



# Rostering I

Developed by  
Jeppesen Crew Academy

for version 22 of Crew Rostering



# Practical Details

To ensure a good learning environment, we appreciate that:

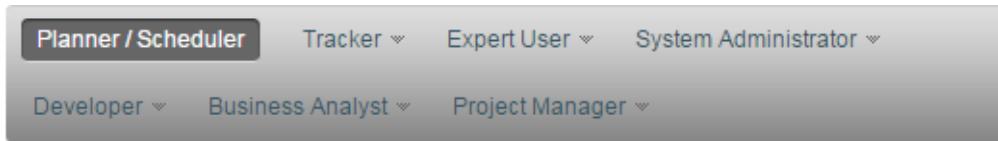
- mobile phones are turned off (or kept on silence)
- phone calls are taken outside the training room
- internet browsing, typing e-mails etc. is done on breaks.

Practical information:

- course hours are 9:00 to 17:00
- restrooms are located outside of training room
- water and fruit are located in back.



# Courses for planners/trackers



A Planner creates, optimizes, maintains and publishes resources, trips or rosters while maintaining minimal cost. A planner has a good understanding of the planning problem and uses both manual and automatic functionality in the Crew & Fleet management system to solve the planning problem.



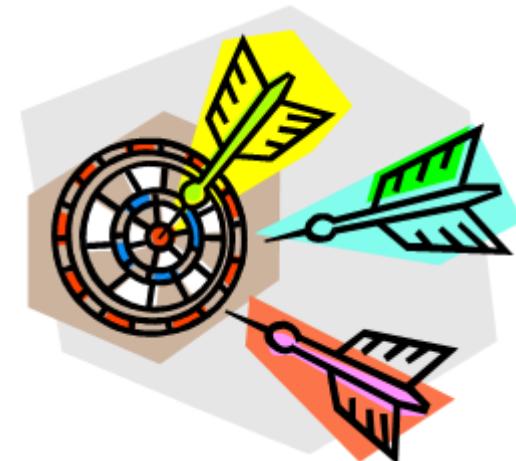
\* Customized course

<http://ww1.jeppesen.com/industry-solutions/aviation/commercial/training/carmen-academy-coursepaths.jsp>

# Course goals

## Enable you to:

- produce production rosters using Jeppesen Crew Rostering
- use both manual and automatic tools
- perform simple simulations.



# Agenda Day 1

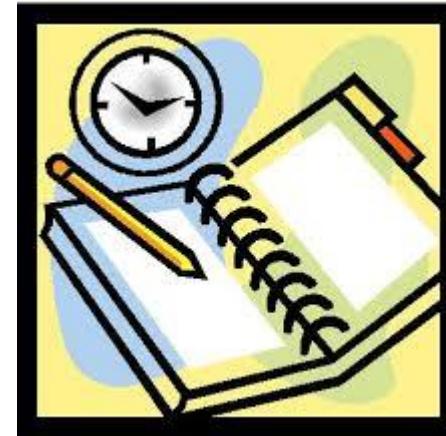
Basic functionality in Crew Rostering

Manual planning

**Lunch around 12.30**

Rules and parameters

Introduction to optimization



**Coffee breaks around 10:00 and 15:00**

# Agenda Day 2

Influence the solution

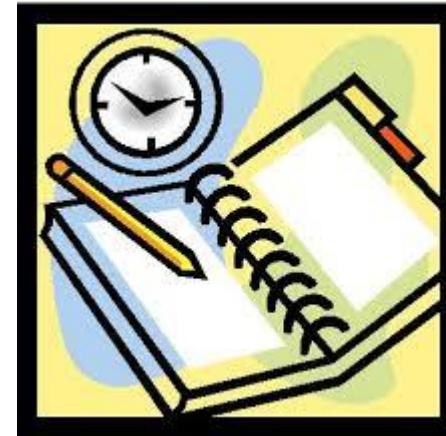
Fairness

Bidding

**Lunch around 12.30**

Repetition, the planning process

Course evaluation



**Coffee breaks around 10:00 and 15:00**

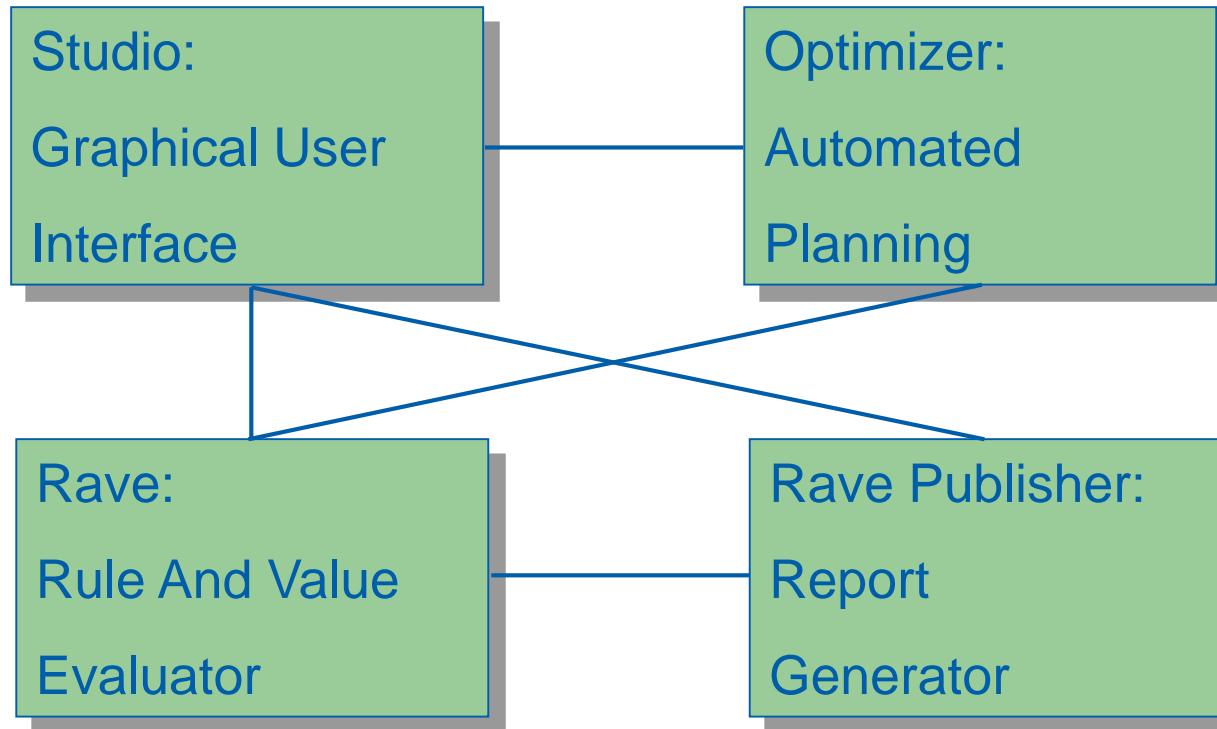
# Course material

- Course slides
- Online documentation
- Crew Pairing and Crew Rostering User Guide



# Basic functionality

# Jeppesen Crew Rostering



# Basic Crew Rostering problem

**Assign objects so that:**

- all rosters are legal
- crew composition rules are respected
- all production (for example trips) is assigned
- training requirements are met
- pre-assignments are considered
- crew preferences are maximized
- quality (fairness, stability etc.) is maximized
- total costs are minimized
- ...

