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Air Traffic Control Project
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: BI-WEEKLY REPORT, DECEMBER 23, 1949

1.0 GENERAL

(W. G. Welchman)

Some time was spent in preparations for the visit of Mr. Goldstein of ANDB on December 16.

A draft note has been prepared reviewing our reasons for studying the behavior of aircraft under guidance.

Thanks to a suggestion made by Mr. Lyman of Sperry's, we have obtained some interesting reports of working groups organized by the International Air Transport Association (IATA). These groups are studying many of the questions to which we are trying to find answers and it will be a help to us if we can keep in touch with their progress. It is encouraging to find that the questions that we regarded as of fundamental importance last July are similarly rated by these groups, but it is clear that the answers are not yet known. In particular, these reports confirm our opinion, expressed in Summary Report 2, that stabilization equipment of the Sperry zero reader type represents a major advance that will make an important contribution to the improvement of instrument flying.

(C. R. Wieser)

The reference in the last Bi-Weekly to a memo on the trip to AIL and Sperry is incorrect. An account of the trip has been issued in M-2026. Another visit to Sperry is scheduled for December 28-29. It is hoped that on the next visit we will be able to learn more about aircraft control equations and experimental checks on their validity.

The problem of guidance of an aircraft during azimuth controlled descent has been investigated. The problem is to keep the aircraft flying at a predetermined angle and angular velocity about a reference point by controlling the bank angle rather than the speed. The aircraft's radial distance from the reference point is not controlled. (This is the system described in SR-3.)

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(C. R. Wieser) - continued

Orden's preliminary analysis of this system indicated that an aircraft's equation for angular progress about the reference point when expressed as a function of the bank angle contained a term

$$\frac{K\Omega^2}{S(S^2+\Omega^2)}$$

in LaPlace notation. The inverse transform of this expression is a sinusoid with no damping, and it was interpreted as representing unstable flight.

I have since independently derived a similar expression for the aircraft's behavior. The presence of the undamped sinusoid was difficult to understand, and a physical explanation was sought. It was found that this behavior is a result of the coordinate system used, and does not mean that the aircraft "wobbles" sinusoidally with respect to its own axes. Consider the aircraft to be turning about the reference point P at a constant angular velocity (circular flight). If a step function of bank angle is inserted, the aircraft will immediately assume circular flight at a new radius about a new center which is displaced from P. Its angular progress measured from P will now be sinusoidal even though the motion of the aircraft is a uniform circle.

The sinusoidal term must be dealt with in the closed-loop control system in order to hold constant angular progress about P. Preliminary analysis indicates that this might be accomplished by feeding back the aircraft's instantaneous angular velocity about P. Further study is necessary.

(W. K. Linvill)

By use of the flight equations in the simplified form which were given in the last Bi-Weekly report and necessary coordinate conversions, we are analyzing the behavior of an aircraft on straight flight paths with distance time schedule and on circular paths with an azimuth time schedule. A memorandum on this study is being written. At a conference with Wieser and Orden, we found ourselves in substantial agreement on the procedure.

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1.0 GENERAL - continued

(A. Orden)

Preliminary control systems were drawn up for study of four types of air path control which may be useful in the study of air traffic control. The four controls are: 1) deviation from a straight line, 2) progress along a straight line, 3) deviation from a circle, 4) angular progress control about a fixed center.

A rough calculation was made to examine the effect of an a/c running into a headwind on progress control. A memo is being prepared to show the results.

(F. A. Foss)

An air to ground communications system of interest has been developed over the last two years at R.L.E. and is now in its flight test stage. This work has been done under Project Meteor with the goal of a telemetering system capable of a basic repetition rate of 100,000 with provision for as many as 100 individual channels. Pulse amplitude modulated subcarriers with a frequency modulated radio frequency carrier (PAM-FM) was chosen as the mode of operation because of its superior signal-to-noise ratio when operated above threshold for a large number of channels. The fact that the basic system can be expanded to obtain a larger number of channels makes it worth consideration for the private line application.

(D. R. Israel)

Several days were spent during the past two-week period in catching up on the various articles which Lassie Ulman has uncovered. The chief attention has been on the programming for approach to the helix. This investigation has revealed several interesting points which require further consideration:

a) Loss of time along a straight path is rather difficult to achieve in a short distance without large speed reductions.

b) The rate of descent of 500 feet/minute will mean the start of the descent for some a/c at least 60 miles from the helix.

c) Because of the entry into the helix from different directions, sequencing into the helix is not in the same order as landing. This means that there is a certain time before entry into the helix during which aircraft cannot change sequence.

d) Because of random effects of the wind it would seem to be a preferable procedure to have all a/c travel at all times with enough reserve to maintain a schedule.

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1.0 GENERAL

(D. R. Israel) - continued

e) It appears that a realistic system of approach will require a good deal of information concerning the a/c beyond a 100 mile zone about the terminal.

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