

Part IV
Appendixes

Appendix A

MASDIMA - Multi-Agent System for Disruption Management

The Multi-Agent System for Disruption Management (MASDIMA) is the advanced prototype we have developed to test our proposal. As we mention in the *Research Methodology* we follow (Section 1.3), MASDIMA is our *test laboratory*.

The advanced prototype we show in this appendix, implements the ideas of our proposal for a new approach for disruption management (Chapter 5) and uses the Generic Q-Negotiation Protocol as the decision mechanism (Section 5.4).

To implement the MASDIMA we have used Java¹ as the programming language and JADE (Bellifemine *et al.*, 2004) as the framework for developing the agents and as the runtime environment. Additionally, we have used the NASA Worldwind API² as our flight visualization tool.

In Section A.1 we describe the features of the system available through the main user interface. In Section A.2 we present the charts and information related to the negotiation process and the winning solution. Finally, in Section A.3 we give an example that shows the messages exchanged by the agents during the negotiation through a protocol sequence diagram.

A.1 MASDIMA User Interface

MASDIMA runs autonomously requiring little intervention from a human operator. Actually, the system is designed in a way that requires only the intervention of a human operator to validate and give feedback regarding the solutions found automatically. It is prepared to receive information from several sources. Section 5.5 provides more information regarding this subject. Figure A.1 shows the MASDIMA User Interface. It has six main parts as follows:

1. *Flight Monitoring*: This window shows the movement of aircraft in real-time sorted by departure date and time. For example, in the example of Figure A.1, the first line shows flight 813, departing from *MXP* (Milan) to *OPO* (Porto) at 12:15

¹ <http://www.java.com>

² <http://worldwind.arc.nasa.gov/java/>

The screenshot displays the MASDIMA Full User Interface, which is divided into several functional areas:

- Flight Data Table (Top Left):** A table with columns for Airborne, Flight, Origin, Departure, Destination, and Arrival. Row 602 is highlighted in red, indicating a flight delay. Row 844 is highlighted in green, indicating a solved problem.
- Aircraft Details (Top Right):** A panel with tabs for Aircraft, Crew, and Pax and Airport. It lists details for aircraft A320, including tail number, name, model, fleet, and various cost metrics.
- Globe (Middle):** A 3D globe showing flight paths as yellow lines connecting various airports across Europe and Africa. A red '5' is placed on the globe.
- Violations and Solution Plan (Bottom Left):** A table with columns for Flight Affected, Estimated Delay, Delay, Violations, and Status. Row 844 is highlighted in green.
- Supervisor Default Values (Bottom Right):** A table with columns for Disruption type, Impacted order, Affected, and Delay. It lists values for different problem types like AIRCRAFT, CREW, and PASSENGER.
- Navigation and Controls (Bottom):** Buttons for Supervisor Utility Round, Managers Utility Round, and Human Supervisor. A red '6' is placed near these buttons.

Red numbers 1 through 6 are overlaid on the interface to highlight specific features: 1 on the flight data table, 2 on the aircraft details, 3 on the violations table, 4 on the supervisor default values table, 5 on the globe, and 6 on the navigation buttons.

Fig. A.1 MASDIMA Full User Interface

UTC. This flight has already departed as the column *airborne* indicates. Clicking in a flight will show information regarding the aircraft, crew and passengers (see Part 2) and will center the *globe* in that specific flight (see Part 5). When an event causes a flight delay, the row of the affected flight turns red and the delayed flight will appear in the problem status windows (see Part 3). After the problem is solved, the row turns green.

2. *Flight Information*: After clicking in a flight, this window allows access to information related to the three dimensions of the problem: aircraft, crew and passenger. For example, clicking in tab *aircraft* it is possible to see the tail number of the aircraft as well as several information related to costs, e.g., *maintenance average cost per minute*, *fuel average cost per minute*, etc. Clicking on the other tabs, similar information will appear for that specific dimension.
3. *Problem Resolution Status*: Every time an event causes a flight to be delayed, that flight will appear in this window, including the flight number, estimated time of departure, the expected delay (before the problem is solved), the number of violations and the current status of problem (*unsolved* or *solved*). Clicking on a flight, it will be possible to see the specific violations and the default values used by the supervisor agent to solve the problems (even before the problem is solved) and, after the problem is solved, the proposal that won the negotiation and the corresponding plan to be applied (see Part 4).
4. *Solution Information*: In this window it is possible to have access to the specific violations of the flight (e.g. aircraft and crew members affected as well as passengers) through tab *violations* and to the default values used by the supervisor agent during the disruption management process through the tab *Supervisor Default Values*. After the problem is solved, it is possible to have access to the proposed solution through tab *Solution Proposal* (Figure A.4) and the solution plan through tab *Solution Plan* (Figure A.5). More information about the solution found will be given in Section A.2.
5. *Flight Visual Representation*: In this window it is possible to have a visual representation of all flights that are being monitored in a earth globe. This information includes the flight number, origin and destination airport and the *orthodromic route* of the flight. If the MASDIMA is connect to a *datalink server* (a server that receives information in real-time from the aircraft) it is possible to see the flight plan route and the real route being used by the aircraft. This visual representation allows several interactions with the user, for example, it is possible to zoom in, zoom out, rotate, etc. All these features are possible due to the use of NASA Worldwind API.
6. *Charts and Human Feedback*: This part allows access to the supervisor utility by round chart (Figure A.2), managers utility by round chart (Figure A.3) and to the human-in-the-loop user interface. More information about the charts is provided in Section A.2. The human-in-the-loop feature is not completely implemented and more information about it is provided in the advanced features Section 5.6.

A.2 Decision Process Information

After choosing a problem that is solved in the *Solution Information* window (Part 3) it is possible to have access to the buttons that appear in Part 6.

Clicking on the button *Supervisor Utility/Round* in Figure A.1 it is possible to access the chart with the Supervisor utilities for each proposal presented by each manager in every negotiation round. Figure A.2 shows the chart for flight 608. In

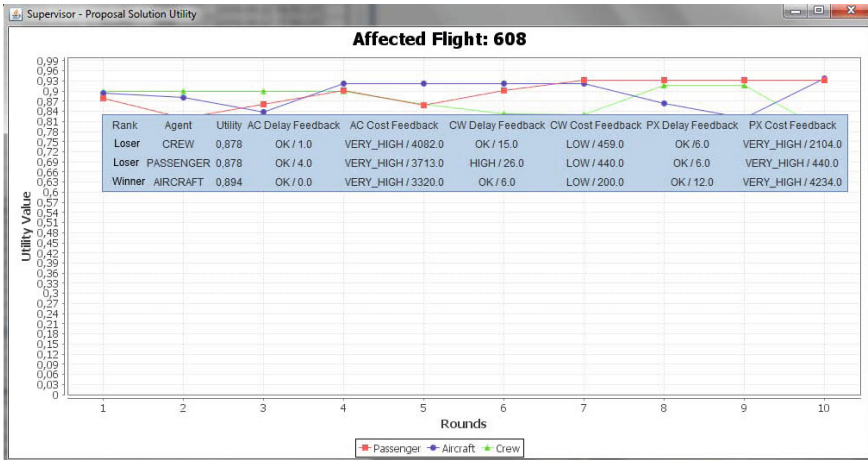


Fig. A.2 Supervisor Proposals Utilities Chart

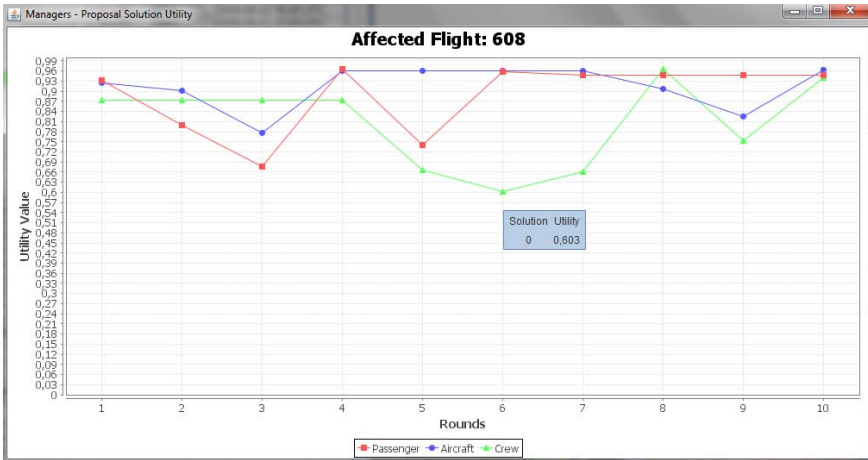


Fig. A.3 Manager Proposals Utilities Chart

red it appears the supervisor utility for the proposal presented by the passenger manager agent. In blue and green, we have the utilities calculated for the proposals presented by the aircraft and crew manager agents, respectively.