# Basic Crew Rostering problem

**Rosters**

**Best possible way**

**Assignable objects**

BA 94* YUL - LHR J 77J Pos FA U.T.C.: 0130 - 0805 FLT 6:35 CXN 0:00 Assigned: 0/0/0/0/0/1 Local : 2130 - 0905 FLT 6:35 DUT 8:05 REST 0:00 Booked: 0/0/0/0/0/1 FLT 28:35 DUT 34:35 DAYS 6 Need: 0/0/0/0/0/1	29Jul2004 - 30Nov2004 0/0/0/1/1/1/0 On/Off/On ALL LHR Course/Rostering1/Dated/Rostering_ex_1 default_ccr
---	---

# Basic functionality – walkthrough

- main menu
- different windows
- show rosters and trips
- zooming
- customized rudobs
- toolbar buttons for frequent commands
- airport manager.

# Exercise 1

## Basic functionality



### Purpose

- get familiar with the working screen and menus
- change settings
- work with and create different scenarios (sub-plans).

~45 mins

# Exercise 1 summary



# Manual planning

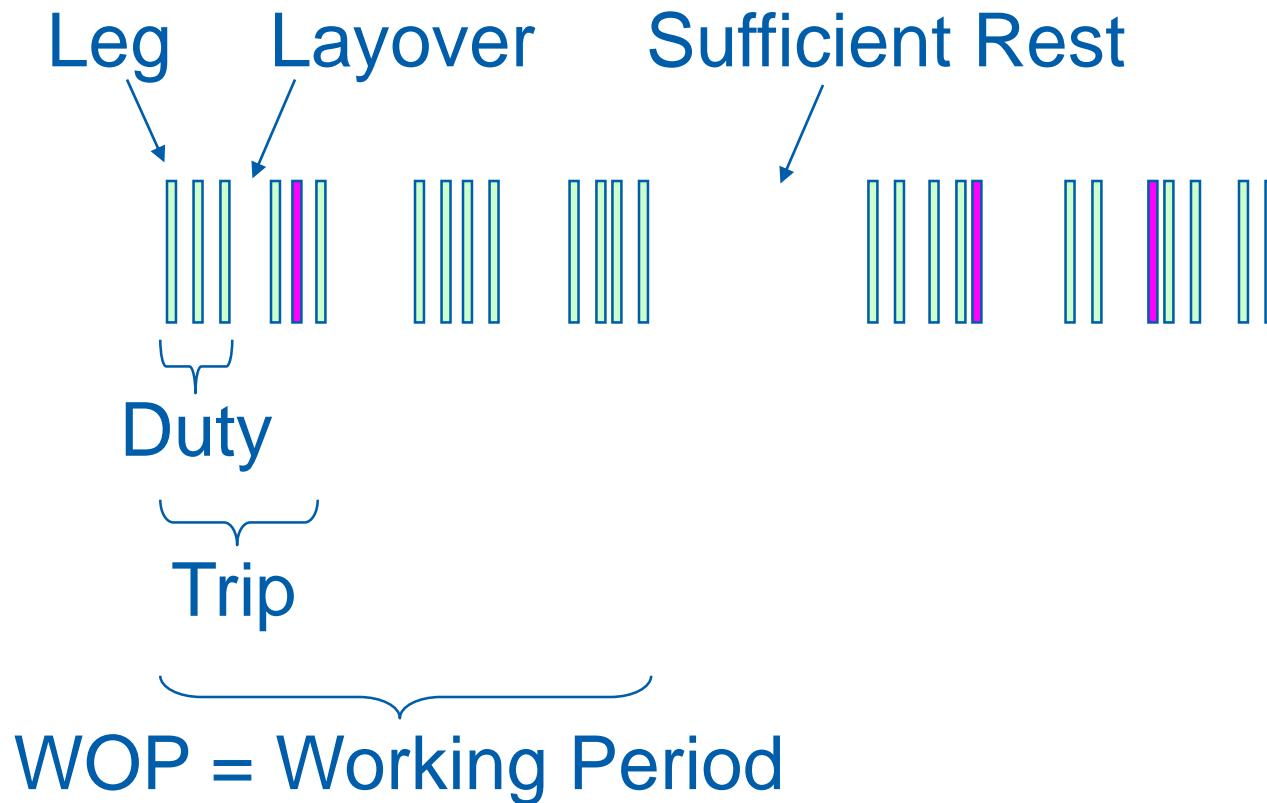
# Input and output



# Planning Data

- planning objects
- local plan
- sub-plan
- rule set
- parameter set
- basic data model
- crew categories.

# Planning Objects



# Planning concepts – local plan

Contains

- all the timetable data: Leg Sets
- the aircraft rotations (turns): Rotations

Many sub-plans can use the same local plan.

Leg Set = a set of legs that are equal except for operation date

Rotation = a chain of legs associated with an aircraft

# Planning concepts – sub-plan

## Contains

- all the data you want to plan ‘right now’
- a sub-selection of the local plan (sub-problem)
- trips, ground duties, crew, rosters, rules and parameter settings
- one planning problem, either a production plan or a scenario
- (environment plan, trips from previous month).

