SYSTEM OF REGISTRATION DATA AND QUALITY INCREASING OF CROP DUSTING DURING AVIATION CHEMICAL WORKS

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Abstract. Aviation chemical works need a system that will be able to indicate optimal way and save data about the crop dusting according with weather conditions and flight parameters. Chemical mark depends from many factors but most important of them are crosswind, airspeed and altitude. Airspeed and altitude can be defined by means of board instruments which have digital output. Direction and speed of wind have to be calculated by using of data from GPS, airspeed device and 3D-axis pointer of magnetic field. All those data calculate in special controller according with model of dusting. The directional indicator of controller shows to the pilot optimal parallel tracks during crop dusting. GPS or DGPS allows attaching calculation data to map of fields and controller save data and then translating to owner of fields. This system allows spreading the droplets more regular and decreasing harm of chemical works.

Keywords. Chemical works, Crop Dusting.

1 Introduction

At present GPS-based systems are used more widely in agricultural works. Parallel tracking system is particular of these systems. They are designed for vehicle parallel driving in various sow, plow and crop dusting works. Requirements for crop dusting systems are more soft than for other works and sphere of application of these systems is limited by land vehicle because they has small speed of positioning.

Aviation chemical works need a system that allows showing the direct of movement and recording the data of air vehicle with sufficiently high speed and accuracy. There are many means that allow raising precision. One of them is using differential correction. However, wind is important factor that have an influence on accuracy of chemical substance bringing and it isn't considered by systems that used in crop dusting.

2 Main Problem

2.1 Influence of the crosswind

Tracks of liquid drops accumulating without crosswind have appearance that is showed on figure 1, a. Distribution of drops accumulating with crosswind influence is sufficiently changing and looks as showed on figure 1, b.

Crosswind introduces significant changes of dusted area and it position of spot relatively track of aerial vehicle movement.