Leaving the mouse for a few seconds in one of the points, it will appear a *tooltip* window showing the proposals presented by each agent as well as the information of which agent won the round and the qualitative feedback given by the supervisor to each attribute of the proposals. For example, in Figure A.2 we have the information for the first round. We can see that the winner proposal was presented by the aircraft manager agent with an utility value for the supervisor of 0,894. Continuing with the example, the proposal presented by the crew manager (one that lost the round) re-

Violations	Solution Proposal	Solution Plan	Supervisor Default Values
Attribute		Value	
Aircraft Delay		2.0	
Aircraft Cost		1423.0	
Crew Delay		1.0	
Crew Cost		286.0	
Passenger Delay		2.0	
Passenger Cost		1044.0	
Solution Utility		0.956 (95.6%)	

Fig. A.4 Example Solution Proposal

Violations	Solution Proposal	Solution Plan	Supervisor Default Values
Attribute		Value	
Dimension		Aircraft	
Plan		EXCHANGE CSTOB with CS-TOF	
Dimension		Crew	
Plan		ACCEPT_DELAYED_CREW	
Dimension		Passenger	
Plan		KEEP_SAME_FLT	

Fig. A.5 Example Solution Plan

ceived as qualitative feedback *ok, very_high, ok, low, ok, very_high* for the values of the attributes *AC Delay, AC Cost, CW Delay, CW Cost, PX Delay* and *PX Cost*, respectively.

Clicking on the button *Managers Utility/Round* it is possible to access a similar chart but, this time, with the individual utilities that each proposal has for each manager (Figure A.3).

The values for the negotiation winning proposal and the correspondent operational plan, are available by selecting the *Solution Proposal* tab and the *Solution Plan* tab, respectively, in the *Solution Information* window (Part 4).

Figure A.4 shows an example of a winning proposal. In blue we have the values for the attributes of the aircraft dimension, in dark green the values for the attributes of the crew dimension and in light green the ones for the passenger dimension. It is also possible to see that this proposal won with an utility of 0,956.

The correspondent operational plan is presented in Figure A.5, using the same color scheme. In this case, the solution plan is to *exchange* aircraft *CSTOB* with aircraft *CS-TOF*, *accept the delayed crew* and to *keep* the passengers in the same flight.

Finally, clicking on the button *Human Supervisor* we will have access to the *human-in-the-loop* user interface. This feature is not implemented in the current version of the prototype. However, a description of it is given in Section 5.6. At the present time, a Master Thesis is being developed around this subject.

A.3 Protocol Sequence Chart

As we stated in the beginning of this appendix the MASDIMA advanced prototype implements the GQN protocol we propose in Section 5.4. Additionally, we use

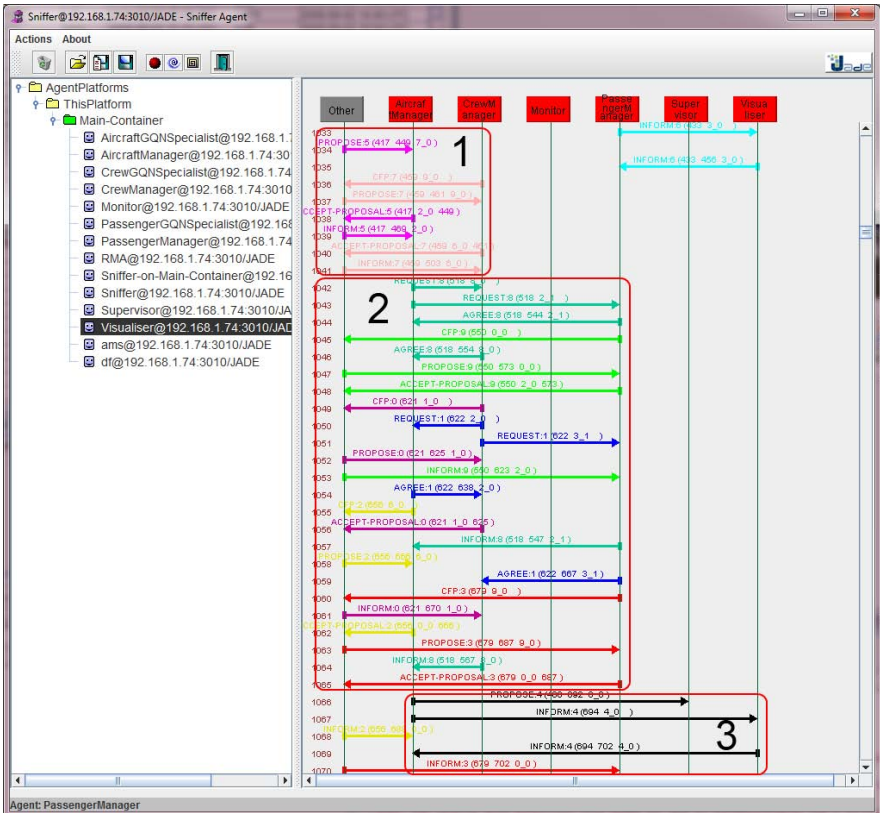


Fig. A.6 MASDIMA GQN Protocol (Partial) Sequence Chart

the JADE framework not only to develop the agents and protocols but, also, as the runtime environment.

Figure A.6 shows the information we can get regarding the agent’s interaction during the negotiation process, using a tool called *Sniffer* from JADE. On the left hand side we can see the implemented agents as well as the ones that are part of the JADE runtime. For example, *df@192.168.1.74:3010/JADE* that is the directory facilitator agent.

On the right hand side, we can see (partially) the performatives and messages exchanged by the agents, including the interactions with agents that do not participate in the negotiation process, like the *monitoring* and *visualizer* agents (the role of these agents is described in Section 5.5). To make the figure more clear we did not include the interactions with the specialist agents. In the figure they appear as *Other*.

It is also possible to see the negotiation protocols in action. For example, the round square one in Figure A.6 shows the *contract net* protocol between the aircraft and crew manager and their team of specialist agents. Round square two shows the

inter-manager negotiation of the *GQN* protocol. Finally, round square three shows the main negotiation of the *GQN* protocol between the managers and the supervisor agent.

More information about these protocols is given in Section 5.4 and 6.3.

Acknowledgements We wish to thank to António Pedro Pereira, Leonardo Fraga and Francisca Teixeira for their contribution in implementing parts of the MASDIMA system.