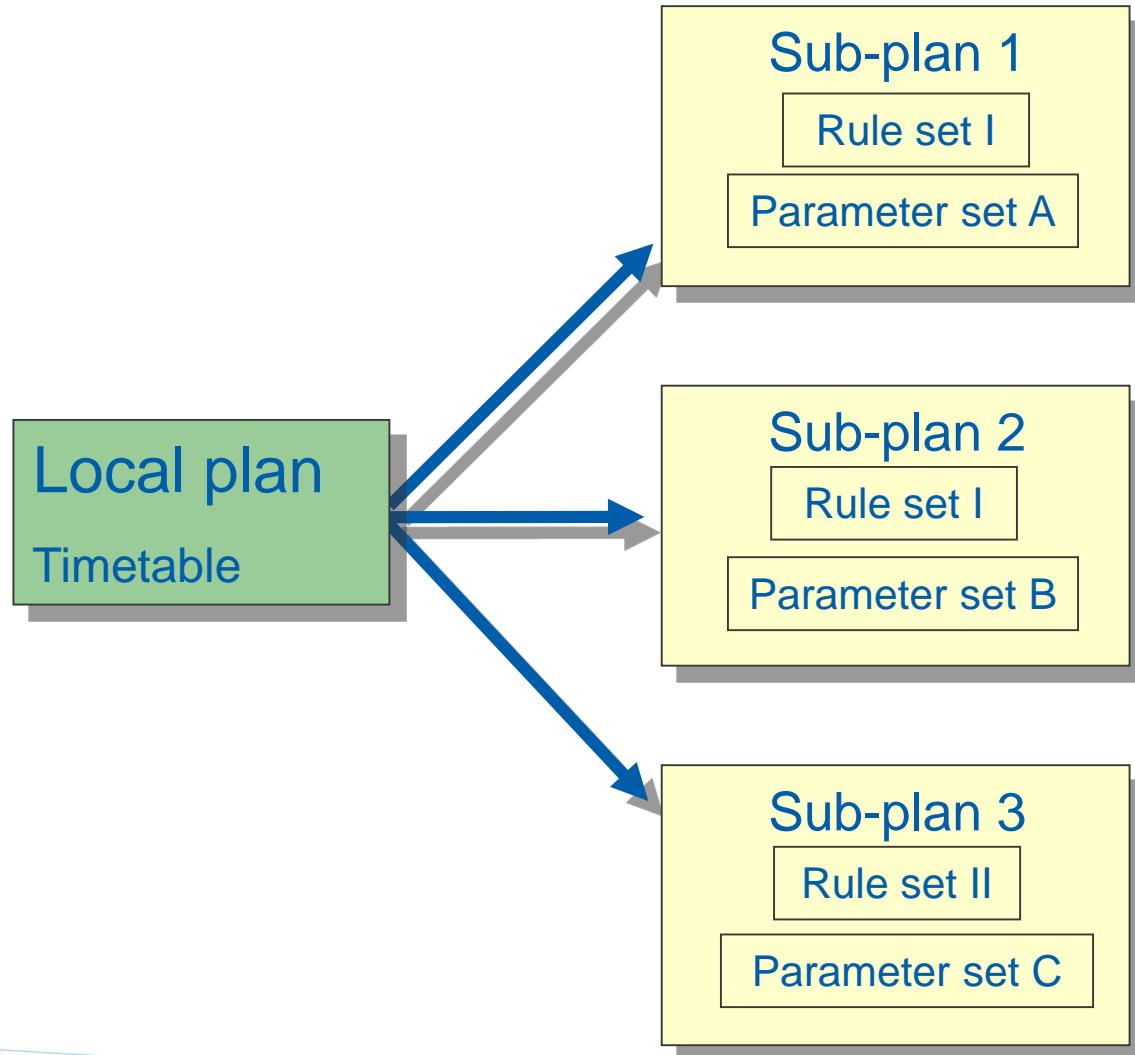
# Planning concepts – rule set

- Rave is a programming language
- must be compiled for the system to understand
- a rule set is a compiled file with Rave definitions
- includes rules, parameters, costs, crew need etc.
- rule sets for flight deck/cabin, long-/short haul etc.

# Parameter set

- a text file where good parameter settings are saved
- rules can be turned on and off
- cost values (parameters) can be changed
- the behaviour of the optimizer can be controlled
- often loaded in the start of the planning process
- often there are ‘monthly’ parameters that need to be changed manually.

# Plan structure



# Crew categories

A non-personal activity needs crew to carry out tasks.  
Different tasks need different types of crew. Therefore, crew  
is divided into crew categories.  
Crew categories differ between companies.

A typical use would be:

## **Flight deck crew:**

captain / first officer / second officer

## **Cabin crew:**

purser / assistant purser / flight attendant

# Crew categories

Each non-personal activity has a crew need (required crew complement), describing the required amount of crew in different crew categories.

Example (varies between airlines):

A leg has crew need:

1 / 1 / 0 // 1 / 1 / 3



Flight deck crew      Cabin crew

This leg should be assigned to:

1 captain/1 first officer//1 purser/1 assistant purser/3 flight attendants

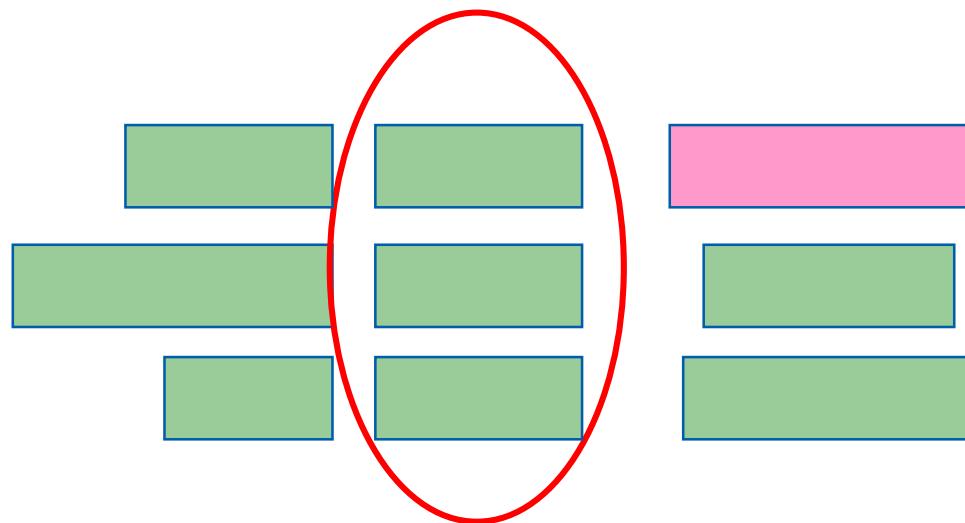
# Crew categories

The leg need (1/1/3) can be covered by several trips:

Purser:

Assistant purser:

Flight attendant:



# Crew categories

The trip can be planned for more than one crew;  
This is defined by the trip crew complement:

PU+AP+FA (1/1/1)



FA (0/0/2)



FA (0/0/1)



