity to slight finger movements was changed so that the touch screen was more responsive.

By far, the largest challenge was ensuring the time spent outlining the tract and field boundaries was about the same using the digital aerial imagery in lieu of the aerial photograph. With the initial prototype, the field enumerators spent significantly more time performing this activity. Since the merge tool was much quicker than the split tool, pre-delineated field boundaries were added to the digital aerial imagery (Abreu et. al, 2016). NASS cartographers created these boundaries by intersecting the JAS segments with USDA-certified polygons and then outlining fields in blank polygons by employing the same products used to create the area sampling frame. Figure 6 shows a JAS segment without and with the pre-delineated field boundaries. With this enhancement, the field enumerators spent about the same amount of time identifying the boundaries in the digital aerial imagery when compared to the 24" x 24" aerial photograph.

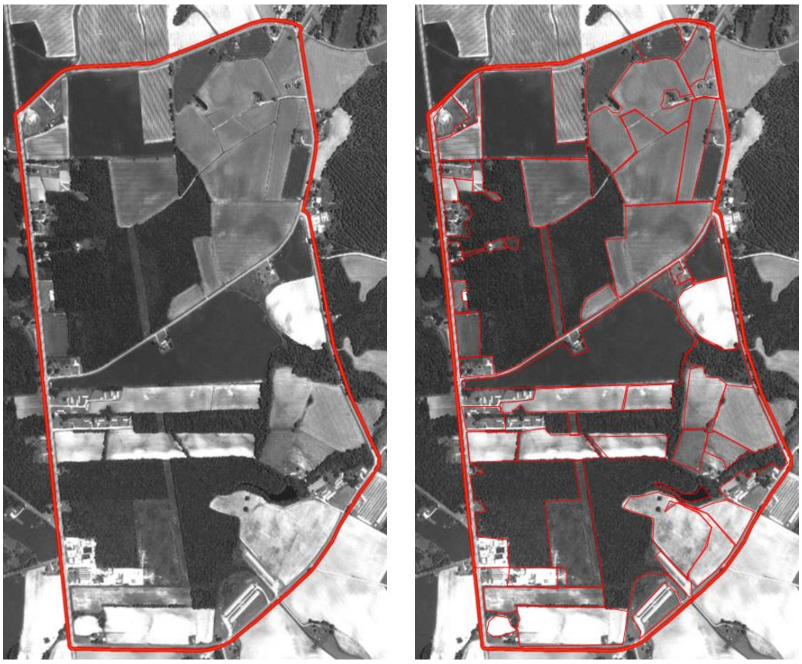

**Figure 6: JAS segment without and with pre-delineated field boundaries**

During testing, the field enumerators reported that glare, especially in bright sunlight, hindered their ability to collect data via the iPad. This issue was expected because it was already identified by field enumerators when NASS implemented CAPI data collection. In an attempt to reduce the visibility issue, two modifications were made to the mobile mapping instrument (Lawson et. al, 2015). First, the red outline of the segment boundary was increased in width to better distinguish it from the roads. Second, the invert colors option within the iPad was utilized which allowed the field enumerators to change the color of both the electronic questionnaire and the digital aerial imagery.

**6. Conclusions**

Most survey questionnaires within NASS are available electronically via CAPI data collection. The JAS is different from other NASS surveys because the field enumerators collect field-level data using a 24” x 24” aerial photograph in addition to a paper questionnaire. The goal of the prototype mobile mapping instrument was to convert the 24” x 24” aerial photograph and field-level paper questionnaire to electronic format. The prototype was thoroughly tested and enhancements were made based on feedback from the field enumerators. The largest hurdle to overcome was ensuring the time spent outlining the tract and field boundaries was about the same using the digital aerial imagery in lieu of the aerial photograph. This solution along with the necessary additional field enumerator training will increase the survey’s “start-up” cost. However, costs should be saved in other areas, such as the elimination of printing and mailing the aerial photographs and survey questionnaires. The field enumerators will have more time to collect the JAS data because they can electronically submit the materials rather than mailing them. In the future, automated edit checks can be incorporated into the instrument to improve the data’s quality. The mobile mapping instrument was deemed successful for the JAS; both the prototype and lessons learned will be utilized to develop an optimal solution which interfaces with NASS’s current CAPI system.

**7. Acknowledgements**

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**8. References**

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