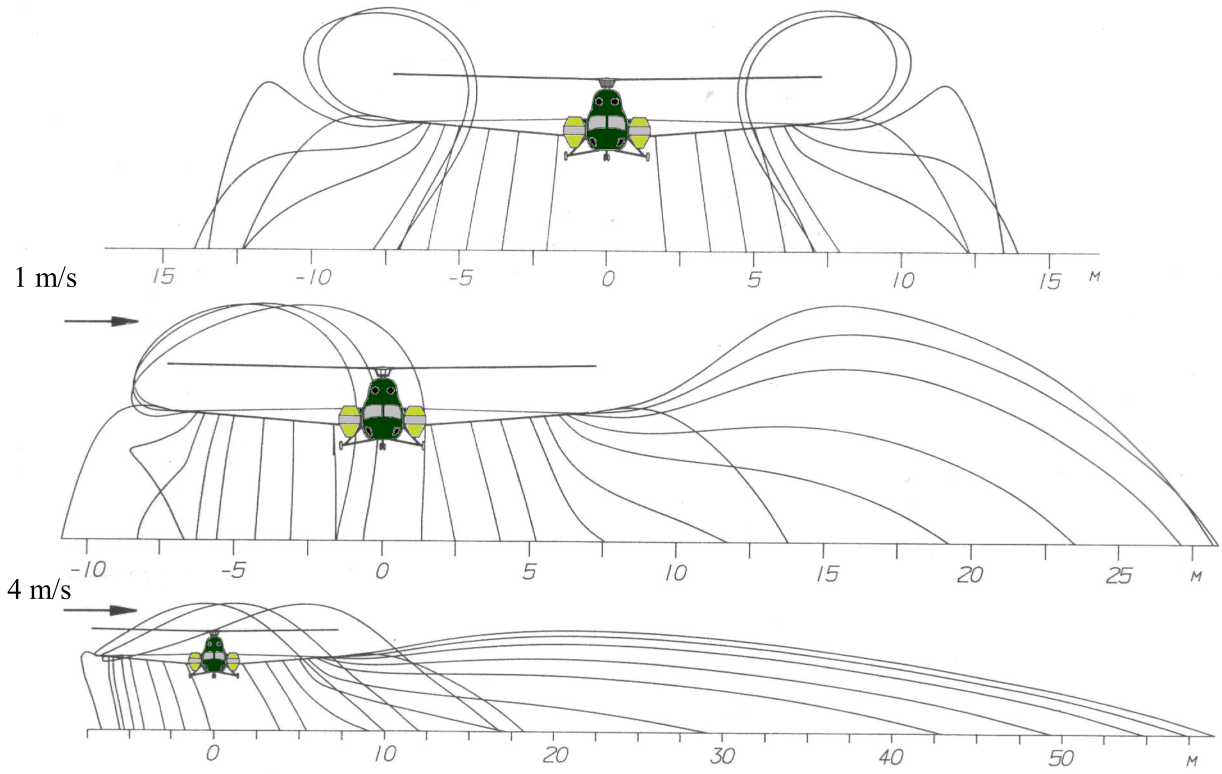

Figure 1: Example of calculated trajectory of middle droplets for Mi-2 agricultural helicopter

The pilot has possibility to take an influence on quality of territory processing with utilization of suggesting system. The system tracks the direction and strength of crosswind, calculates receiving data according with model of droplets movement and gives pilot data. Changing orthogonal multiplier has to change the trajectory of spraying. Influence of cross wind on dusting area is showed on figure 2.

Too much or losing spot of dusting area don't appear during right equidistant movement and constant crosswind level. Drift and distortion of spot width would be case of crosswind value changing and absence of wind correction. It provides double density or losing of dusted area (fig. 2, 3). Mistakes of dusting are present also even in the case of wind correction, but size of spoiling area is less (fig. 2, 2).

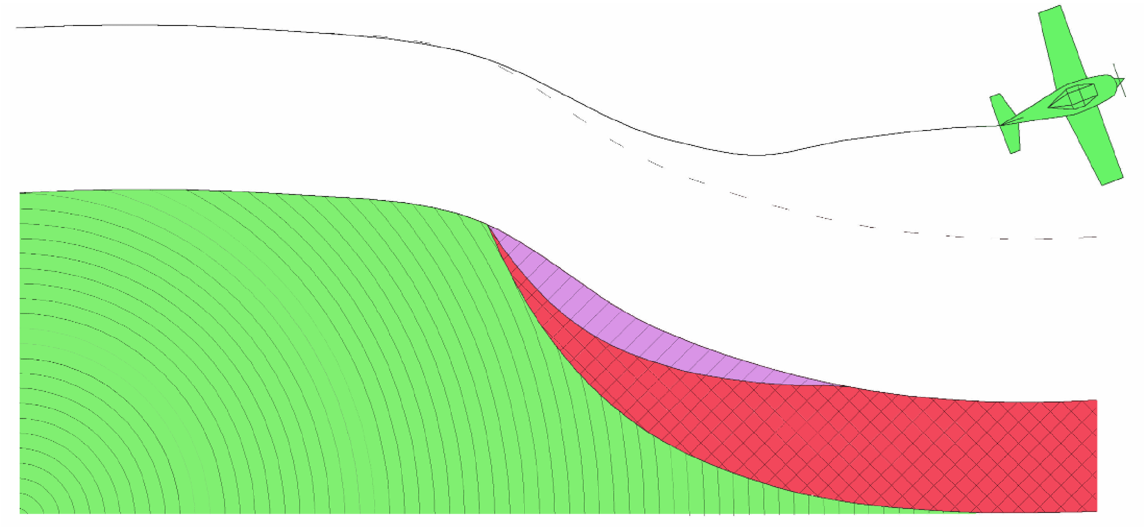

Figure 2: Agricultural aerial vehicle motion during crop dusting with changing of crosswind

2.2 The method of calculation of strength and direction of the crosswind

Many parameters have a sufficient influence on drops behavior in air among them:

- airspeed of aerial vehicle;
- altitude;
- direction and speed of crosswind;
- size of droplets of chemical substance.

Direction and strength of crosswind are defined by angle of drift (see fig. 3).
For angle of drift measuring it is necessary to calculate difference between azimuth and magnetic course:

$$\alpha = M - \psi \tag{1}$$

where α - angle of drift;
M - magnetic course;
ψ - azimuth.