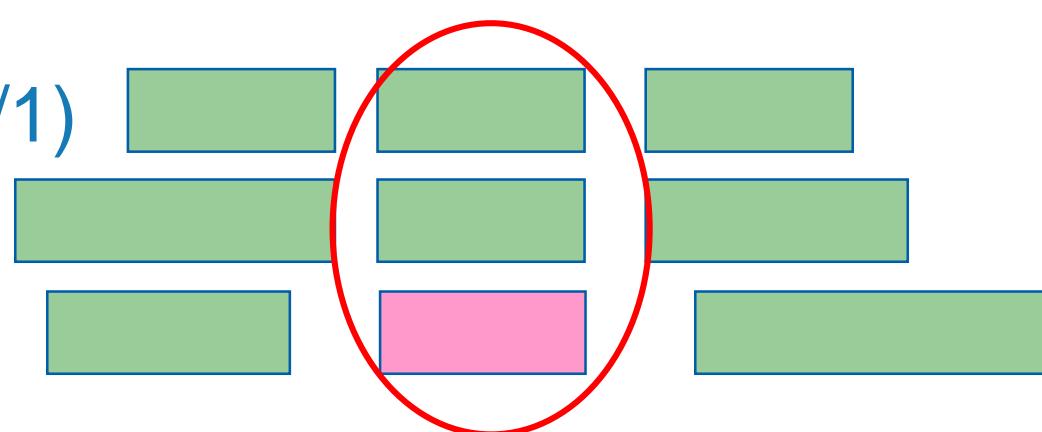
# Crew categories

The leg booked value, is the sum of all crew complement values for all trips the leg is part of:

PU+AP+FA (1/1/1)

FA (0/0/2)

FA (0/0/1)



$$1/1/1 + 0/0/2 + DH = 1/1/3$$

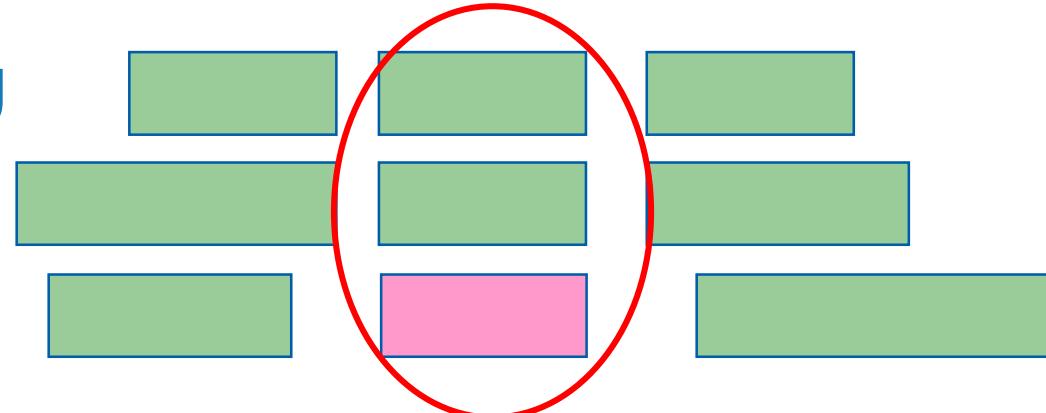
# Crew categories

The leg assigned crew, is the sum of all rosters operating this leg:

Miss Carmen, PU

Mr Smith, FA

Mr Jones, FA



$$\text{FA} + \text{DH} + \text{FA} = 0/0/2$$

# Crew complement

**Need** – the total amount of crew required on the *leg*

“What does Rave say?”

Example: 1/1/3

**Assign value** – the default amount of crew that new trips will get as crew complement (displayed in toolbar) when created (*Studio*)

**Crew Complement** – amount of crew this *trip* is meant for

“How many share this trip”

Example: 1/1/1 & 0/0/2

**Booked** – the sum of all crew complements for all active *legs*

“How many crew are planned on trips” Example: 1/1/3

**Assigned** – the sum of rosters with this *leg*

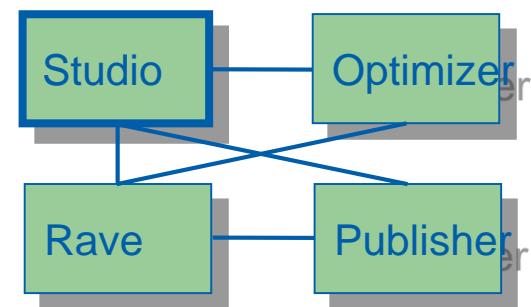
“How many crew are rostered”

Example: 1/0/0

# Studio

Includes tools for:

- importing data
- modifying crew and planning information
- manual planning
- switching rules on and off
- changing parameters (limitations, penalties etc.)
- starting and monitoring the optimizer – look at solutions
- finding user assistance – online help.



# Manual planning – walkthrough

- compare plans
- sort trips/rosters
- filter trips/rosters
- assign (to), deassign
- find assignable trips/rosters
- move/copy trips/rosters
- create assignment
- generate reports.

# Filter by form

**BA flight legs**

**LHR trips**

**Deadhead**

**Touching MEX**

**Not before 10Jan**

The screenshot shows the 'Trip Filter' dialog box with several filter criteria applied:

- Time Base:** RDOP
- Reference Airport:** LHR
- Leg Values:**
  - Flight:** Airline Designator: BA
  - Departure:** Airport: LHR
  - Arrival:** Airport: LHR
  - Touched:** Airport: MEX
- Other Properties:**
  - User Tags: None
  - Tags: None
  - Changes: None
  - Not Operating: None
  - Overbooked: None
  - Ground Duty: None
  - Deadhead: YES
  - Hard Locks: None
  - Area: None
  - Booked Crew: CP
  - Remaining Crew Need:
    - CP: None
    - FO: None
    - FE: None
    - PU: None
    - AP: None
- Duty Values:**
  - Basic: Number of Aircraft Changes: None
  - On Duty Legs: None
  - Legs: None
  - City: None
  - Date: None
  - Time: None
  - Traffic Days: None
- Trip Values:**
  - Basic: Home Base: LHR
  - Trip Name: None
  - Legal Trips: None
  - Plausible Trips: None
  - Block Time: None
  - Area Trip: None
  - Number of Aircraft Changes: None
  - Aircraft Types: None
  - On Duty Legs: None
  - Legs: None
  - Duty Days: None
  - Duties: None
  - Departure: Date: >=10Jan2004
  - Arrival: Airport: None
  - City: None
  - Date: None
  - Time: None
  - Traffic Days: None

At the bottom are buttons: OK, Cancel, Reset, Default, Print.

