



AGIFORS Crew Management Study Group@Cancun, April 2001

Airline crew recovery OR model at Alitalia

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Introduction

In Kuala Lumpur the Alitalia OR group presented:

Crew Pairing Regeneration

we gave an overview of the process

Then last year in Cape Town we made a technical presentation about

Crew Pairing Regeneration & Crew Pairing Reassignment

a complete prototype for Crew Pairing Maintenance (CPM)

Now we deal with the

State of art of model for CPM at Alitalia

we will present flowchart of process, description of models and demo of application.





Crew process

The focus is on the "*pre-operative*" *activities of cockpit*, that is *one week until the day of operations*.

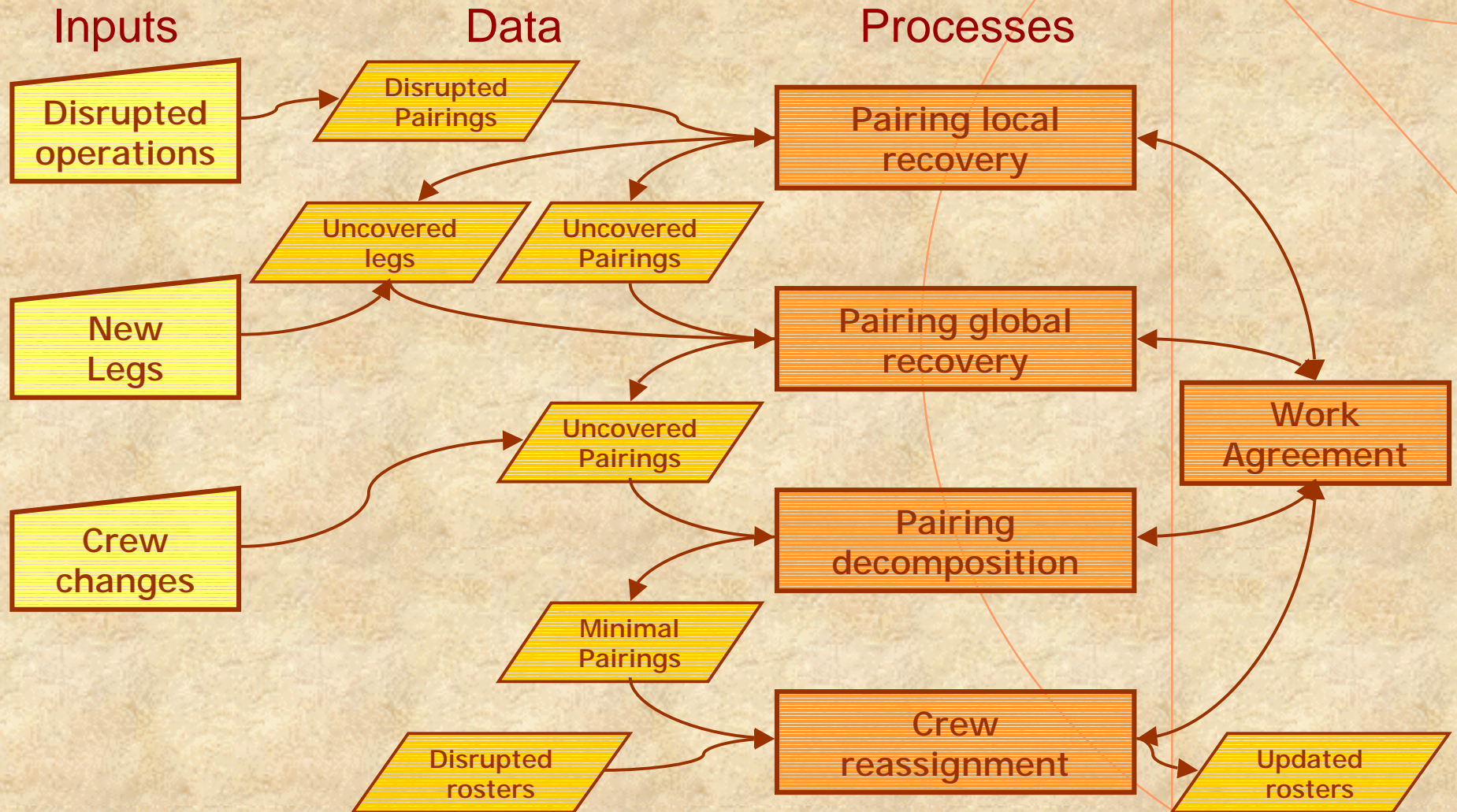
Aim of our work is to manage different disruptive events:

