PROBABILISTIC MODELING OF LORAN-C
FOR NONPRECISION APPROACHES

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Abstract

The overall idea of this work is to predict the errors to be encountered during an approach using available data from the U.S. Coast Guard and standard normal distribution probability analysis for a number of airports in the North East CONUS.

The work consists of two parts: an analytical model that will predict the probability of an approach falling within a given standard (AGS, a given standard), not necessarily AC90-45A), and a series of flight tests designed to test the validity of the model.

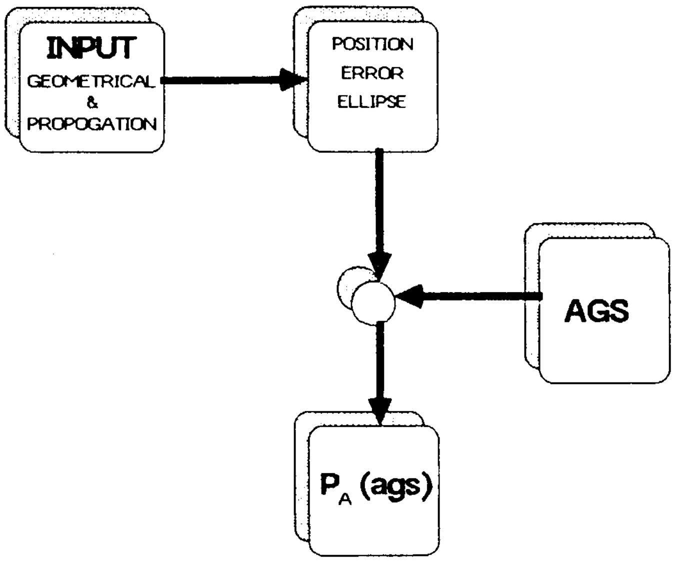
GOALS

- Develop a mathematical model that will predict the probability that an approach using LORAN-C will fall within a given standard (AGS).

- Conduct flight tests to determine the validity of the model.

This figure outlines the mathematical model. A computer program takes as input geometrical considerations such as receiver and transmitter location, and propagation factors such as update frequency (these factors to be explained in the next figure). From these, a position error ellipse is created. The probability of falling within the ellipse is known and can be adjusted by varying its size. Once along- and cross-track error standards are chosen, such as those in AC90-45A, these will be compared with the error ellipse, and a probability of falling within the standard will be computed.

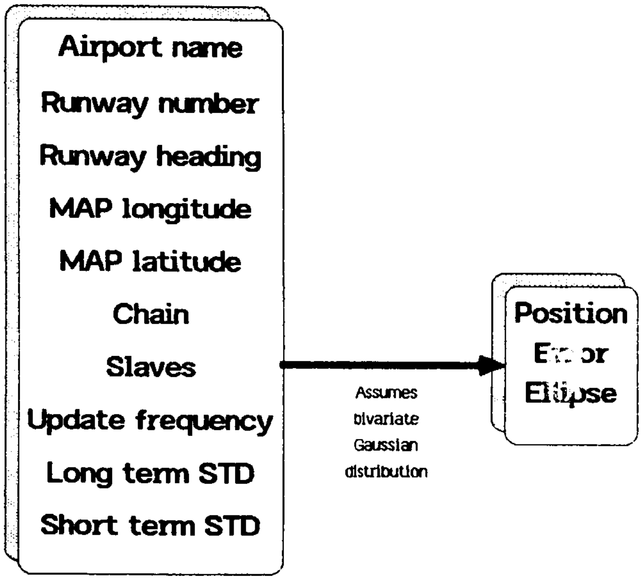
MATHEMATICAL MODEL



This figure shows the completed work. The program that creates the position error ellipse has been completed and is in FORTRAN. It takes into account runway heading, touchdown point, and chain and slaves, all of which are self-explanatory. The program also needs expected standard deviations of the TD coordinates. These are broken down into long-term and short-term σ's. The short-term σ is on the order of 1 to 5 minutes, and the long-term σ is on the order of weeks and months. The long-term σ is a function of what is called "update frequency." This assumes that the TD's of the touchdown point are updated on certain intervals, such as every 8 weeks, with the publication of approach plates. Using two slaves and their respective σ's, a position error ellipse is generated.