# Filter form - expressions

Different expressions can be used in the filter form:

<, <=, >, >=

/ – interval (e.g. 1Jan2008/31Jan2008)

! – not

\* – replacing several characters

? – replacing one character

For more information, see the online help

# Exercise 2

## Manual planning



### Purpose

Use manual planning tools and reports

**~1.5 hours**

# Exercise 2 summary



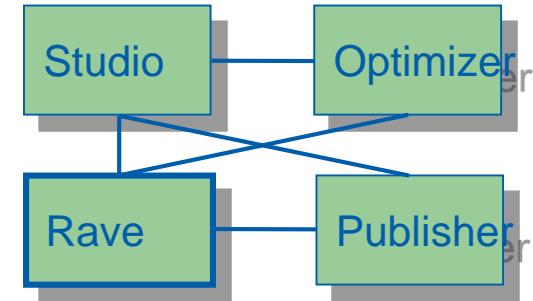
# Rules and parameters

# Rave

Rave is a programming language for modelling rules, costs and report definitions.

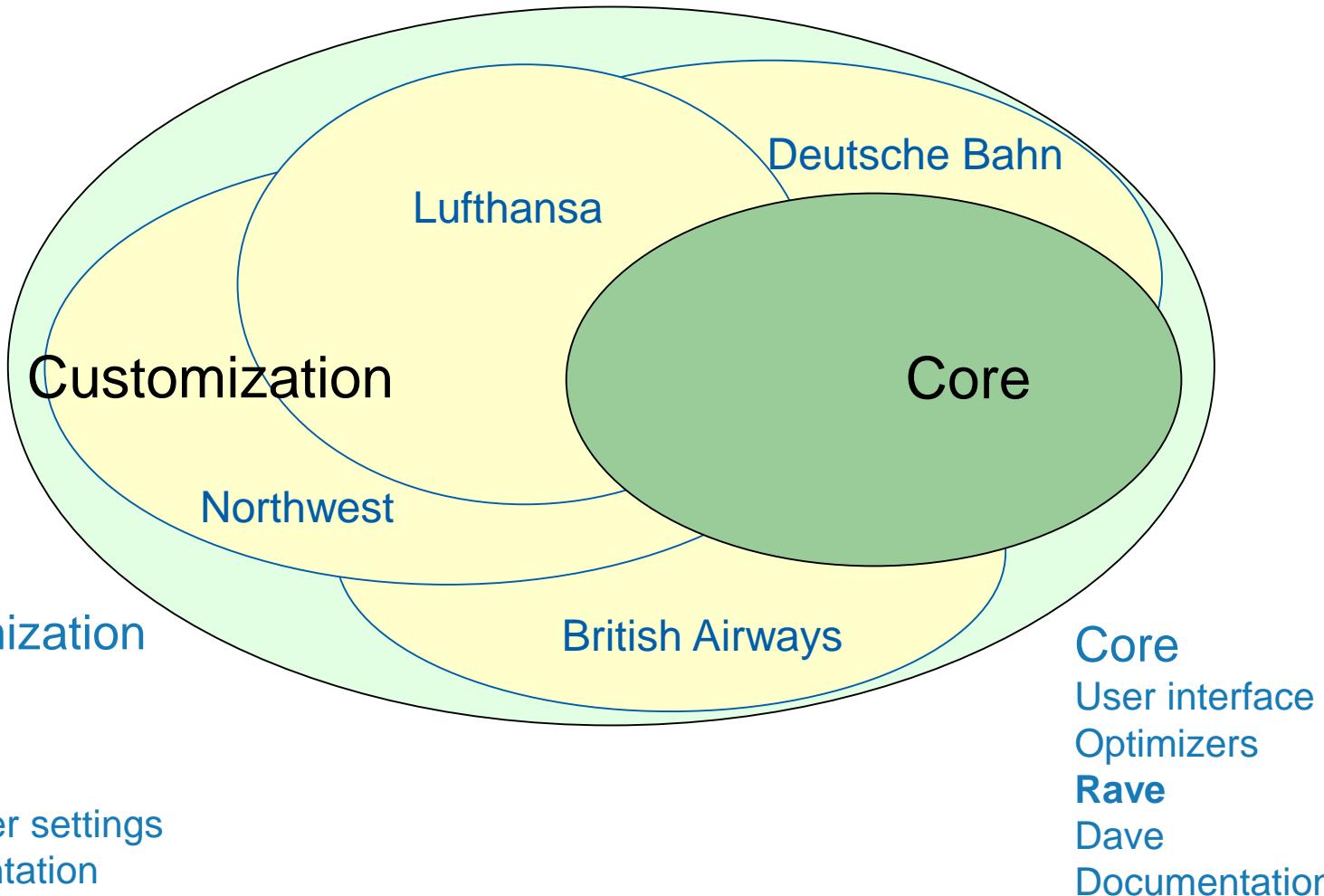
Rave:

- must be compiled for the system to understand
- is easy to learn
- facilitates extensive simulations
- allows system to change with reality
- allows for turning rules on/off and parameters to be changed by planners.



Rule code is administered by rule writers at the customer.

# Rave



# Rules

**Trips must be assigned according to rules.**

**There are different kinds of rules:**

- authority rules
- union rules
- quality rules.

**Rules are always enforced strictly.**

Rosters which do not comply with the rules are illegal rosters.

# Rave code – rules

```
rule max_duty =  
    %duty% <= 10:00;  
    remark "Max 10 hours duty";  
end  
  
%duty% =  
    %duty_end% - %duty_start%;
```

Rule with fixed limit

# Rave code – rules

```
rule max_duty =  
    %duty% <= %max_duty%;  
    remark "Maximal duty";  
end  
  
%max_duty% =  
    parameter 10:00  
    remark "Duty limit";
```

Rule with  
parameterized limit,  
allows planners to  
modify limit during  
planning

# Rule parameters

Rule Parameters

BASIC VALUES Visualization ROSTER RULES STD Reports Matador BIDS CCR Penalties

Roster Rules

Only trips from the right base.....	<input checked="" type="checkbox"/> On
Unknown task code in trip.....	<input type="checkbox"/> On
Max credit block time in month.....	<input type="checkbox"/> Off
Max credit time in a month.....	80:00
Not two duties in the same day (in wop).....	<input type="checkbox"/> Off
Not two duties in the same day (btwn wop's).....	<input checked="" type="checkbox"/> On
Max number of duty days in a working period.....	<input checked="" type="checkbox"/> On
Max consecutive working days without a calander day of rest.....	9
Min rest days in month.....	<input type="checkbox"/> Off
Min rest after a trip inside a wop.....	<input checked="" type="checkbox"/> On
Min rest days after wop.....	<input checked="" type="checkbox"/> On
Max credit time in a month.....	80:00
Max consecutive working days without a calander day of rest.....	9
Min month rest days.....	9
Maximum number of inexperienced crew on a flight.....	1

Qualifications

Crew have to be qualified for this TRIP.....	<input type="checkbox"/> On
Qualification recency expired.....	<input checked="" type="checkbox"/> On
Use language qualification, by country.....	<input type="checkbox"/> False
Use visa qualification, by country.....	<input type="checkbox"/> False
Use language qualification, by airport.....	<input type="checkbox"/> False
Use aircraft qualifications, by IATA aircraft type.....	<input checked="" type="checkbox"/> True

