

A. V ROE CANADA LIMITED

MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

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INDEX

	PAGE
Introduction and Summary	1
References	2
Notation	2
Longitudinal Equations Of Motion	3
Conclusions	4

INTRODUCTION AND SUMMARY

In the knowledge that the bare essentials are required at the present time and that a more comprehensive presentation will be required at a later stage, this report is simply a record of the longitudinal equations which may be used relevant to longitudinal response in the Emergency Mode with negligible speed and height variation.

The equations may be used in two ways;-

- 1) The calculation of aircraft longitudinal response assuming the aerodynamic derivatives are known, for any given variation in longitudinal stick force or thrust.
- 2) Analysis of longitudinal response records to determine the derivatives which generated the response.

Only normal aerodynamic derivatives are involved but transient motion with a varying forcing function is involved and hence the analysis method of reference 3 cannot be applied in these circumstances.

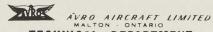
The principles of the method of evaluation of longitudinal derivatives from longitudinal response records are given in reference 1. The application in the Emergency Mode is obvious and it is thought that a description is not necessary in this presentation of this report.

Use of this method as applied to the equations in this report will greatly increase the scope of longitudinal flight analysis as the boundary conditions for analysis are less stringent than in the method of reference 3.

However it is considered that experimental evaluation of derivatives by the method of reference 3 is possibly more reliable because of the averaging process and the self-checking nature of the inter-dependent functions.

The principles of the step by step time solution of response are given in reference 2.

Records of response solutions to various test cases will be included in a more comprehensive presentation of this report.



TECHNICAL DEPARTMENT

REPORT No. 71/Stab/	17
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References

AIRCRAFT:

 Digital Computation Of Response Using An Approximation To Pitch Damper System.

71/Stab/10

M.V. Jenkins

2. Digital Computation Of Response Using An Approximation To Lateral Damper System.

71/Stab/9

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 Digital Computer Determination Of Longitudinal Derivatives From Oscillatory Flight Tests.

71/Stab/6

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4. Dynamic Equations Relative To Body Axes.

P/Stab/132

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Notation

Relevant to a body axes system is given in reference 4.

EMERGENCY MODE OZ EQUATION OF MOTION

$$-\frac{\sqrt{2}}{27} - \frac{\dot{\alpha}(z_{x}^{2} - 9\sqrt{z_{y}^{2}} - \sqrt{z_{x}^{2}})}{4\mu_{i}} - \frac{\sqrt{2}}{mV_{i}} - \frac{\sqrt{2}}{mV_{i}} - \frac{\sqrt{2}}{2}$$

$$+ \frac{\sqrt{9}}{V_{i}} \sin \theta \cos \phi_{i} = \frac{\sqrt{2}}{27} \cdot K_{E} \cdot F_{E} + \frac{\sin i}{mV_{i}} \cdot T_{i}$$

EMERGENCY MODE PITCHING EQUATION

$$- \propto \frac{C_{m_{\chi}}}{7^{2}R} - \frac{1}{2} \cdot \frac{C_{m_{\chi}} \cdot \overline{z}^{2}}{4 \cdot K^{2} \cdot 7} - \frac{1}{4} \cdot \frac{C_{m_{\eta}} \cdot \overline{z}^{2}}{4 \cdot K^{2} \cdot 7}$$

$$- \frac{e}{I_{\gamma}} \cdot \frac{\partial T}{\partial \alpha} \cdot \propto + \frac{1}{4} = \frac{C_{m_{\delta}} \cdot K_{E} \cdot F_{E}}{7^{2}R} \cdot K_{E} \cdot F_{E} + \frac{e}{I_{\gamma}} T$$

$$\ddot{z} = V_{i} \left[\left(q_{i} \cdot s_{i} \times \alpha_{i} \right) \propto + \left(\cos \alpha_{i} \right) \dot{\alpha} - q_{i} \cos \alpha_{i} + \Theta_{i} \frac{g}{V_{i}} \cdot s_{i} \times \Theta_{i} \cos \alpha_{i} \right]$$

WHERE Z IS THE ACCELERATION MEASURED IN FEET SEC BY AN ACCELEROMETER ALIGNED IN THE OZ DIRECTION.

$$K_{E} = \left[\frac{S_{e}}{F_{E}}\right]$$
 incremental from trimmed steady state condition

FE - INCREMENTAL STICK FORCE POSITIVE PRODUCING NEGATIVE
INCREMENTAL VALUES OF ELEVATOR DEFLECTION

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Conclusions

If in the equations of motion contained in reference 1 with the normal mode pitch damper engaged, the following

values are put to zero, K_0 , K_1 , K_1 , K_2 , K_2 , K_3 and F_E K_2 is substituted for $\left(\left(K_1 \cap -K_1' \right) \right) dt - K_2' N + K_0 \int_Q dt \right)$

the equations become relevant to the Emergency Mode where the normal aerodynamic derivatives only are involved.