Appendix B

MASDIMA - Costs Information

Table B.1 Average Takeoff, Landing and Parking charges

IATA Code	Fleet Type	Value (m.u.)	IATA Code	Fleet Type	Value (m.u.)
ACE	NB LND	422,142	ACE	NB PRK	45,034
ACE	WB LND	1511,447	ACE	WB PRK	110,221
AGP	NB LND	422,142	AGP	NB PRK	45,034
AGP	WB LND	1511,447	AGP	WB PRK	110,221
AMS	NB LND	270,271	AMS	NB PRK	101,083
AMS	WB LND	892,548	AMS	WB PRK	333,817
ARN	NB LND	343,459	ARN	NB PRK	109,896
ARN	WB LND	912,815	ARN	WB PRK	362,922
AZS	NB LND	93,472	AZS	NB PRK	17,19
AZS	WB LND	308,685	AZS	WB PRK	56,77
BCN	NB LND	422,142	BCN	NB PRK	45,034
BCN	WB LND	1511,447	BCN	WB PRK	110,221
BIO	NB LND	422,142	BIO	NB PRK	45,034
BIO	WB LND	1511,447	BIO	WB PRK	110,221
BLQ	NB LND	146,248	BLQ	NB PRK	137,645
BLQ	WB LND	482,97	BLQ	WB PRK	454,56
BRU	NB LND	266,916	BRU	NB PRK	1015,13
BRU	WB LND	881,468	BRU	WB PRK	3352,38
BSB	NB LND	275,833	BSB	NB PRK	1321,66
BSB	WB LND	910,915	BSB	WB PRK	4364,668
BUD	NB LND	607,931	BUD	NB PRK	156,284
BUD	WB LND	1609,9	BUD	WB PRK	516,115
CCS	NB LND	292,403	CCS	NB PRK	1169,611
CCS	WB LND	965,635	CCS	WB PRK	3862,538
CDG	NB LND	460,423	CDG	NB PRK	618,398
CDG	WB LND	1779,253	CDG	WB PRK	2042,206
CFE	NB LND	358,014	CFE	NB PRK	272,852
CFE	WB LND	1752,715	CFE	WB PRK	901,07

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IATA Code	Fleet	Type	Value (m.u.)	IATA Code	Fleet	Type	Value (m.u.)
CMN	NB	LND	478,918	CMN	NB	PRK	524,793
CMN	WB	LND	2081,033	CMN	WB	PRK	1733,084
CNF	NB	LND	275,833	CNF	NB	PRK	1321,66
CNF	WB	LND	910,915	CNF	WB	PRK	4364,668
CPH	NB	LND	621,832	CPH	NB	PRK	1572,162
CPH	WB	LND	2053,547	CPH	WB	PRK	5191,927
DKR	NB	LND	0,374	DKR	NB	PRK	86,558
DKR	WB	LND	1,684	DKR	WB	PRK	285,851
DME	NB	LND	405,647	DME	NB	PRK	40,565
DME	WB	LND	1339,613	DME	WB	PRK	133,961
EWR	NB	LND	617,778	EWR	NB	PRK	81,574
EWR	WB	LND	2040,157	EWR	WB	PRK	396,722
FAO	NB	LND	374,939	FAO	NB	PRK	102,517
FAO	WB	LND	1456,013	FAO	WB	PRK	338,553
FCO	NB	LND	125,457	FCO	NB	PRK	137,645
FCO	WB	LND	414,312	FCO	WB	PRK	454,56
FNC	NB	LND	785,005	FNC	NB	PRK	102,517
FNC	WB	LND	3049,34	FNC	WB	PRK	338,553
FOR	NB	LND	275,833	FOR	NB	PRK	1321,66
FOR	WB	LND	910,915	FOR	WB	PRK	4364,668
FRA	NB	LND	63,087	FRA	NB	PRK	1002
FRA	WB	LND	208,34	FRA	WB	PRK	1426
FUE	NB	LND	422,142	FUE	NB	PRK	45,034
FUE	WB	LND	1511,447	FUE	WB	PRK	110,221
GIG	NB	LND	275,833	GIG	NB	PRK	1321,66
GIG	WB	LND	910,915	GIG	WB	PRK	4364,668
GRU	NB	LND	275,833	GRU	NB	PRK	1321,66
GRU	WB	LND	910,915	GRU	WB	PRK	4364,668
GVA	NB	LND	325,508	GVA	NB	PRK	2277,299
GVA	WB	LND	1150,232	GVA	WB	PRK	7520,582
HAM	NB	LND	189,978	HAM	NB	PRK	688,224
HAM	WB	LND	627,387	HAM	WB	PRK	2272,8
HEL	NB	LND	407,4	HEL	NB	PRK	281,025
HEL	WB	LND	1536,41	HEL	WB	PRK	928,06
HER	NB	LND	99,802	HER	NB	PRK	58,499
HER	WB	LND	351,14	HER	WB	PRK	272,736
HOR	NB	LND	263,819	HOR	NB	PRK	2460,401
HOR	WB	LND	1025,128	HOR	WB	PRK	8125,26
JNB	NB	LND	619,312	JNB	NB	PRK	34,115
JNB	WB	LND	2135,866	JNB	WB	PRK	70,99
KGS	NB	LND	99,802	KGS	NB	PRK	58,499
KGS	WB	LND	351,14	KGS	WB	PRK	272,736
LAD	NB	LND	293,839	LAD	NB	PRK	64,329
LAD	WB	LND	1107,327	LAD	WB	PRK	212,44
LCG	NB	LND	379,384	LCG	NB	PRK	45,034
LCG	WB	LND	1359,891	LCG	WB	PRK	110,221

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IATA Code	Fleet	Type	Value (m.u.)	IATA Code	Fleet	Type	Value (m.u.)
LGW	NB	LND	544,153	LGW	NB	PRK	2729,449
LGW	WB	LND	544,153	LGW	WB	PRK	5983,163
LHR	NB	LND	565,779	LHR	NB	PRK	3416,334
LHR	WB	LND	565,779	LHR	WB	PRK	7614,674
LIN	NB	LND	118,443	LIN	NB	PRK	137,645
LIN	WB	LND	420,502	LIN	WB	PRK	454,56
LIS	NB	LND	374,939	LIS	NB	PRK	102,517
LIS	WB	LND	1456,013	LIS	WB	PRK	338,553
LPA	NB	LND	379,384	LPA	NB	PRK	45,034
LPA	WB	LND	1359,891	LPA	WB	PRK	110,221
LUX	NB	LND	462,401	LUX	NB	PRK	88,896
LUX	WB	LND	1527,038	LUX	WB	PRK	293,57
LYS	NB	LND	304,905	LYS	NB	PRK	449,066
LYS	WB	LND	1541,647	LYS	WB	PRK	1483,002
MAD	NB	LND	422,142	MAD	NB	PRK	45,034
MAD	WB	LND	1511,447	MAD	WB	PRK	110,221
MED	NB	LND	389,105	MED	NB	PRK	77,821
MED	WB	LND	1284,984	MED	WB	PRK	256,997
MPM	NB	LND	353,009	MPM	NB	PRK	194,935
MPM	WB	LND	970,138	MPM	WB	PRK	643,756
MRS	NB	LND	258,063	MRS	NB	PRK	395,729
MRS	WB	LND	1526,101	MRS	WB	PRK	1306,86
MUC	NB	LND	103,95	MUC	NB	PRK	179,225
MUC	WB	LND	343,287	MUC	WB	PRK	591,875
MXP	NB	LND	127,579	MXP	NB	PRK	137,645
MXP	WB	LND	447,795	MXP	WB	PRK	454,56
NAT	NB	LND	275,833	NAT	NB	PRK	1321,66
NAT	WB	LND	910,915	NAT	WB	PRK	4364,668
NCE	NB	LND	505,811	NCE	NB	PRK	430,14
NCE	WB	LND	1446,994	NCE	WB	PRK	1420,5
OPO	NB	LND	374,939	OPO	NB	PRK	102,517
OPO	WB	LND	1456,013	OPO	WB	PRK	338,553
ORY	NB	LND	460,423	ORY	NB	PRK	618,398
ORY	WB	LND	1779,253	ORY	WB	PRK	2042,206
OSL	NB	LND	803,672	OSL	NB	PRK	0
OSL	WB	LND	3420,567	OSL	WB	PRK	0
OXB	NB	LND	338,886	OXB	NB	PRK	584,805
OXB	WB	LND	1404,436	OXB	WB	PRK	1931,269
PDL	NB	LND	263,819	PDL	NB	PRK	102,517
PDL	WB	LND	1025,128	PDL	WB	PRK	338,553
PIX	NB	LND	374,939	PIX	NB	PRK	102,517
PIX	WB	LND	1456,013	PIX	WB	PRK	338,553
PNA	NB	LND	316,168	PNA	NB	PRK	45,034
PNA	WB	LND	1133,948	PNA	WB	PRK	110,221
PRG	NB	LND	517,683	PRG	NB	PRK	935,169
PRG	WB	LND	1215,858	PRG	WB	PRK	3088,316