- ◆ schedule changes (strike calls, closure of airports, commercial opportunities,...)
- ◆ addition of new legs (ferry or special flights, aircraft type changes...)
- ◆ crew changes (planned absences,...)

They are managed applying different combinations of the same modules.



The whole process flows





Short description of optimization models

1/4

- ◆ The **Pairing local recovery** step is an heuristic model based on an iterative procedure and taboo search that allows to repair disrupted crew pairings looking for best deadheads and local solution (limited scope)
- ◆ Its objective is a linear combination of:
 - ◆ minimize the number of **uncovered legs**
 - ◆ minimize the number of **deadhead legs**
 - ◆ minimize the **pairing changes**
 - ◆ find the **best legal planned pairings** to cover new flights to schedule





Short description of optimization models

2/4

- ◆ The **Pairing global recovery** step is an optimization IP model based on set covering and column generation technique.
- ◆ Its aim is to regenerate the disrupted pairings
 - ◆ covering all legs
 - ◆ minimizing the differences among the new and the planned pairings
 - ◆ taking in account the available crew in each home base
- ◆ Bounded time domain (typically one day)
- ◆ Larger scope for involved pairings
 - ◆ with respect to pairing local recovery solution, that offers legs and deadhead initial domain.



Short description of optimization models

3/4

- ◆ The **Crew Reassignment** step is described as an optimization MIP model and it is solved with CPLEX.
- ◆ Its aim is to replace the disrupted pairings in the schedule with the new ones
 - ◆ minimizing the **differences** among the new and the planned schedule.
 - ◆ minimizing the **sum of duty days** for the new pairings
 - ◆ minimizing the **reserve utilization**
 - ◆ maximize **likeness** between new pairings and planned ones.



Short description of optimization models

4/4

New implementation of **Work Agreement** module.

Now it seems to be like a **Rules Editor & configuration PNT**

It is developed as an independent module (external library) from optimization models. It is easy to personalize and to implement a new rules set and change parameters of agreement.





Rules Editor

RuleSet = "PairingLegalityCheck"

Rule : "AgreementPairingNumDays"
Rule : "AgreementDailyActivity"
Rule : "DutyLengthAfterRest"
Rule : "MaxTransitTime"
Rule : "MinTransitTime"
Rule : "NonConsecutiveDailyActivity"
Rule : "SingleDutyInDaySoftRule"
Rule : "NoStationSwitchInDuty"
Rule : "AgreementRestValidate"

RuleSet = "SoftRulesCheck"

Rule : "NoStationSwitchInDuty"
Rule : "SingleDutyInDaySoftRule"
Rule : "MinTransitTime"
Rule : "MaxTransitTime"



Improvement in optimization models: Time

- ◆ Time savings is the result of improvement in models formulation .
What have we reduced to save time?
 - ◆ Clear definition of a **bounded domain** of flights
(Pairing local recovery)
 - ◆ Number of **legal pairings** involved in solution (Pairing global recovery)
 - ◆ Number of "**Useful combinations**" between new pairings and hole
(Crew Reassignment)



Improvement :Quality of Result

1/2

- ◆ The cost for the new pairing is reduced in different aspects:
 - ◆ Number of **deadheads** used in solution
 - ◆ **Scope**, the use of legal pairings to find an optimal solution is limited.
 - ◆ **Multi-hub**, the number of new pairings are distributed in a proportional way respect to the original planned pairings. So the activities on the hubs are always balanced in new schedule.
 - ◆ Number Of **duty days** for the new pairings