After angle of drift calculation it is possible to estimate strength and direction of crosswind. The module of crosswind speed vector is calculated in the following way:

$$|W| = \sqrt{|V_{gps}|^2 + |V_{air}|^2 + 2 \cdot |V_{gps}| \cdot |V_{air}| \cdot \cos(\alpha)} \tag{2}$$

where W - crosswind strength vector;
V_{gps} - GPS speed vector;
V_{air} - airspeed vector

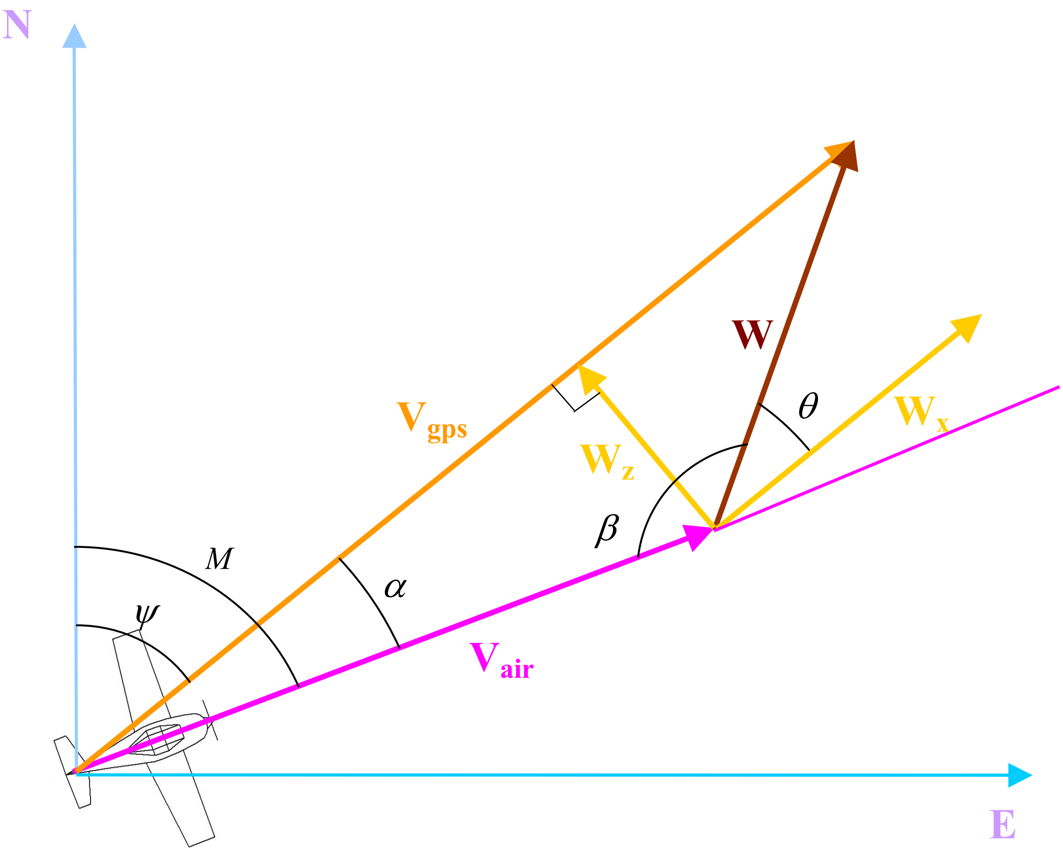

Figure 3: Vectors of aerial vehicle during moving with wind

After that it is necessary to calculate angle between airspeed vector and crosswind strength vector:

$$\beta = \arccos\left(\frac{|V_{air}|^2 + |W|^2 - |V_{gps}|^2}{2 \cdot |V_{air}|^2 \cdot |W|^2}\right) \tag{3}$$

If these values are calculated, there is no difficulty to estimate the angle of deviation of crosswind strength vector from azimuth:

$$\theta = 180 - \beta - \alpha \tag{4}$$

Multipliers of crosswind vector are defined by the following formula:

$$W_x = |W| \cdot \cos\theta \tag{5}$$

$$W_z = |W| \cdot \sin\theta \tag{6}$$

Airspeed is measured by on board system of air signals, speed of motion is measured by satellite navigation system (GPS), and size of droplets is defined by duster parameters. Use these methods the system computes required track of motion and saves statistics of field processing. Control of duster system is possible in the case of presence of chemical substance flow regulator. It allows to do equal spraying.

High frequency defining of speeds rates of and angles necessary for calculating of crosswind influence of by offering method it is to calculate. Analysis of the data shows that frequency of 10 Hz is enough for agricultural vehicle.