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IATA Code	Fleet Type	Value (m.u.)	IATA Code	Fleet Type	Value (m.u.)
PUJ	NB LND	214,879	PUJ	NB PRK	21,911
PUJ	WB LND	709,62	PUJ	WB PRK	72,358
PXO	NB LND	785,005	PXO	NB PRK	102,517
PXO	WB LND	3049,34	PXO	WB PRK	338,553
RAI	NB LND	463,868	RAI	NB PRK	133,594
RAI	WB LND	1531,885	RAI	WB PRK	441,183
RAK	NB LND	333,982	RAK	NB PRK	45,371
RAK	WB LND	1644,016	RAK	WB PRK	149,834
REC	NB LND	250,492	REC	NB PRK	1204,699
REC	WB LND	827,227	REC	WB PRK	3978,415
SCQ	NB LND	379,384	SCQ	NB PRK	45,034
SCQ	WB LND	1359,891	SCQ	WB PRK	110,221
SID	NB LND	463,868	SID	NB PRK	133,594
SID	WB LND	1531,885	SID	WB PRK	441,183
SSA	NB LND	275,833	SSA	NB PRK	1321,66
SSA	WB LND	910,915	SSA	WB PRK	4364,668
SVQ	NB LND	422,142	SVQ	NB PRK	45,034
SVQ	WB LND	1511,447	SVQ	WB PRK	110,221
TER	NB LND	374,939	TER	NB PRK	102,517
TER	WB LND	1456,013	TER	WB PRK	338,553
TLS	NB LND	292,138	TLS	NB PRK	387,126
TLS	WB LND	1390,2	TLS	WB PRK	1278,45
TMS	NB LND	194,935	TMS	NB PRK	1949,351
TMS	WB LND	643,756	TMS	WB PRK	6437,564
TUN	NB LND	645,21	TUN	NB PRK	275,29
TUN	WB LND	3551,25	TUN	WB PRK	909,12
VCE	NB LND	131,446	VCE	NB PRK	137,645
VCE	WB LND	458,265	VCE	WB PRK	454,56
VRA	NB LND	248,799	VRA	NB PRK	49,862
VRA	WB LND	821,637	VRA	WB PRK	164,663
WAW	NB LND	516,238	WAW	NB PRK	2280,621
WAW	WB LND	2306,329	WAW	WB PRK	7531,554
ZAG	NB LND	810,097	ZAG	NB PRK	179,225
ZAG	WB LND	2675,275	ZAG	WB PRK	591,875
ZRH	NB LND	406,167	ZRH	NB PRK	2277,299
ZRH	WB LND	1449,361	ZRH	WB PRK	7520,582

Table B.2 City Pairs Distance

Origin	Name	Latitude	Longitude	Latitude	Longitude	Dist (nmi)	Dist (km)
Destination	Name						
ACE	Lanzarote (Spain)	28,94556	-13,60528				
OPO	Porto	41,23547	-8,67796			775,69	1436,58
AGP	Malaga (Spain)	36,675	-4,49917				
LIS	LISBOA	38,77416	-9,13419			253,42	469,34

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Origin	Name	Latitude	Longitude		
Destination	Name	Latitude	Longitude	Dist (nmi)	Dist (km)
AMS	Amterdam (Schiphol)	52,30805	4,76416		
LIS	LISBOA	38,77416	-9,13419	996,56	1845,62
AMS	Amterdam (Schiphol)	52,30805	4,76416		
OPO	Porto	41,23547	-8,67796	861,15	1594,85
ARN	Stockholm (Arlanda)	59,65194	17,91859		
LIS	LISBOA	38,77416	-9,13419	1618,19	2996,9
AZS	Saman? (Dominican Republic)	19,27	-69,7375		
LIS	LISBOA	38,77416	-9,13419	3323,7	6155,5
BCN	Barcelona	41,29707	2,07846		
LIS	LISBOA	38,77416	-9,13419	536,42	993,46
BCN	Barcelona	41,29707	2,07846		
OPO	Porto	41,23547	-8,67796	484,81	897,87
BIO	Bilbao	43,30111	-2,91056		
LIS	LISBOA	38,77416	-9,13419	391,08	724,27
BLQ	Bologna (Borgo Panigale)	44,53083	11,29694		
LIS	LISBOA	38,77416	-9,13419	975,68	1806,95
BLQ	Bologna (Borgo Panigale)	44,53083	11,29694		
ZAG	Zagreb (Pleso)	45,74293	16,06877	214,62	397,48
BRU	Brussels	50,90138	4,48457		
LIS	LISBOA	38,77416	-9,13419	927,05	1716,89
BRU	Brussels	50,90138	4,48457		
OPO	Porto	41,23547	-8,67796	795,53	1473,32
BSB	BRASILIA (Pres. J. Kubitschek)	-15,86917	-47,92084		
LIS	LISBOA	38,77416	-9,13419	3935,27	7288,12
BUD	Budapest	47,43931	19,2618		
LIS	LISBOA	38,77416	-9,13419	1338,63	2479,14
BUD	Budapest	47,43931	19,2618		
PRG	Prague	50,10083	14,26	254,12	470,63
CCS	Maiquetia (Simon Bolivar)	10,60118	-66,99124		
FNC	Madeira	32,69424	-16,77808	3062,63	5671,98
CCS	Maiquetia (Simon Bolivar)	10,60118	-66,99124		
LIS	LISBOA	38,77416	-9,13419	3508,31	6497,39
CCS	Maiquetia (Simon Bolivar)	10,60118	-66,99124		
OPO	Porto	41,23547	-8,67796	3562,03	6596,89
CDG	Paris (Charles de Gaule France)	49,00973	2,5478		
BRU	Brussels	50,90138	4,48457	135,9	251,69
CDG	Paris (Charles de Gaule France)	49,00973	2,5478		
LIS	LISBOA	38,77416	-9,13419	793,29	1469,17
CDG	Paris (Charles de Gaule France)	49,00973	2,5478		
LUX	Luxembourg	49,62325	6,20431	147,66	273,47
CDG	Paris (Charles de Gaule France)	49,00973	2,5478		
OPO	Porto	41,23547	-8,67796	664,59	1230,82
CMN	Mohammed V (Marocco)	33,36722	-7,58972		
LIS	LISBOA	38,77416	-9,13419	332,93	616,6
CNF	Belo Horizonte (Tancredo Neves)	-19,62446	-43,97196		