Improvement: Quality of Output

2/2

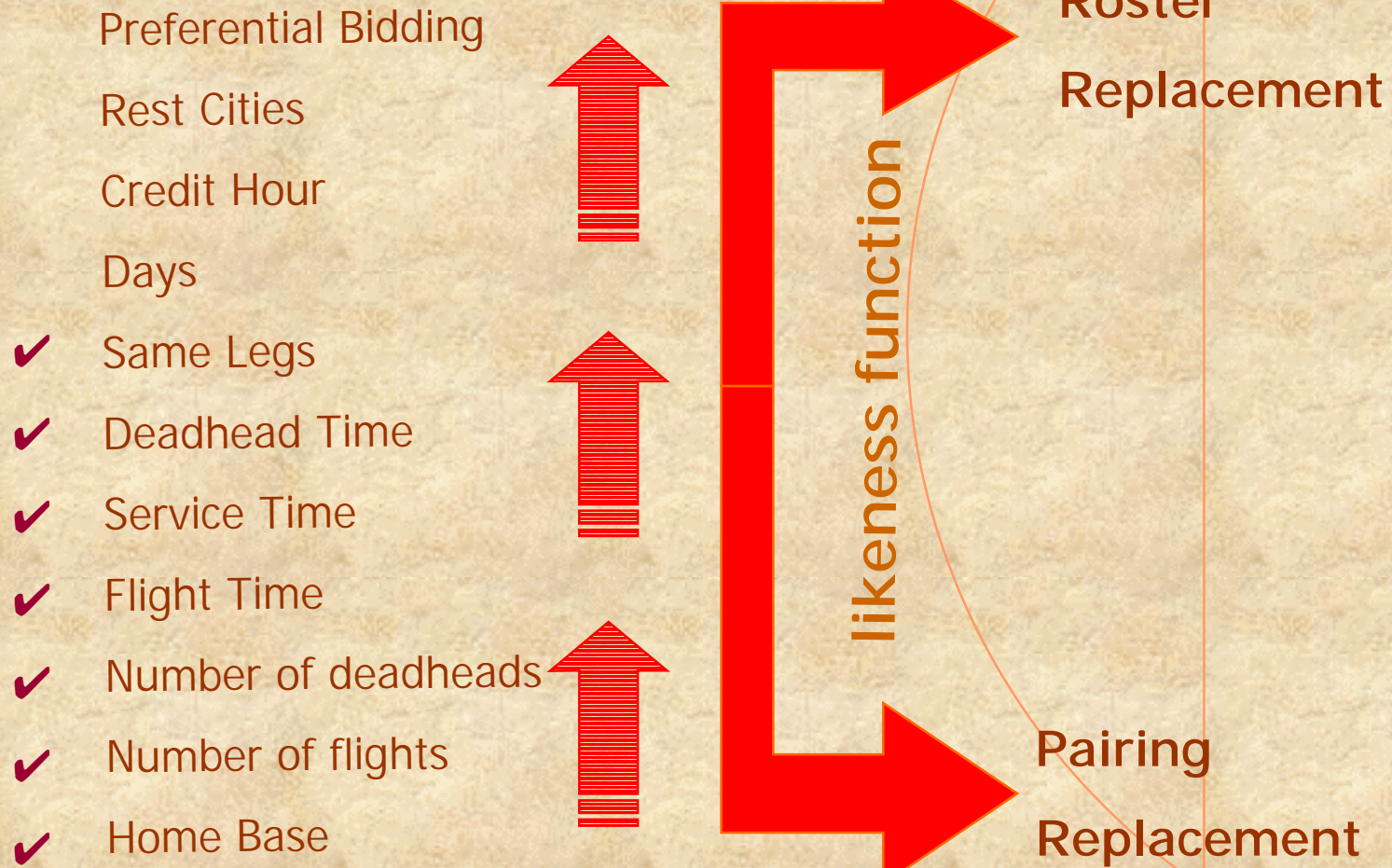
- ◆ Definition of "Likeness" function
 - ◆ to weight and compare new pairings to scheduled ones.
- ◆ It is one of most important feature to determinate the value of objective function, when the output must be a proposal of replacement good for roster viewpoint.

