Contents

LIST OF ABBREVIATIONS				xv
LIST OF FIGURES				xxi
LIST OF TABLES			xxv	
PREFACE				xxix
ABOUT THE	Аитн	ORS		xxxv
COGNITIVE E	NGINI	EERING	IN A CHANGING WORLD	xxxvii
PART I A	N 0	VERV	IEW OF MANAGEMENT OF	
C	PER	ATION	S AND SAFETY	1
CHAPTER 1	THE AIR TRAFFIC MANAGEMENT SYSTEM			3
	1.1	Introduction		3
	1.2	The A	ΓM System	4
			Procedures and Regulations	7
			Air Traffic Controllers (ATCOs)	9
			Automation Systems	9
			Communication Systems	13
			Navigation Systems	14
		1.2.6		15
	1.3	ATC I		16
	1.4		rt Control Tower (TWR) Operations	18
		1.4.1	Airport Controller Duties	20
		1.4.2	Pilot Duties during Taxiing, Start up, or	
			Landing	21

CONTENTS

	1.5	Approx	ach Control (APP) Operations	22
		1.5.1	Approach Controller Duties	23
		1.5.2	Pilot Duties during Take-off, Climb,	
			Descent, and Approach for Landing	25
	1.6	Area C	Control Center (ACC) Operations	27
		1.6.1	Area Controller Duties	27
		1.6.2		28
	1.7	Air Tr	affic Flow and Capacity Management	
			CM) Operations	29
	1.8		Regulatory Framework	31
	1.9		nts and Accidents	33
	1.10		nding Remarks	35
CHAPTER 2	FACTORS AFFECTING ATM PERFORMANCE			
		2.1 Introduction		
	2.2	Introduction Challenges in Coping with Abnormal Situations		
	2.3	Work Demands and Stress in the Operating		
			onment	43
	2.4		cal Performance Models in Aviation	48
	2	2.4.1		48
			Navigate	49
		2.4.3		50
	2.5		cal Performance Models in ATC	52
	2.5	2.5.1	Management of Occurrences	52
		2.5.2	and Talana	53
	2.6			33
	2.0	2.6 Aspects of Complexity and Coupling in the ATM Environment		
	2.7		ts of Uncertainty in Making Sense of Information	55
	2.1	2.7.1	Missing Information	59
		2.7.2	Unreliable Information	
		2.7.3		60
				61
		2.7.4	Information Noise	61
	20	2.7.5	Hard to Interpret Information	62
	2.8	Concli	uding Remarks	63
CHAPTER 3		SAFETY ORGANIZATION AND RISK MANAGEMENT		
	3.1	Introd		65
	3.2		Safety Concepts	67
	3.3		fety Envelope of Aviation Systems	69
	3.4		our Quadrants or Pillars of Safety Management	72
		3.4.1	Safety Policy	72
		3.4.2	Hazards and Risks	73
		3.4.3	Safety Assurance	75
		3.4.4	Safety Promotion	77
	3.5	A Cor	ntrol Framework Linking the Four SMS Pillars	77
	3.6		enges to Safety Management	80
		3.6.1	Safety Policy	80
		3.6.2	Risk Management	83
		3.6.3	Safety Assurance	84
		3.6.4	Safety Promotion	85

			CONTENTS	IX
	3.7	Revisi	ting the Safety Envelope and Applying	
		Resilie	ence Engineering	87
	3.8	Risk A	Assessment Approaches	88
		3.8.1	Systemic Risk Assessment	89
		3.8.2	Operational Risk Management	95
	3.9	EASA	Requirements of Risk Assessment Methods	97
	3.10	Concl	uding Remarks: Toward Resilient Risk	
		Assess	ment Methods	102
PART II	Cogn	NITIVE	ENGINEERING	105
CHAPTER 4	DEC	ISION-	MAKING	107
	4.1	Introd	uction	107
	4.2	Theore	etical Foundations	109
	4.3	Ration	nal or Analytical Decision-Making	110
	4.4	Natura	alistic Decision-Making	114
	4.5	Towar	d a Decision-Making Model in ATC	120
	4.6	Taskw	ork Functions and Strategies	121
		4.6.1	Recognition	122
		4.6.2	Modeling and Critiquing	126
		4.6.3	Anticipation	127
		4.6.4	Planning	128
		4.6.5	Workload Management	130
		4.6.6	The Taskwork Model	131
	4.7	Teamy	work Functions and Strategies	134
		4.7.1	Team Orientation and Shared Understanding	137
		4.7.2	Team Coordination	138
		4.7.3	Information Exchange—Communication	139
		4.7.4	Error Management	140
		4.7.5	Task Distribution or Change Management	141
		4.7.6		143
	4.8	Applie	cations of T2EAM in Training, Debriefing,	
		and In	vestigation of Mishaps	143
CHAPTER 5	SENSEMAKING			145
	5.1			
	5.2	Frame	s and Cognitive Functions of Sensemaking	145
	5.3	The C	hallenges of Low Level Wind Shear Phenomen	a 149
	5.4	Expla	natory Frames and Sensemaking Strategies	151
		5.4.1	Identifying a Frame	153
		5.4.2	Questioning a Frame	154
		5.4.3	Reframing: Comparing Multiple Frames	154
		5.4.4	Reframing: Creating a New Frame	155
		5.4.5	Preserving the Frame	156