COMPLETED WORK

Program that computes ellipse semi-diameters.



A way must be found in the future to accurately predict the long term σ. Two routes to be investigated are 1) looking at seasonal variations in the Loran signal, and 2) looking at the U.S. Coast Guard "Double-Range difference (DRD)" model. In addition, the short-term must be predicted. Possibilities are:

1) Picking a σ needed to achieve AGS and calculating necessary SNR to achieve that σ. In order to make the approach, the SNR must be at least that high.

2) Examine models for σ as a function of distance from transmitters.

3) Use the "DRD" model to predict σ.

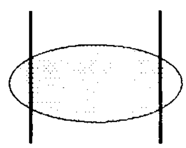
Finally, the probability that an approach will be inside AGS by looking at how much probability inside the ellipse is within the overlayed standard (most likely through numerical integration) must be completed.

FUTURE WORK

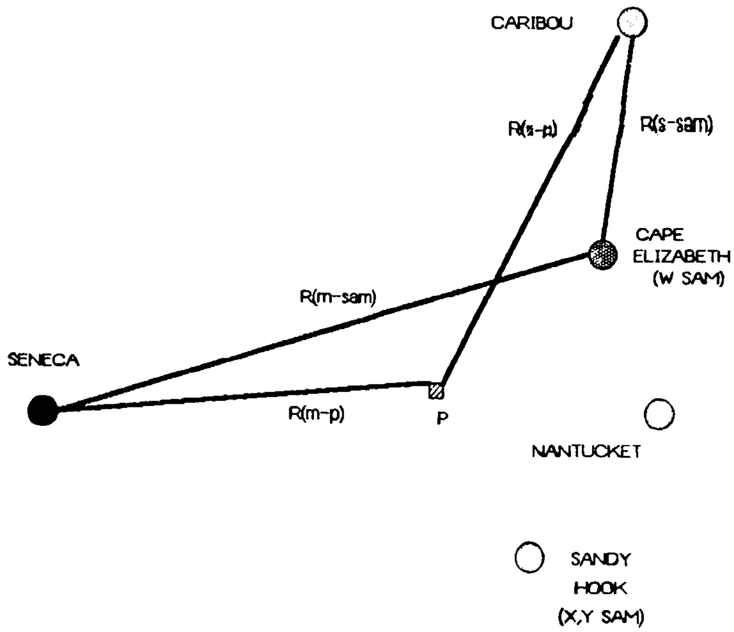
- Long term STD modeling
  - Seasonal changes
    - USCG "DRD" model

- Short term STD modeling
  - Pick a short term STD, minimum SNR to achieve that accuracy
  - Models for STD as a function of distance from transmitters
  - "DRD" model to predict STD

- Compute what % of ellipse is inside AGS



This is a simple "definition" of the Coast Guard "Double-Range difference" model, the key to which is the so-called "Double Range difference" (DRD).



DRD={ R(s-p) - R(m-p) - [R(s-sam) - R(m-sam)] }

This figure outlines the basic idea for the flight tests.

1) Choose airports that have both good and poor probabilities of falling within AGS

2) Fly approaches to those airports using recorded data from the ILS localizer as a "control" reference

3) Eliminate error due to pilotage, using ILS data

4) Plot path that Loran says was flown.

The equipment needed to go up in the tests (for which a pallet is being constructed) includes:

1) Apple II Plus with disc drive and monitor

2) Loran-C (Micrologic ML-3000)

3) Power inverter

4) Gel-cell batteries to power equipment

FLIGHT TESTS

- Pick several airports with both "good" and "bad" probabilities

- Compare LORAN to ILS localizer error for X-track and use visual references for along track error.

Work in progress

- Building a pallet to carry equipment