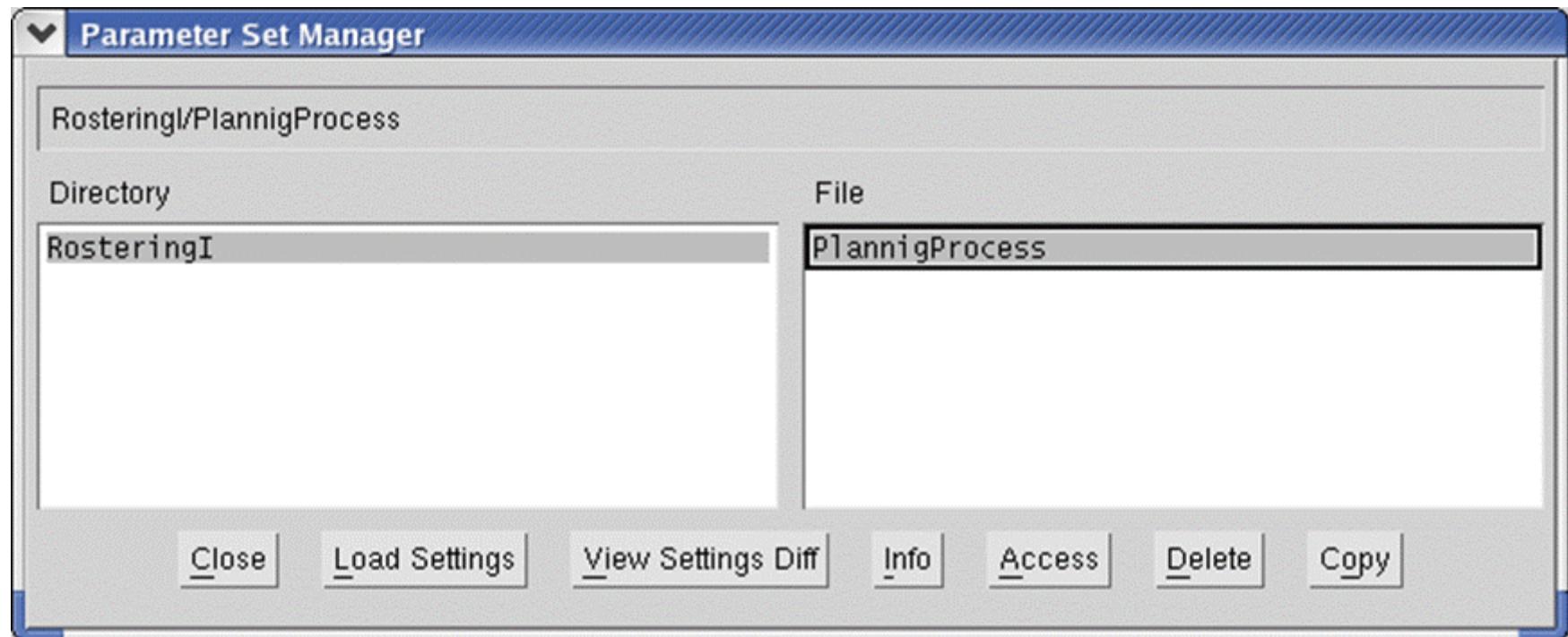
OK Cancel Load from File Load from Sub-plan Save to File... Reset Print Default diff Search Help

0:00

Rule switched off

Active rule and parameterized limit

# Parameter files



# Rules

Rostering I (15.5.1) (/users/anna/work/Customization/RosteringI\_system/user)

File Edit Planning Tools Admin Tools Options Jobs Window Special Help

Opt 10/0/0//1/1/1/0 Leg Filter Rotation Filter Trip Filter 09:10 academyserver.academy.carmen.se ?

**Rosters**

		2004Aug	Sep	Oct	Nov													
		Sep 04	Sat 4	Sun 5	Mon 6	Tue 7	Wed 8	Thu 9	Fri 10	Sat 11	Sun 12	Mon 13	Tue 14	Wed 15	Thu 16	Fri 17	Sat 18	Sun 19
749265-AMB 89:05	FA LHR	MBT 2259	LHR YYZ YYZ	LHR LHR YYZ								LHR HKG				HKG LHR		
870077-ANA 42:10	FA LHR		FL7					2259										LHR HRE
832528-AND 94:45	FA LHR	MBT 2259	LHR 069	FHL 068	PHL 295	LHR ORD						LHR 017 SIN				SIN MEL MEL SIN	017 018	
103240-AND 60:20	AP LHR	247	LHR GRU	GRU GRU	GRU 246	LHR												
864476-AND 21:50	FA LHR																	
871335-AND 61:55	FA LHR	BOS 21	LHR									LHR 047 DAR	DAR 046	2300	AL			
778128-AND 28:35	FA LHR	096	LHR 095	VUL VUL	09 LHR													
699455-AND 69:50	FA LHR	KWI 156	LHR 145	LHR DAC								LHR 215	21	055		056		
727709-AND 60:50	AP LHR	GRU 246	GRU GRU	LHR					LHR 099	VYZ VYZ	096 LHR	LHR 09						
937169-ANG 70:10	PU LHR	2 LHR	LHR EWR	EWR 184	LHR							LHR 1						
75 rows																		
		2004Aug	Sep															
		Sep 04	Sat 4	Sun 5	Mon 6	Tue 7	Wed 8	Thu 9	Fri 10	Sat 11								
0/0/0/0/0/1/0	6315 LHR	LHR 247 GRU																
0/0/0/0/0/1/0	6171 FLHR	LHR 129 ISB																
0/0/0/0/0/1/0	6171 LHR	LHR 129 ISB																
0/0/0/0/0/1/0	6171 LHR	LHR 129 ISB																
0/0/0/0/0/1/0	6258 LHR	LHR 213 BOS																
0/0/0/0/0/1/0	6053 LHR	LHR 055 JNB																
0/0/0/0/0/1/0	6306 FLHR	LHR 243 MEX																
0/0/0/0/0/1/0	6228 LHR	LHR 185 JFK																
0/0/0/0/0/1/0	6054 LHR	LHR 057 JNB																
0/0/0/0/0/1/0	6054 LHR	LHR 057 JNB																
27 rows																		

Only legal continuations  
are suggested when using  
Studio commands for  
manual planning.

