Section 16 Rotary Wing

16.1 Principal Aeroderivatives

16.2 Forward Flight Static And Dynamic Stability

16.1 PRINCIPAL AERODERIVATIVES

Derivative	Common Name	Principal Contributors	Typical Sign
CONTROL POWER			
M_{B_1}	Pitch control power	MR Thrust vector Mast bending moment Control gearing Rotor type Effective hinge offset	-
L_{A_1}	Roll control power	MR Thrust vector Mast bending moment Control gearing Rotor type Effective hinge offset	-
$N_{\theta_{TR}}$	Yaw control power	TR thrust TR moment arm Control gearing	-
Z_{θ_C}	Heave control power	MR thrust Control gearing	-
STATIC STABILITY			
M_u	Speed stability	MR flap back Mast bending moment Horizontal tailplane	+
M_w	Static/Incidence/Angle of Attack stability	MR flap back Mast bending moment Horizontal tailplane Fuselage	
L_v	Lateral static stability (dihedral effect)	MR 'flap back' TR vertical moment arm Fuselage	-
N_v	Directional static stability (weathercock effect)	TR thrust Vertical tailplane Fuselage	+
DAMPING			
X_u	Drag damping	Rotor drag Fuselage drag	-
Y_v	Side force	Rotor drag Fuselage drag	-
Z_w	Heave damping	MR characteristics	-
L_p	Roll damping	Main rotor Effective hinge offset	-
M_q	Pitch damping	Main rotor Effective hinge offset Horizontal tailplane	-
N_r	Yaw damping	Tail rotor Vertical tailplane Fuselage	-

16.1 PRINCIPAL AERODERIVATIVES (Continued)

Derivative	Common Name	Principal Contributors	Typical Sign
CROSS COUPLING			
$L_{\theta_{TR}}$	Tail rotor roll	Tail rotor vertical position	+
M_{θ_C}	Pitch change with power	Forward speed Main rotor	+
N_{θ_C}	Torque reaction	Torque	
$Y_{\theta_{TR}}$	Tail rotor drift	Tail rotor	

References:

Padfield, G.D., (2007), *Helicopter Flight Dynamics*, 2nd Edition, Blackwell Publishing, UK.

Cooke, A., Fitzpatrick, E., (2002), *Helicopter Test and Evaluation*, Wiley Blackwell, UK.

Leishman, J.G., (2006), *Principles of Helicopter Aerodynamics*, 2nd Edition, Cambridge University Press, UK.

16.2 FORWARD FLIGHT STATIC AND DYNAMIC STABILITY

Stability Characteristic	Principal Influences	Typical Test	Role Relation
Longitudinal Static Stability	• M_w • M_u • M_{θ_C} • $M_{\theta_{TR}}$	• Trimmed flight control positions • Trimmed flight control positions - collective	• Control margins • Control inputs progressive, predictable, and in correct sense
		• Apparent static stability	• Speed selection
		• Collective fixed static stability	• Speed maintenance
Manoeuvre Stability	• M_w • M_q • M_{θ_C}	• Apparent manoeuvre stability • Collective fixed manoeuvre stability • Pull-ups/push-overs	• Aggressive turning and manoeuvring flight
Longitudinal Dynamic Stability	• M_w • M_u • M_q	• Excitation of dynamic long term mode • Natural turbulence, release to trim, pulse input	• IMC flight • Transit • Nuisance mode
Lateral-Directional Static Stability	• L_v • N_v	• Trimmed flight control positions	• Control margins • Control inputs progressive, predictable, and in correct sense
	• Y_v	• Steady heading sideslip (SHSS)	• Sideforce cues • Maintaining balanced flight
Lateral Static Stability (Dihedral)	• L_v	• SHSS • Turns on one control – pedal	• Transit • Lateral and out-of-wind transitions • Instrument approaches
Directional Static Stability	• N_v	• SHSS • Turns on one control - cyclic	• Transit • Instrument approaches
Lateral-Directional Dynamic Stability – Lateral-Directional Oscillations (Dutch Roll Mode	• L_v • N_v	• Excitation of LDO via doublet, pulse, or SHSS release to trim	• IMC flight • Transit • Nuisance mode
Lateral-Directional Dynamic Stability – Spiral Stability	• L_v • N_r • N_v • L_r	• Turns on one control – cyclic • Time to half/double bank angle	• IMC flight • Turns • Lateral gust response

16.3 References:

Padfield, G.D., (2007), *Helicopter Flight Dynamics*, 2nd Edition, Blackwell Publishing, UK.

Cooke, A., Fitzpatrick, E., (2002), *Helicopter Test and Evaluation*, Wiley Blackwell, UK.

Leishman, J.G., (2006), *Principles of Helicopter Aerodynamics*, 2nd Edition, Cambridge University Press, UK.

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