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Origin	Name	Latitude	Longitude			
Destination	Name	Latitude	Longitude	Dist (nmi)	Dist (km)	
LIS	LISBOA	38,77416	-9,13419	4013,79	7433,54	
CPH	Copenhagen Denmark	55,6179	12,65597			
ARN	Stockholm (Arlanda)	59,65194	17,91859	295,03	546,39	
CPH	Copenhagen Denmark	55,6179	12,65597			
LIS	LISBOA	38,77416	-9,13419	1334,08	2470,71	
DKR	Dakar (Leopold S. Senghor)	14,74389	-17,47946			
LIS	LISBOA	38,77416	-9,13419	1507,8	2792,44	
DME	MOSCOW/DOMODEDOVO	55,40833	37,90833			
LIS	LISBOA	38,77416	-9,13419	2111,9	3911,24	
EWR	Newark	40,69248	-74,16868			
LIS	LISBOA	38,77416	-9,13419	2932	5430,07	
EWR	Newark	40,69248	-74,16868			
OPO	Porto	41,23547	-8,67796	2893,05	5357,93	
FAO	Faro	37,01444	-7,96584			
LIS	LISBOA	38,77416	-9,13419	119,19	220,75	
FAO	Faro	37,01444	-7,96584			
OPO	Porto	41,23547	-8,67796	255,42	473,03	
FCO	Roma (Fiumicino)	41,80028	12,23888			
LIS	LISBOA	38,77416	-9,13419	992,22	1837,6	
FCO	Roma (Fiumicino)	41,80028	12,23888			
OPO	Porto	41,23547	-8,67796	937,98	1737,14	
FNC	Madeira	32,69424	-16,77808			
CCS	Maiquetia (Simon Bolivar)	10,60118	-66,99124	3062,63	5671,98	
FNC	Madeira	32,69424	-16,77808			
LGW	London (Gatwick)	51,14805	-0,19029	1325,27	2454,39	
FNC	Madeira	32,69424	-16,77808			
LIS	LISBOA	38,77416	-9,13419	520,84	964,59	
FNC	Madeira	32,69424	-16,77808			
MAD	Madrid (Barajas)	40,47222	-3,56096	788,04	1459,44	
FNC	Madeira	32,69424	-16,77808			
OPO	Porto	41,23547	-8,67796	642,32	1189,58	
FOR	Fortaleza (Pinto Martins)	-3,77612	-38,53251			
LIS	LISBOA	38,77416	-9,13419	3028,08	5608,01	
FRA	Frankfurt (Main)	50,03331	8,57045			
LIS	LISBOA	38,77416	-9,13419	1011,37	1873,06	
FUE	Fuerteventura (Spain)	28,45278	-13,86389			
OPO	Porto	41,23547	-8,67796	807,94	1496,3	
GIG	Rio De Janeiro (Galeao)	-22,81002	-43,25056			
LIS	LISBOA	38,77416	-9,13419	4162,73	7709,38	
GIG	Rio De Janeiro (Galeao)	-22,81002	-43,25056			
OPO	Porto	41,23547	-8,67796	4297,47	7958,91	
GRU	Sao Paulo (Guarulhos)	-23,43558	-46,47307			
LIS	LISBOA	38,77416	-9,13419	4281,52	7929,38	
GRU	Sao Paulo (Guarulhos)	-23,43558	-46,47307			
OPO	Porto	41,23547	-8,67796	4413,41	8173,64	

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Origin	Name	Latitude	Longitude			
Destination	Name	Latitude	Longitude	Dist (nmi)	Dist (km)	
GVA	Geneva (Cointrin)	46,23832	6,01094			
FAO	Faro	37,01444	-7,96584	833,97	1544,51	
GVA	Geneva (Cointrin)	46,23832	6,01094			
LIS	LISBOA	38,77416	-9,13419	803,68	1488,42	
GVA	Geneva (Cointrin)	46,23832	6,01094			
OPO	Porto	41,23547	-8,67796	702,54	1301,11	
GVA	Geneva (Cointrin)	46,23832	6,01094			
ZRH	Zurich	47,45832	8,54805	127,26	235,68	
HAM	Hamburg	53,63038	9,98823			
LIS	LISBOA	38,77416	-9,13419	1186,15	2196,76	
HEL	Helsinki (Vantaa)	60,31722	24,96332			
LIS	LISBOA	38,77416	-9,13419	1815,44	3362,19	
HER	Heraklion (Greece)	35,33583	25,17361			
LIS	LISBOA	38,77416	-9,13419	1645,98	3048,35	
HOR	Horta	38,51989	-28,71639			
LIS	LISBOA	38,77416	-9,13419	916	1696,44	
JNB	Johannesburg (O. R. Tambo Intl)	-26,13371	28,24231			
LIS	LISBOA	38,77416	-9,13419	4423,11	8191,6	
JNB	Johannesburg (O. R. Tambo Intl)	-26,13371	28,24231			
MPM	Maputo	-25,92085	32,5726	233,81	433,01	
KGS	Kos Island (Greece)	36,79334	27,09167			
HER	Heraklion (Greece)	35,33583	25,17361	127,67	236,45	
LAD	Luanda	-8,85771	13,22833			
LIS	LISBOA	38,77416	-9,13419	3118,7	5775,83	
LCG	A Coru?a (Spain)	43,30194	-8,37722			
LIS	LISBOA	38,77416	-9,13419	273,81	507,1	
LGW	London (Gatwick)	51,14805	-0,19029			
FNC	Madeira	32,69424	-16,77808	1325,27	2454,39	
LGW	London (Gatwick)	51,14805	-0,19029			
LIS	LISBOA	38,77416	-9,13419	832,47	1541,73	
LGW	London (Gatwick)	51,14805	-0,19029			
OPO	Porto	41,23547	-8,67796	690,34	1278,51	
LHR	London (Heathrow)	51,47749	-0,46141			
LIS	LISBOA	38,77416	-9,13419	844,62	1564,24	
LHR	London (Heathrow)	51,47749	-0,46141			
OPO	Porto	41,23547	-8,67796	701,41	1299,01	
LIN	MilaN (Linate)	45,44943	9,27832			
LIS	LISBOA	38,77416	-9,13419	909,3	1684,03	
LIS	LISBOA	38,77416	-9,13419			
ACE	Lanzarote (Spain)	28,94556	-13,60528	630,16	1167,05	
LIS	LISBOA	38,77416	-9,13419			
AGP	Malaga (Spain)	36,675	-4,49917	253,42	469,34	
LIS	LISBOA	38,77416	-9,13419			
AMS	Amterdam (Schiphol)	52,30805	4,76416	996,56	1845,62	
LIS	LISBOA	38,77416	-9,13419			

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Origin	Name	Latitude	Longitude		
Destination	Name	Latitude	Longitude	Dist (nmi)	Dist (km)
ARN	Stockholm (Arlanda)	59,65194	17,91859	1618,19	2996,9
LIS	LISBOA	38,77416	-9,13419		
AZS	Saman? (Dominican Republic)	19,27	-69,7375	3323,7	6155,5
LIS	LISBOA	38,77416	-9,13419		
BCN	Barcelona	41,29707	2,07846	536,42	993,46
LIS	LISBOA	38,77416	-9,13419		
BIO	Bilbao	43,30111	-2,91056	391,08	724,27
LIS	LISBOA	38,77416	-9,13419		
BLQ	Bologna (Borgo Panigale)	44,53083	11,29694	975,68	1806,95
LIS	LISBOA	38,77416	-9,13419		
BRU	Brussels	50,90138	4,48457	927,05	1716,89
LIS	LISBOA	38,77416	-9,13419		
BSB	BRASILIA (Pres. J. Kubitschek)	-15,86917	-47,92084	3935,27	7288,12
LIS	LISBOA	38,77416	-9,13419		
BUD	Budapest	47,43931	19,2618	1338,63	2479,14
LIS	LISBOA	38,77416	-9,13419		
CCS	Maiquetia (Simon Bolivar)	10,60118	-66,99124	3508,31	6497,39
LIS	LISBOA	38,77416	-9,13419		
CDG	Paris (Charles de Gaule France)	49,00973	2,5478	793,29	1469,17
LIS	LISBOA	38,77416	-9,13419		
CMN	Mohammed V (Marocco)	33,36722	-7,58972	332,93	616,6
LIS	LISBOA	38,77416	-9,13419		
CNF	Belo Horizonte (Tancredo Neves)	-19,62446	-43,97196	4013,79	7433,54
LIS	LISBOA	38,77416	-9,13419		
CPH	Copenhagen Denmark	55,6179	12,65597	1334,08	2470,71
LIS	LISBOA	38,77416	-9,13419		
DKR	Dakar (Leopold S. Senghor)	14,74389	-17,47946	1507,8	2792,44
LIS	LISBOA	38,77416	-9,13419		
DME	MOSCOW/DOMODEDOVO	55,40833	37,90833	2111,9	3911,24
LIS	LISBOA	38,77416	-9,13419		
EWR	Newark	40,69248	-74,16868	2932	5430,07
LIS	LISBOA	38,77416	-9,13419		
FAO	Faro	37,01444	-7,96584	119,19	220,75
LIS	LISBOA	38,77416	-9,13419		
FCO	Roma (Fiumicino)	41,80028	12,23888	992,22	1837,6
LIS	LISBOA	38,77416	-9,13419		
FNC	Madeira	32,69424	-16,77808	520,84	964,59
LIS	LISBOA	38,77416	-9,13419		
FOR	Fortaleza (Pinto Martins)	-3,77612	-38,53251	3028,08	5608,01
LIS	LISBOA	38,77416	-9,13419		
FRA	Frankfurt (Main)	50,03331	8,57045	1011,37	1873,06
LIS	LISBOA	38,77416	-9,13419		
FUE	Fuerteventura (Spain)	28,45278	-13,86389	662,57	1227,08
LIS	LISBOA	38,77416	-9,13419		
GIG	Rio De Janeiro (Galeao)	-22,81002	-43,25056	4162,73	7709,38