It is linear function of some factors:

$$f(x_i) = \sum_{i \in P} \left(1 - \frac{x_i' - x_i''}{x_i' + x_i''} \right) p_i$$



Crew reassignment: likeness function



The IT Project

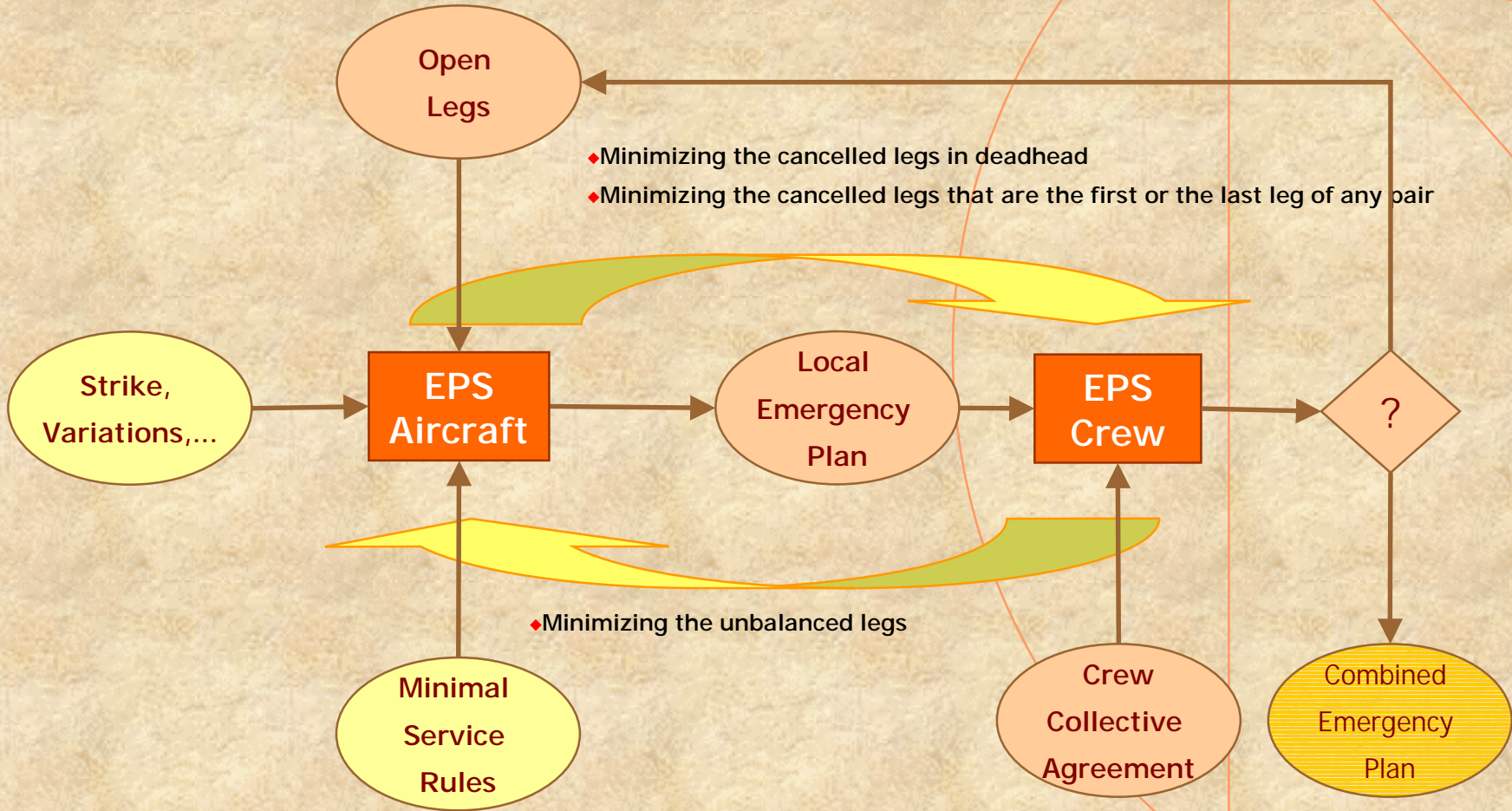
The system of models, that we have presented, has begun part of the kernel for an IT Project at Alitalia called Emergency Plan System (EPS).