# Rules

The screenshot shows a flight rostering application with two main sections: 'Rosters' and 'Trips'. The 'Rosters' section displays a grid of flight segments and crew assignments for the months of August, September, and October. A specific segment in September 4th is highlighted with a red border. A modal dialog box titled 'Legality Check for 025669-ASHBURN' is overlaid on the interface, containing the following message:  
The following rule(s) are illegal.  
Do You want to continue?  
Max number of duty days in a working period : 10 [9]  
At the bottom of the dialog are 'Yes', 'No', and 'Print' buttons.

When creating illegal rosters, the system displays a warning.

# Rules

The screenshot shows a flight rostering interface with a calendar at the top and a detailed view below. The calendar highlights a working period from August 31 to September 23, 2004. A red box labeled '1' points to the 'Rosters' section. The main area displays flight segments: AP-LHR, BOS-B-LHR-EWR, JNB-B-JNB-LHR, YYZ-B-LHR-JFK, and CAT-CAT. A legality report window titled 'Check\_Legality\_Crew' is open, showing a violation for rule 025669 regarding the maximum number of duty days in a working period. The report details a violation on Sep 06, 2004, at 20:00, with an actual value of 10 and a limit of 9, resulting in a difference of 1. The window includes buttons for Close, Save As..., Search..., Print Report, Settings..., and Help.

1 Rosters 2004 AUG 31 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 SEP 23 2004 025669- 90:1 AP LHR LHR BOS B EWR JNB B JNB LHR LHR YYZ B LHR JFK LHR AL CAT CAT 2300

Check\_Legality\_Crew

Page: 1 (1) 0 - 100 %

ASHBURN (AP), Id:025669

Violated Rule	Date	Actual	Limit	Diff
Max number of duty days in a working period	06Sep2004 20:00	10	9	1

[Close](#) [Save As...](#) [Search...](#) [Print Report](#) [Settings...](#) [Help](#)

You may generate a legality report with rule details at any time.

# Rule exception

The screenshot shows a flight rostering interface. At the top, there's a header with 'Rosters' and a red number '1'. Below it is a timeline from AUG 31 to SEP 23, 2004. The timeline shows several segments: LHR-BOS (01), BOS-LHR (02), LHR-EWR (03), EWR-B (04), B-JNB (05), JNB-LHR (06), LHR-YYZ (09), YYZ-LHR (10), LHR-JFK (12), JFK-LHR (13), LHR-AL (14), AL-LHR (15), LHR-CAT (16), CAT-CAT (17), and CAT-FL7 (19). A blue callout box points to the segment from 05 to 12, which is highlighted in green. A modal window titled 'Check\_Legality\_Crew' is open, showing a table with the following data:

Page: 1 (1) 0 - 100 %				
Line	Date	Actual	Limit	Diff
of duty days in a working period	06Sep2004 20:00	10	9	1

At the bottom of the software interface, there are buttons for 'Close', 'Save As...', 'Search...', 'Print Report', 'Settings...', and 'Help'. A status bar at the bottom left says 'One row'.

An illegal roster before using rule exception...

# Rule exception

The screenshot shows a flight rostering interface. On the left, a 'Rosters' tab displays a weekly schedule from August 31 to September 6, 2004. A brown marker is placed over the flight segment on August 31st from AP (LHR) to BOS. Another brown marker is placed over the flight segment on September 1st from BOS to LHR. The right side of the interface shows a monthly view for October 2004, with a red marker placed over the flight segment on October 19th from LHR to JFK. A callout box with the text "...and after" points to the monthly view. Another callout box with the text "A brown marker indicates rule exception." points to the brown markers on the weekly view.

...and after

A brown marker indicates rule exception.

Rosters 2004 AUG 31 01 02 03 04 05 06 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 2004 SEP 23

025669- 80:1  
AP LHR LHR BOS LHR EWR JNB

OCT 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 2004 SEP 23

BA LHR LHR YYZ LHR LHR JFK LHR CAT CAT 2300

Check\_Legality\_Crew

ASHBURN (AP), Id:025669  
Roster is legal

Page: 1 (1) 0 - 100 %

Close Save As... Search... Print Report Settings... Help

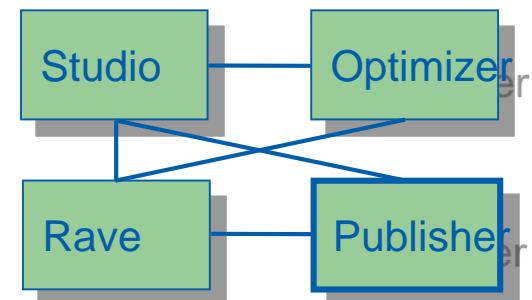
One row

# Reports – Rave Publisher

## Rave Publisher:

- is an internally developed language for generating reports
- generates both graphical reports and text reports (system output).

Report code is administered by report writers at the customer.



# Reports – Rave Publisher

**All kinds of information in the system can be calculated and shown in reports, for example:**

- roster data
- productivity figures
- solution quality figures
- data for other systems.

**Reports can be generated for:**

- single objects
- objects shown in a working window
- all objects in the plan.

**Reports use definitions made in Rave.**

# Exercise 3

## Rules and parameters



### Purpose

Use rules and parameters

**~20 mins**

# Exercise 3 summary

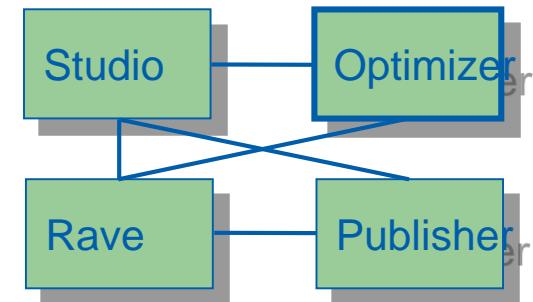


# Introduction to optimization

# The optimizer

The optimizer solves rostering problems using different optimization methods designed for various kinds of problems.

All rosters will comply with rules as defined in Rave.



# Optimization - definition

## Merriam Webster:

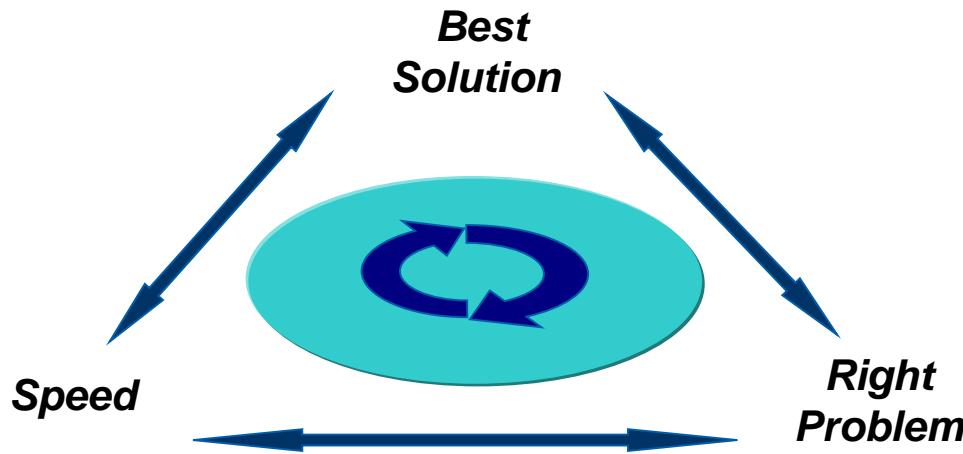
op-ti-mi-za-tion *n* (1857) : an act, process or methodology of making something (as a design, system, or decision) as fully perfect, functional, or effective as possible; *specific*: the mathematical procedures (as finding the maximum of a function) involved in this.