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Origin	Name	Latitude	Longitude		
Destination	Name	Latitude	Longitude	Dist (nmi)	Dist (km)
LIS	LISBOA	38,77416	-9,13419		
GRU	Sao Paulo (Guarulhos)	-23,43558	-46,47307	4281,52	7929,38
LIS	LISBOA	38,77416	-9,13419		
GVA	Geneva (Cointrin)	46,23832	6,01094	803,68	1488,42
LIS	LISBOA	38,77416	-9,13419		
HAM	Hamburg	53,63038	9,98823	1186,15	2196,76
LIS	LISBOA	38,77416	-9,13419		
HEL	Helsinki (Vantaa)	60,31722	24,96332	1815,44	3362,19
LIS	LISBOA	38,77416	-9,13419		
HOR	Horta	38,51989	-28,71639	916	1696,44
LIS	LISBOA	38,77416	-9,13419		
JNB	Johannesburg (O. R. Tambo Intl)	-26,13371	28,24231	4423,11	8191,6
LIS	LISBOA	38,77416	-9,13419		
KGS	Kos Island (Greece)	36,79334	27,09167	1710,72	3168,25
LIS	LISBOA	38,77416	-9,13419		
LAD	Luanda	-8,85771	13,22833	3118,7	5775,83
LIS	LISBOA	38,77416	-9,13419		
LCG	A Coru?a (Spain)	43,30194	-8,37722	273,81	507,1
LIS	LISBOA	38,77416	-9,13419		
LGW	London (Gatwick)	51,14805	-0,19029	832,47	1541,73
LIS	LISBOA	38,77416	-9,13419		
LHR	London (Heathrow)	51,47749	-0,46141	844,62	1564,24
LIS	LISBOA	38,77416	-9,13419		
LIN	MilaN (Linate)	45,44943	9,27832	909,3	1684,03
LIS	LISBOA	38,77416	-9,13419		
LPA	Gran Canaria (Spain)	27,93194	-15,38667	721,58	1336,37
LIS	LISBOA	38,77416	-9,13419		
LUX	Luxembourg	49,62325	6,20431	923,47	1710,26
LIS	LISBOA	38,77416	-9,13419		
LYS	Lyon (St Exupery)	45,72563	5,08109	754,94	1398,15
LIS	LISBOA	38,77416	-9,13419		
MAD	Madrid (Barajas)	40,47222	-3,56096	276,92	512,86
LIS	LISBOA	38,77416	-9,13419		
MPM	Maputo	-25,92085	32,5726	4532,32	8393,86
LIS	LISBOA	38,77416	-9,13419		
MRS	Marseille (Provence)	43,43666	5,21499	705,26	1306,14
LIS	LISBOA	38,77416	-9,13419		
MUC	Munich	48,35377	11,78608	1070,55	1982,66
LIS	LISBOA	38,77416	-9,13419		
MPX	Milan (Malpensa)	45,63	8,72304	891,2	1650,51
LIS	LISBOA	38,77416	-9,13419		
NAT	Natal	-5,90835	-35,24918	3048,81	5646,39
LIS	LISBOA	38,77416	-9,13419		
NCE	Nice (Cote D Azur)	43,6654	7,21497	792,38	1467,48
LIS	LISBOA	38,77416	-9,13419		

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Origin	Name	Latitude	Longitude		
Destination	Name	Latitude	Longitude	Dist (nmi)	Dist (km)
OPO	Porto	41,23547	-8,67796	149,16	276,24
LIS	LISBOA	38,77416	-9,13419		
ORY	Paris (Orly)	48,72327	2,37957	776,29	1437,7
LIS	LISBOA	38,77416	-9,13419		
OSL	Oslo (Gardemoen)	60,20276	11,08388	1494,34	2767,52
LIS	LISBOA	38,77416	-9,13419		
OXB	Bissau (Oswaldo Vieira)	11,8886	-15,65556	1650,27	3056,29
LIS	LISBOA	38,77416	-9,13419		
PDL	Ponta Delgada	37,74196	-25,69766	781,75	1447,8
LIS	LISBOA	38,77416	-9,13419		
PIX	Pico	38,55433	-28,44135	902,94	1672,24
LIS	LISBOA	38,77416	-9,13419		
PNA	Pamplona (Spain)	42,77	-1,647	415,93	770,31
LIS	LISBOA	38,77416	-9,13419		
PRG	Prague	50,10083	14,26	1202,79	2227,57
LIS	LISBOA	38,77416	-9,13419		
PUJ	Punta Cana (Dominican Republic)	18,56667	-68,35194	3282,96	6080,05
LIS	LISBOA	38,77416	-9,13419		
PXO	Porto Santo	33,07082	-16,34974	489,59	906,72
LIS	LISBOA	38,77416	-9,13419		
RAI	Praia	14,94111	-23,48471	1618,36	2997,2
LIS	LISBOA	38,77416	-9,13419		
RAK	Marrakech (Marocco)	31,60694	-8,03639	433,38	802,62
LIS	LISBOA	38,77416	-9,13419		
REC	Recife (Guararapes)	-8,12641	-34,92279	3160,22	5852,73
LIS	LISBOA	38,77416	-9,13419		
SID	Sal (Amilcar Cabral)	16,74194	-22,94889	1507,55	2791,99
LIS	LISBOA	38,77416	-9,13419		
SSA	Salvador (Dep. Luis Magalhaes)	-12,90861	-38,3225	3505,87	6492,88
LIS	LISBOA	38,77416	-9,13419		
SVQ	Seville (Spain)	37,41806	-5,89889	173,07	320,52
LIS	LISBOA	38,77416	-9,13419		
TER	Lajes	38,76193	-27,0909	838,68	1553,24
LIS	LISBOA	38,77416	-9,13419		
TLS	Toulouse (Blagnac)	43,63512	1,36784	555,96	1029,65
LIS	LISBOA	38,77416	-9,13419		
TUN	Tunis - Carthage (Tunisia)	36,85111	10,22722	923,22	1709,8
LIS	LISBOA	38,77416	-9,13419		
VCE	Venice (Tessera)	45,50526	12,35194	1033,65	1914,32
LIS	LISBOA	38,77416	-9,13419		
VRA	Varadero (Cuba)	23,03444	-81,43528	3744,52	6934,85
LIS	LISBOA	38,77416	-9,13419		
WAW	Warszawa - Ociecie Poland	52,016	20,967	1480,38	2741,66
LIS	LISBOA	38,77416	-9,13419		
ZAG	Zagreb (Pleso)	45,74293	16,06877	1188,63	2201,34

