II.22 Aircraft Guidance for Grasshopper Control on Rangelands

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Guidance methods and systems for aerial application have evolved throughout the years from the most rudimentary to the most sophisticated. The purpose was to provide aircraft guidance for the proper distribution of agricultural chemicals to field crops. In order to achieve this, pilots had to develop a method of guiding the aircraft over the ground.

Initially the pilot attempted to fly evenly spaced passes over the field by free-flying—visually estimating the distance between passes. This procedure was not accurate, and better methods were developed as time went by. Free flying is still in use, but only on smaller fields, where it is easier for the pilot to estimate the distance between passes and keep track of the number of passes. The following is a list of guidance methods/systems in the approximate chronological order that they were developed and a brief description of each.

Flaggers

Ground personnel waving flags guide the aircraft. The flagger indicates to the pilot the starting point for each pass. When the aircraft is properly lined up, the flagger steps off the required distance to get in position for the next pass. There may be one or two flaggers—one flagger at one end of the field, or one at each end. Long runs may require multiple flaggers. Flags are easy to see because of their waving motion, and this method is more accurate than free flying. Multiple flaggers may vary distance and introduce error when stepping off the spacing between passes and cause skips.

Kytoons

Ground personnel holding kytoons (tethered balloons) guide the aircraft much the same way flaggers do. This method is useful when there are visual obstructions, such as trees, buildings, or terrain, and where long runs are required. Some disadvantages of this method are that kytoons tend to get out of control under certain meteorological conditions that cause the balloons to dive into or have their tethers get tangled in trees. There are also safety hazards involved, such as collisions with the aircraft and contact with electrical power-lines.

Mirrors

Ground personnel using mirrors to flash reflected sunlight at the pilot guide the aircraft. The pilot flies toward the flashing light. This method is especially effective on long passes over flat terrain with few or no landmarks since the flashes are visible over long distances. Two disadvantages of using mirrors are that they are difficult to aim when there is a large angle between the sun and the aircraft, and they won’t work if clouds block the sun. An alternate backup guidance method would be required during these conditions.

Automatic Flagman

This system consists of a mechanical device attached to the upper inboard area of the aircraft wing. The equipment is loaded with paper flags or streamers that the pilot releases at the end of each pass to assist in establishing the next pass. This system is used independently or to supplement other guidance methods.

Smoker

In this guidance system, the pilot releases a puff of smoke into the airstream by injecting a small amount of paraffin oil into the aircraft exhaust system. This procedure enables the pilot to mark the last pass momentarily in order to set up for the next one, much as with the Automatic Flagman. The Smoker also assists the pilot in determining wind direction and drift. This system supplements other methods of guidance but is not useful when winds displace the smoke while the pilot makes the turn for the next pass.

LORAN-C

LORAN (an acronym for LOng RAnge Navigation) is a radio navigation system that uses time-synchronized pulsed signals from ground transmitting stations spaced several hundred miles apart. The stations are configured in chains of three to five that transmit with the same time-synchronized signals. Within each chain, one station is designated as the master, and the remainder are secondaries.

An aircraft-mounted LORAN-C receiver converts the "time difference" between the arrival of radio signals from the master and the secondaries into latitude/longitude coordinates. Navigational values such as distance and bearing to the treatment area are computed from the aircraft's present latitude/longitude (geographic location).

A computer software program called GRIDNAV provides aircraft guidance to the pilot during aerial application. The pilot enters the geographic coordinates for the first pass plus the desired swath width into the program before leaving on the mission. The GRIDNAV software automatically provides directional and spacing guidance for each pass and keeps track of the number of passes during the aerial application operation.

This system eliminates the need for ground personnel. Mountainous terrain, mineral deposits, and position of the aircraft with relation to the stations can affect the precision of the system. LORAN-C is unsuitable for applications that require swath widths of less than 60 ft. The system is especially useful for releasing sterile insects where swath width is much wider and accuracy less critical.

Global Positioning System (GPS)

GPS is a location system based on a constellation of satellites orbiting the Earth at high altitude. The Department of Defense developed GPS for military operations, and the system proved itself during the Gulf War in 1992. GPS presently is the most accurate navigational system in the world.

Geographic position is developed in much the same way as with LORAN-C. One difference is that GPS operates in three dimensions because the transmitting stations are satellites and are not located on the surface of the Earth. The distance between several satellites and the aircraft-mounted GPS receiver is measured by highly sophisticated equipment and converted to geographic coordinates.

Although GPS is still in a developmental stage for agricultural use, it is capable of providing aircraft guidance for aerial application in the same manner as LORAN-C. This system also eliminates ground personnel and is not affected by the physical conditions that affect LORAN-C. However, it must maintain line-of-sight contact with the satellites being used. A position error of 60–100 ft can be expected under normal conditions and can be reduced to 3–6 ft or less with differential correction. Differential correction is accomplished by placing a GPS receiver base unit at a known location and using it to determine exactly what errors the satellite data contain. The base unit then transmits an error correction to the GPS receiver in use, which can use that information to correct its position. A disadvantage of this system is that it requires an additional stationary receiver placed at a known location in order to achieve maximum accuracy.

GPS will expand its use for agricultural applications and already has proven its accuracy and use in rangeland grasshopper and cotton boll weevil control programs in the United States.

Conclusions

Aircraft guidance for aerial application has made significant progress through the years. The trend has been toward greater accuracy and the elimination of ground personnel. Eliminating the need for ground personnel also reduces the exposure of humans to pesticides. Accuracy is very important in reducing damage to the environment and to threatened and endangered plant and animal species.