2.3 Mock up of system

The mock up of the system was created. It contains GPS module Leadtek LR9023, ARM7 microcontroller by NXP semiconductor, liquid crystal display, 512mb of DataFlash and several LEDs that indicates direction of correction. The appearing of created model is shown on fig. 4.

Figure 4: Mock up of system

The model allows calculate current position, optimal track and saving data into flash. Flash memory is needed for attaching calculated data for a map that may be read and analyzed. At this moment parallel driving is available.

Software for personal computer has been created on C++ programming language. This software allows making analysis and evaluating accuracy of system work. As a result of realized experiments data about accuracy of parallel tracking has been obtained (fig. 5).

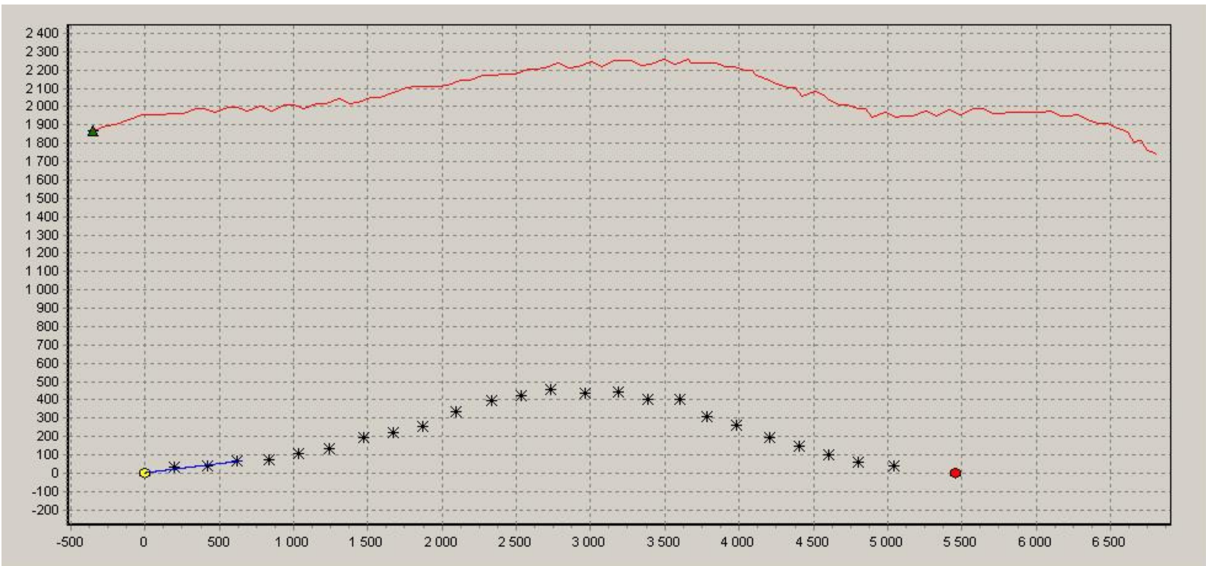

Figure 5: Result of system's parallel tracking experiment

Simple GPS chipset for optimal equidistant system was overlooked. Mediatek 3328 has precision of positioning about 3 meters. In first half-hour after beginning of parallel tracking its accuracy is about 0.3 meter. Then accuracy is decreasing and reach not more 3 meters. It is not possible to use differential correction on Mediatek because it has static navigation mode and it is no way to disable it. At this reason correction land station is not available.

SirfStar3 has precision of positioning about 6 meters. In first half-hour after beginning its accuracy reach value of 3 meter on next half-hour its reach maximum value. But the main difference is ability to disable static navigation, so it is possible to design differential positioning.

In case of using inertial navigation there is possibility to reduce errors of position measuring more than 50 percents. But such system is very difficulty in designing and calibrating. As a result the most cheap and easy way to obtain precision system is using differential correction with SirfStar3.

The developed system is based on Mediatek. With algorithmic processing and supporting from on board complex device it has precision of parallel tracking 50 centimeters in first half-hour and 2 meters in other time. It's enough for aviation chemical works even without additional correction from ground station. It allows creating of system with wind correction.

3 Conclusion

Low cost system for aviation chemical works based on GPS, magnetometer and electronic on board device of air signal allows calculating real spraying area for statistics and calculating optimal real-time track for increasing quality of crop dusting.