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Origin	Name	Latitude	Longitude			
Destination	Name	Latitude	Longitude	Dist (nmi)	Dist (km)	
LIS	LISBOA	38,77416	-9,13419			
ZRH	Zurich	47,45832	8,54805	929,98	1722,32	
LPA	Gran Canaria (Spain)	27,93194	-15,38667			
OPO	Porto	41,23547	-8,67796	863,55	1599,3	
LUX	Luxembourg	49,62325	6,20431			
LIS	LISBOA	38,77416	-9,13419	923,47	1710,26	
LUX	Luxembourg	49,62325	6,20431			
OPO	Porto	41,23547	-8,67796	801,23	1483,89	
LYS	Lyon (St Exupery)	45,72563	5,08109			
LIS	LISBOA	38,77416	-9,13419	754,94	1398,15	
MAD	Madrid (Barajas)	40,47222	-3,56096			
FNC	Madeira	32,69424	-16,77808	788,04	1459,44	
MAD	Madrid (Barajas)	40,47222	-3,56096			
LIS	LISBOA	38,77416	-9,13419	276,92	512,86	
MAD	Madrid (Barajas)	40,47222	-3,56096			
OPO	Porto	41,23547	-8,67796	236,66	438,29	
MED	Medina (Saudi Arabia)	24,55333	39,705			
LIS	LISBOA	38,77416	-9,13419	2602,07	4819,04	
MPM	Maputo	-25,92085	32,5726			
JNB	Johannesburg (O. R. Tambo Intl)	-26,13371	28,24231	233,81	433,01	
MPM	Maputo	-25,92085	32,5726			
LIS	LISBOA	38,77416	-9,13419	4532,32	8393,86	
MRS	Marseille (Provence)	43,43666	5,21499			
LIS	LISBOA	38,77416	-9,13419	705,26	1306,14	
MUC	Munich	48,35377	11,78608			
FAO	Faro	37,01444	-7,96584	1099,8	2036,83	
MUC	Munich	48,35377	11,78608			
LIS	LISBOA	38,77416	-9,13419	1070,55	1982,66	
MXP	Milan (Malpensa)	45,63	8,72304			
LIS	LISBOA	38,77416	-9,13419	891,2	1650,51	
MXP	Milan (Malpensa)	45,63	8,72304			
OPO	Porto	41,23547	-8,67796	800,76	1483,01	
NAT	Natal	-5,90835	-35,24918			
LIS	LISBOA	38,77416	-9,13419	3048,81	5646,39	
NCE	Nice (Cote D Azur)	43,6654	7,21497			
LIS	LISBOA	38,77416	-9,13419	792,38	1467,48	
OPO	Porto	41,23547	-8,67796			
AMS	Amterdam (Schiphol)	52,30805	4,76416	861,15	1594,85	
OPO	Porto	41,23547	-8,67796			
BCN	Barcelona	41,29707	2,07846	484,81	897,87	
OPO	Porto	41,23547	-8,67796			
BRU	Brussels	50,90138	4,48457	795,53	1473,32	
OPO	Porto	41,23547	-8,67796			
CCS	Maiquetia (Simon Bolivar)	10,60118	-66,99124	3562,03	6596,89	
OPO	Porto	41,23547	-8,67796			

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Origin	Name	Latitude	Longitude			
Destination	Name	Latitude	Longitude	Dist (nmi)	Dist (km)	
CDG	Paris (Charles de Gaulle France)	49,00973	2,5478	664,59	1230,82	
OPO	Porto	41,23547	-8,67796			
EWR	Newark	40,69248	-74,16868	2893,05	5357,93	
OPO	Porto	41,23547	-8,67796			
FAO	Faro	37,01444	-7,96584	255,42	473,03	
OPO	Porto	41,23547	-8,67796			
FCO	Roma (Fiumicino)	41,80028	12,23888	937,98	1737,14	
OPO	Porto	41,23547	-8,67796			
FNC	Madeira	32,69424	-16,77808	642,32	1189,58	
OPO	Porto	41,23547	-8,67796			
GIG	Rio De Janeiro (Galeao)	-22,81002	-43,25056	4297,47	7958,91	
OPO	Porto	41,23547	-8,67796			
GRU	Sao Paulo (Guarulhos)	-23,43558	-46,47307	4413,41	8173,64	
OPO	Porto	41,23547	-8,67796			
GVA	Geneva (Cointrin)	46,23832	6,01094	702,54	1301,11	
OPO	Porto	41,23547	-8,67796			
LGW	London (Gatwick)	51,14805	-0,19029	690,34	1278,51	
OPO	Porto	41,23547	-8,67796			
LHR	London (Heathrow)	51,47749	-0,46141	701,41	1299,01	
OPO	Porto	41,23547	-8,67796			
LIS	LISBOA	38,77416	-9,13419	149,16	276,24	
OPO	Porto	41,23547	-8,67796			
LUX	Luxembourg	49,62325	6,20431	801,23	1483,89	
OPO	Porto	41,23547	-8,67796			
MAD	Madrid (Barajas)	40,47222	-3,56096	236,66	438,29	
OPO	Porto	41,23547	-8,67796			
MXP	Milan (Malpensa)	45,63	8,72304	800,76	1483,01	
OPO	Porto	41,23547	-8,67796			
ORY	Paris (Orly)	48,72327	2,37957	648,45	1200,93	
OPO	Porto	41,23547	-8,67796			
PXO	Porto Santo	33,07082	-16,34974	611,46	1132,43	
OPO	Porto	41,23547	-8,67796			
SCQ	Santiago de Compostela (Spain)	42,89639	-8,41528	100,34	185,83	
OPO	Porto	41,23547	-8,67796			
TUN	Tunis - Carthage (Tunisia)	36,85111	10,22722	917,28	1698,8	
OPO	Porto	41,23547	-8,67796			
ZRH	Zurich	47,45832	8,54805	825,6	1529,01	
ORY	Paris (Orly)	48,72327	2,37957			
LIS	LISBOA	38,77416	-9,13419	776,29	1437,7	
ORY	Paris (Orly)	48,72327	2,37957			
OPO	Porto	41,23547	-8,67796	648,45	1200,93	
OSL	Oslo (Gardemoen)	60,20276	11,08388			
LIS	LISBOA	38,77416	-9,13419	1494,34	2767,52	
OXB	Bissau (Osvaldo Vieira)	11,8886	-15,65556			
LIS	LISBOA	38,77416	-9,13419	1650,27	3056,29	