Preserving the Frame

Elaborating a Frame

Requirements for Team Sensemaking

Data Synthesis

Strategies

Behavioral Markers for Team Sensemaking

5.4.6

5.4.7

5.5.1

5.5

156

156

158

158

CONTENTS

		5.5.2	Seeking Data	158
		5.5.3	Monitoring Data Quality	159
		5.5.4	0 1	159
		5.5.5	Dissemination	160
	5.6	Conclu	ading Remarks	160
CHAPTER 6	Hu		ROR DETECTION AND RECOVERY	163
	6.1	The Co	oncept of Human Error	163
	6.2	Error I	Management Processes	166
	6.3	Classif	ication of Human Error	169
		6.3.1	A Model of Unsafe Acts	169
		6.3.2	The TRACEr Classification	173
	6.4	A Fran	nework for Understanding Error Detection	
		and Re		175
	6.5	Cognit	tive Strategies in Error Detection and	
		Identif		178
		6.5.1	Strategies in Awareness-Based Detection	182
		6.5.2	Strategies in Planning-Based Detection	184
		6.5.3	Strategies in Action-Based Detection	185
		6.5.4	Strategies in Outcome-Based Detection	186
	6.6	Cognit	ive Strategies in Error Recovery	188
		6.6.1	Planning and Replanning in Error Recovery	188
		6.6.2	Coordination Tactics in Error Recovery	191
	6.7	Conclu	ding Remarks	192
CHAPTER 7	ADA	PTIVE	PRACTICES IN AIR TRAFFIC CONTROL	197
	7.1	Introdu		197
	7.2	Condit	ions Creating Performance Variability in	177
			Practices	199
		7.2.1	Variability of Task Characteristics	200
		7.2.2	Organizational Changes and Transitions	201
		7.2.3	Goal Conflicts That Cannot be Reconciled	202
		7.2.4	Unruly Technology	203
		7.2.5	Professional Norms and Social Context	204
	7.3	A Syste	em Dynamics View of Work Practices	205
	7.4	Reflecti	ion-in-Action: Mindful Work Practices and	203
		Improv		209
	7.5		ion-on-Action: Organizational Learning and	207
		Practice	e Communities	212
	7.6		ding Remarks	218
				210
PART III	RED	UCING	COMPLEXITY BY DESIGN	
		TRAIN		221
CHAPTER 8	TRA	INING E	OR ABNORMAL SITUATIONS	222
	8.1	Introdu		223
	8.2		ng Abnormal Situations in the ATM Domain	223
	0.2	Landin	ig Abhormal Situations in the ATM Domain	224

	CONTENTS		
	8.3	Anomaly Response and Cognitive Strategies	225
		EAS Scenarios in Simulator Training	228
		Patterns of Resilience, Coordination, and Affordances	231
		8.5.1 Patterns of Resilient Taskwork	231
		8.5.2 Patterns of Adaptive Teamwork	232
		8.5.3 Patterns of Affordances	233
	8.6	Cognitive Tasks Analysis (CTA)	234
		8.6.1 The Airspace Clearing Scenario	235
		8.6.2 The Airport Diversion Scenario	238
	8.7	The ABCDE Method of Cognitive Task Analysis	240
		Concluding Remarks	246
CHAPTER 9	WORKLOAD AND COMPLEXITY		
	9.1 Introduction		
	9.2	Complexity in the ATM System	249
	9.3	Complexity Mitigation Strategies	252
		9.3.1 Adjustments in Monitoring and Anticipation	252
		9.3.2 Replanning and Managing Uncertainty	254
		9.3.3 Managing Workload and Change	255
		9.3.4 Restructuring Tasks across Sectors	256
		9.3.5 Changes in Communication and Coordination	256
	9.4	Selection of Strategies for Different Levels of	
		Complexity	257
	9.5	Concluding Remarks	259
CHAPTER 10	NEW	CHALLENGES IN ATM	261
	10.1	Introduction	261
	10.2	Taskwork Performance	263
		10.2.1 Recognition and Monitoring	263
		10.2.2 Planning and Conflict Resolution	266
		10.2.3 Anticipating	266
		10.2.4 Critiquing and Adapting to Workload	267
	10.3	Collaborative Decision-Making	269
		10.3.1 Sharing Understanding, Orientation, and	
		Trust	269
		10.3.2 Managing Task Allocation	271
		10.3.3 Team Coordination	272
		10.3.4 Multi-Modal Information Transfer and	
		Communication	273
	10.4	Concluding Remarks	274
PART IV	Svet	EMS AND ORGANIZATIONAL	
	Мор		277
CHAPTER 11	ORG	ANIZATIONAL MODELS OF SAFETY	279
	11.1	Introduction	279
		Defenses-in-Depth and Organizational Safety	281