EPS wants to be a tool to manage all the variations in pre-operative phase from crew and aircraft view point.

In EPS there are two main optimization models, one for crew (that we have dealt with) and one for aircraft, that work together to obtain an optimal global solution.



Cooperative processes diagram





Strike event

- ◆ The event strike in Italy is a remarkable problem for an airline company
- ◆ Statistics of 1998:
 - ◆ 190 called strikes (1805 hours)
 - ◆ 121 cancelled strikes (1292 hours)
 - ◆ 69 confirmed strikes (512 hours)

From the revenue loss point of view the strike call, for an airline company, is nearly equivalent to its execution, while the work process costs to manage the event are the same.



Cooperation rules

EPS Aircraft \Rightarrow EPS Crew - minimization of the impact on the crew rotation guaranteeing the crew critical legs such as:

- ◆ deadhead legs
- ◆ first and last legs of each pairing

EPS Crew \Rightarrow EPS Aircraft - minimization of the impact on the aircraft rotation canceling only the possible legs such as:

- ◆ out & back legs
- ◆ legs chained station-station
- ◆ legs with a low score



Pairing local recovery: results

Aircraft Type	Period	Pairings	Legs	Deadheads
M80	1 day	186	1618	43
		Initial Scenario		Solution
		before	(now)	before (now)
Pairings		14	(44)	20 (54)
Legs		106	(348)	104 (324)
Days		41	(164)	51 (163)
Deadheads		2	(6)	13 (25)
Legal pairing		0		0
Time				28" (16")



Crew pairing maintenance: results

<i>Initial scenario</i>	Pairings to repair (legs)	44	(348)
	Cancelled Legs	64	
<i>Pairing local recovery</i>	Days	151	
	Pairings (legs)	54	(324)
	Added deadheads	19	
	Open Legs	24	
	Days	163	
	Time solution	15"	
<i>Pairing global recovery</i>	Pairings (legs)	60	(348)
	Added deadheads	65	
	Open Legs	0	
	Days	190	
	Time solution	38"	
<i>Crew reassignment</i>	Pairings (legs)	52	(348)
	Added deadheads	33	
	Open Legs	0	
	Days	172	
	Time solution(CPLEX 6.5)	63"	
	Total time solution	≅2'	

Hardware: Pentium II PC with 64 MB RAM



Crew pairing maintenance: results

		Last year	Now
Pairing local recovery	Pairings to repair (legs)	14 (106)	44 (348)
	Added deadheads	11	19
	Involved pairings	0	0
	Time solution	28"	26"
	Legs to cover	2	24
Pairing global recovery	Pairings:	104	66
	Open Legs	0	0
	Planned pairing	0	0
	Deadheads:	33	41
	Time solution	20'	1'
Crew reassignment	Covered pairings	12	44
	Added deadheads	30	25
	New pairing not assigned	3	9
	Time solution(CPLEX 6.5)	100"	85"
	Total time solution	≅ 23'	≅ 3'
Hardware: PentiumII PC with 64 MB RAM			



Pairing global recovery: results

PGS	Before	Now
Flight to cover:	2	24
Covered Flight :	690	348
Pairings:	104	66
Open Legs	0	0
Deadheads:	35	47
Time solution	20'	1'



Crew reassignment: results

Input	Before	Now
Minimal Pairings:	79	111
Composed Pairings:	10,413	870
Holes:	40	44
"Useful" Combinations:	45,118	9298
Output		
Holes used:	38	44
Pairings Uncovered:	7	9
Solve		
CPLEX 6.5 Time:	100"	57"
Hardware:	PentiumII PC with 64 MB RAM	





Conclusion

- ◆ IT Project EPS will be released in the first months of next year

- ◆ Next step:
 - ◆ delay advices to EPS Aircraft to improve crew solution
 - ◆ management of *pre-operative activities for crew cabin*
 - ◆ adjustment of OR model to manage **operative activities**
 - ◆ splitting, problem postponing, roster factors in likeness function,...





Cooperative processes diagram