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Origin	Name	Latitude	Longitude			
Destination	Name	Latitude	Longitude	Dist (nmi)	Dist (km)	
PDL	Ponta Delgada	37,74196	-25,69766			
LIS	LISBOA	38,77416	-9,13419	781,75	1447,8	
PIX	Pico	38,55433	-28,44135			
TER	Lajes	38,76193	-27,0909	64,49	119,43	
PNA	Pamplona (Spain)	42,77	-1,647			
LIS	LISBOA	38,77416	-9,13419	415,93	770,31	
PRG	Prague	50,10083	14,26			
BUD	Budapest	47,43931	19,2618	254,12	470,63	
PRG	Prague	50,10083	14,26			
LIS	LISBOA	38,77416	-9,13419	1202,79	2227,57	
PUJ	Punta Cana (Dominican Republic)	18,56667	-68,35194			
LIS	LISBOA	38,77416	-9,13419	3282,96	6080,05	
PXO	Porto Santo	33,07082	-16,34974			
FNC	Madeira	32,69424	-16,77808	31,25	57,87	
PXO	Porto Santo	33,07082	-16,34974			
LIS	LISBOA	38,77416	-9,13419	489,59	906,72	
PXO	Porto Santo	33,07082	-16,34974			
OPO	Porto	41,23547	-8,67796	611,46	1132,43	
RAI	Praia	14,94111	-23,48471			
LIS	LISBOA	38,77416	-9,13419	1618,36	2997,2	
RAK	Marrakech (Marocco)	31,60694	-8,03639			
MED	Medina (Saudi Arabia)	24,55333	39,705	2542,67	4709,02	
REC	Recife (Guararapes)	-8,12641	-34,92279			
LIS	LISBOA	38,77416	-9,13419	3160,22	5852,73	
SCQ	Santiago de Compostela (Spain)	42,89639	-8,41528			
LGW	London (Gatwick)	51,14805	-0,19029	597,77	1107,07	
SID	Sal (Amilcar Cabral)	16,74194	-22,94889			
LIS	LISBOA	38,77416	-9,13419	1507,55	2791,99	
SSA	Salvador (Dep. Luis Magalhaes)	-12,90861	-38,3225			
LIS	LISBOA	38,77416	-9,13419	3505,87	6492,88	
SVQ	Seville (Spain)	37,41806	-5,89889			
LIS	LISBOA	38,77416	-9,13419	173,07	320,52	
TER	Lajes	38,76193	-27,0909			
LIS	LISBOA	38,77416	-9,13419	838,68	1553,24	
TLS	Toulouse (Blagnac)	43,63512	1,36784			
LIS	LISBOA	38,77416	-9,13419	555,96	1029,65	
TUN	Tunis - Carthage (Tunisia)	36,85111	10,22722			
LIS	LISBOA	38,77416	-9,13419	923,22	1709,8	
TUN	Tunis - Carthage (Tunisia)	36,85111	10,22722			
OPO	Porto	41,23547	-8,67796	917,28	1698,8	
VCE	Venice (Tessera)	45,50526	12,35194			
LIS	LISBOA	38,77416	-9,13419	1033,65	1914,32	
VRA	Varadero (Cuba)	23,03444	-81,43528			
LIS	LISBOA	38,77416	-9,13419	3744,52	6934,85	
WAW	Warszawa - Ociecie Poland	52,016	20,967			

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Origin	Name	Latitude	Longitude		
Destination	Name	Latitude	Longitude	Dist (nmi)	Dist (km)
LIS	LISBOA	38,77416	-9,13419	1480,38	2741,66
ZAG	Zagreb (Pleso)	45,74293	16,06877		
BLQ	Bologna (Borgo Panigale)	44,53083	11,29694	214,62	397,48
ZAG	Zagreb (Pleso)	45,74293	16,06877		
LIS	LISBOA	38,77416	-9,13419	1188,63	2201,34
ZRH	Zurich	47,45832	8,54805		
FAO	Faro	37,01444	-7,96584	961,22	1780,19
ZRH	Zurich	47,45832	8,54805		
LIS	LISBOA	38,77416	-9,13419	929,98	1722,32
ZRH	Zurich	47,45832	8,54805		
OPO	Porto	41,23547	-8,67796	825,6	1529,01

Table B.3 Average ATC, Maintenance, Fuel and Handling Costs by Aircraft Model

Aircraft Model	Fleet	Pax	MTOW	ATC Cost (per nmi)	Maint Cost (per min)	Fuel Cost (per min)	Airp Hand (per a/c)
A310	WB	202	138600	2,24	16,17	22,99	1386
A319	NB	132	68000	2,38	10,5	15,34	950
A320	NB	156	73500	2,88	10,33	16,52	950
A321	NB	194	83000	2,56	12	19,23	1000
A330	WB	230	230000	2,24	16,17	37,11	2250
A340	WB	274	257000	2,75	25	43,78	2520
BEH	NB	19	7688	2,38	6,17	6,35	100
ER4	NB	45	20990	2,38	7,67	8,29	350
F100	NB	99	43090	2,38	9	12,9	580

Table B.4 Crew member DHC (Extra-Crew) Costs

Airline Company	Cost per flight (m.u.)
8X	30
NI	30
S4	30
TM	30
TP	0
UA	30

Table B.5 Hotel Costs per Night for Crew members and Disrupted Passengers

Hotel Code	Airport	Crewmember Cost per night (m.u.)	Passenger Cost per night (m.u.)
AMSHTL	AMS	103,4	113,74
BCNMEL	BCN	83,5	91,85
BRUHIL	BRU	63,5	69,85
BSBALV	BSB	63,45	69,8
CCSMEL	CCS	64,07	70,48
CDGHTL	CDG	75	82,5
CNFHTL	CNF	57,68	63,45
CPHRDS	CPH	123,63	135,99
FAOEVA	FAO	30,67	33,73
FCOSHT	FCO	66,75	73,43
FNCHTL	FNC	47	51,7
FORHT3	FOR	42,3	46,53
FRAHTL	FRA	63	69,3
GVANH	GVA	69,49	76,44
HAMHTL	HAM	68	74,8
HELHTL	HEL	58	63,8
HILORY	ORY	60	66
JNBRAD	JNB	148,21	163,03
LHRHTL	LHR	64,58	71,04
LINSHT	LIN	79	86,9
LISOLI	LIS	46,5	51,15
MADALA	MAD	59,6	65,56
MPMROV	MPM	57,78	63,56
MUCHTL	MUC	59	64,9
NATHTL	NAT	58,45	64,3
NYCHTL	EWR	62,44	68,69
OPOTIR	OPO	42	46,2
RECPAL	REC	40,28	44,31
RIOINT	GIG	49,45	54,39
SAOHTL	GRU	39,72	43,69
SSAHTL	SSA	54,9	60,39
ZRHHTL	ZRH	84,71	93,18

Table B.6 Monthly and Hourly Salary and Perdiem Values for each Crew Salary Rank

Salary Rank	Monthly Salary (m.u.)	Hourly Salary (m.u.)	Perdiem (m.u.)
CAB0	726	18	31
CAB1	924	23	66
CAB2	1238	31	67
CAB3	1540	39	68
CAB4	1712	43	69
CAB5	1795	45	70
CABi	582	15	31
CC1	2029	51	71
CC2	2087	52	72
CC3	2134	53	73
CTE	5886	130	111
OP1	4475	99	86
OP2	3856	85	77
SC1	2316	58	74
SC2	2441	61	75
SC3	2505	63	76

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Glossary

Aircraft Recovery. The process of assigning individual aircraft to a disrupted flight minimizing a specific objective (usually the cost) while complying with required rules.

Benevolence. In a Multi-Agent System it is an *a priori* disposition for the agents to be helpful, e.g., to cooperate.

Bounded-Rationality. The rationality of the agents are limited by the finite amount of time they have to make decisions and, possibly, by the limited information they have.

Crew Recovery. The process of assigning individual crew members to a disrupted flight minimizing a specific objective (usually the cost) while complying with required rules.

Dead Head Crew. See meaning of Extra-crew below.

Disruption. An interruption to the regular flow or sequence of something.

Disrupted Aircraft. An aircraft which cannot complete its original schedule.

Disrupted Crew member. A crew member which cannot complete its original schedule.

Disrupted Flight. A flight that, due to an unexpected event, cannot depart and/or arrive on its schedule time.

Disrupted Passenger. A passenger that has lost one or more flight connections due to a disrupted flight.

Extra-Crew. A crew member assigned to fly as a passenger on a specific flight so he can get to another city to work, where he will pick up his assigned trip sequence, or to return to his operational base after performing a flight.

Flight Recovery. The process of repairing a flight schedule after a disruption, through specific actions like delay, cancel or divert flights from their original schedule, so that the flight delay is minimized.

Hub-and-Spoke Network. A system of air transportation in which local airports offer air transportation to a central airport where long-distance flights are available and vice versa.

Integrated Solution. A solution that takes into consideration all the dimensions (or parts) of a problem simultaneously. In the specific case of the AOC a solution that includes the aircraft, crew and passenger dimensions of the problem.

Passenger Recovery. The process of finding alternate itineraries, commencing at the disrupted passenger location and terminating at their destination or a location nearby, while minimizing a specific objective (usually the passenger trip time and the airline costs).

Rationality. An agent is rational in the sense that it will try to maximize its individual utility and act according to its preferences. It is purely rational if it has full or perfect information about exactly what will occur due to any choice made and has the cognitive ability and time to weight every choice against every other choice.