

---

## Contents

---

<b>Introduction</b> . . . . .	ix
<b>List of Acronyms</b> . . . . .	xiii
<b>Chapter 1. European Commercial Aircraft before the Airbus A320</b> . . . . .	1
1.1. Introduction . . . . .	1
1.2. The Caravelle and irreversible primary flight servocontrols . . . . .	2
1.2.1. Servodyne servocontrol . . . . .	4
1.2.2. Artificial feel of load . . . . .	9
1.2.3. Hydraulic power generation . . . . .	11
1.3. The Concorde and flight controls with analog electrical signals and controllers . . . . .	14
1.3.1. General architecture of flight controls . . . . .	16
1.3.2. Operation modes . . . . .	19
1.3.3. Closed-loop analog electrical control . . . . .	20
1.3.4. Relay jack and PFCU . . . . .	22
1.3.5. Artificial feel . . . . .	25
1.3.6. Hydraulic power generation . . . . .	28
<b>Chapter 2. Airbus A320 and Electrically Signaled Actuators</b> . . . . .	31
2.1. Airbus A320 or Signal-by-Wire with digital computers . . . . .	31
2.2. Flight controls . . . . .	32
2.2.1. General concepts . . . . .	33
2.2.2. Architectures and redundancies . . . . .	34
2.2.3. Actuators . . . . .	38

---

2.3. Landing gears . . . . .	59
2.3.1. Braking . . . . .	59
2.3.2. Auxiliary landing gear steering . . . . .	63
2.4. Hydraulic system architecture . . . . .	66
2.5. Hydraulic pumps . . . . .	69
2.5.1. Engine-driven pump (EDP) . . . . .	73
2.5.2. Electric motor pump (EMP) . . . . .	76
2.5.3. Reversible power transfer unit (PTU) . . . . .	77
2.5.4. Ram air turbine (RAT) . . . . .	78
<b>Chapter 3. Airbus A380 . . . . .</b>	<b>79</b>
3.1. Introduction . . . . .	79
3.1.1. A need for high-capacity long-range aircraft . . . . .	80
3.1.2. Actuation need . . . . .	81
3.1.3. Innovative architectures and technologies . . . . .	83
3.2. Data transmission and processing . . . . .	85
3.3. Power generation and distribution . . . . .	89
3.3.1. 2H-2E architecture . . . . .	89
3.3.2. Hydraulic power generation . . . . .	91
3.4. Flight controls . . . . .	96
3.4.1. Topology . . . . .	96
3.4.2. Displacement control for the actuators of slats and flaps . . . . .	102
3.4.3. Electrohydrostatic actuators . . . . .	107
3.4.4. Trimmable horizontal stabilizer actuator . . . . .	111
3.5. Landing gears . . . . .	116
3.5.1. Topology . . . . .	116
3.5.2. Signal considerations . . . . .	117
3.5.3. Power considerations . . . . .	117
3.5.4. Extension/retraction . . . . .	119
3.5.5. Steering . . . . .	119
3.5.6. Braking . . . . .	123
3.6. Thrust reversers . . . . .	126
3.6.1. Locking in stowed configuration . . . . .	129
3.7. Subsequent programs . . . . .	130
<b>Chapter 4. V-22 and AW609 Tiltrotors . . . . .</b>	<b>133</b>
4.1. V-22 Osprey military tiltrotor . . . . .	134
4.1.1. Overall architecture of flight controls . . . . .	135
4.1.2. Hydraulic power generation architecture . . . . .	139
4.1.3. Control architecture of flight control actuators . . . . .	140
4.1.4. Control surface actuators . . . . .	141

4.1.5. Swashplate actuators . . . . .	143
4.1.6. Pylon conversion actuators . . . . .	146
4.2. AW609 civil tiltrotor . . . . .	161
4.2.1. Overall architecture of flight controls . . . . .	162
4.2.2. Hydraulic power architecture . . . . .	164
4.2.3. Power architecture of electrohydraulic actuators . . . . .	165
4.2.4. Pylon conversion actuators . . . . .	171
4.3. Comparison of the pylon conversion actuator approaches for the V-22 and AW609 . . . . .	182
<b>Bibliography</b> . . . . .	185
<b>Index</b> . . . . .	193