# Optimization - definition

Optimization = Finding the best possible solution to the right problem as fast as possible.

Our view:

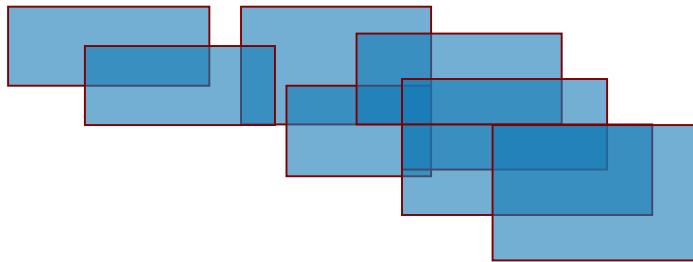
The three dimensions:



# Optimization - examples

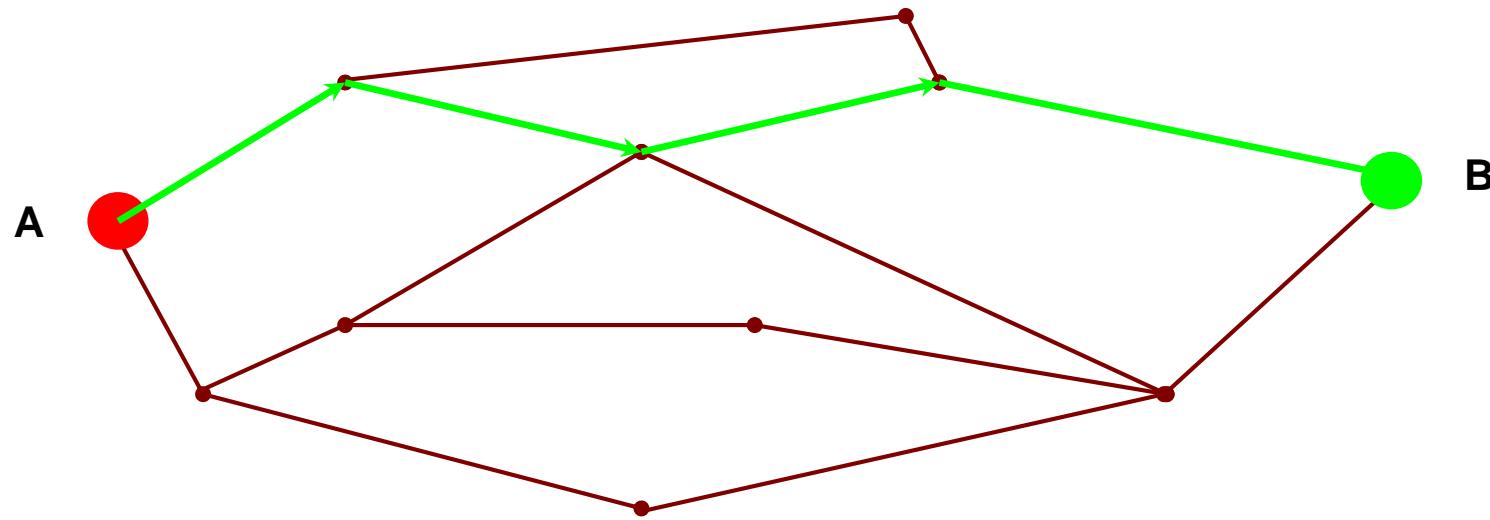
## Packing

Fit as much as you can in your bag.



# Optimization - examples

## Shortest-Path

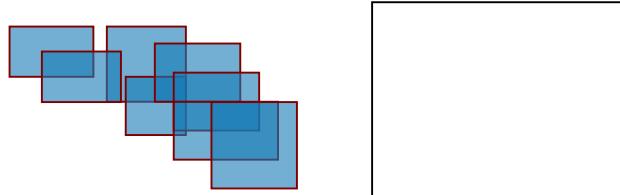
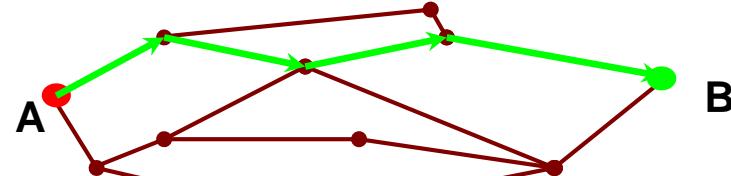


Find the shortest route in the network taking you from A to B.

# Optimization - Objective function

## What is the best solution?

- Quickest?
  - Shortest?
  - Cheapest?
  - Nicest?
- 
- Weight?
  - Volume?
  - Value?



# Optimization

**Two main steps:**

**Model the problem:**

define the objective function and the rules/constraints

**Solve the problem:**

apply the best algorithm(s) to the problem

# Optimization

## Model the problem:

- all production (for example trips) is assigned
- all rosters are legal
- crew composition rules are respected
- pre-assignments are considered
- training requirements are met
- crew preferences are maximized
- quality (fairness, stability etc.) is maximized
- total costs are minimized
- ...

# Optimization

A simple way of finding the optimal solution to the rostering problem:

1. generate all possible solutions (sets of rosters)
2. select the best solution.

Is this possible?

# The beggar made a deal with the King

Doubling rice grains

1, 2, 4...



8, 16, 32, 64, 128

A week later, he brought a teaspoon for 128 grains

256, 512, 1024, 2048, 4096, 8192, 16384, 32768

In two weeks it was a non-negligible amount of half a kilo

65536, 131072, 262144, 524288, 1048576,

..., 1073741824, 2147483648

At the end of the month it had grown to a whopping 35 ton

A few days later the king had to declare bankruptcy.



# Optimization

All possible solutions  
(sets of rosters)

Too many possible solutions.

Optimal  
solution

A solution

An illegal  
solution

# Optimization

**We need to limit the solution space and/or only search in parts of it:**

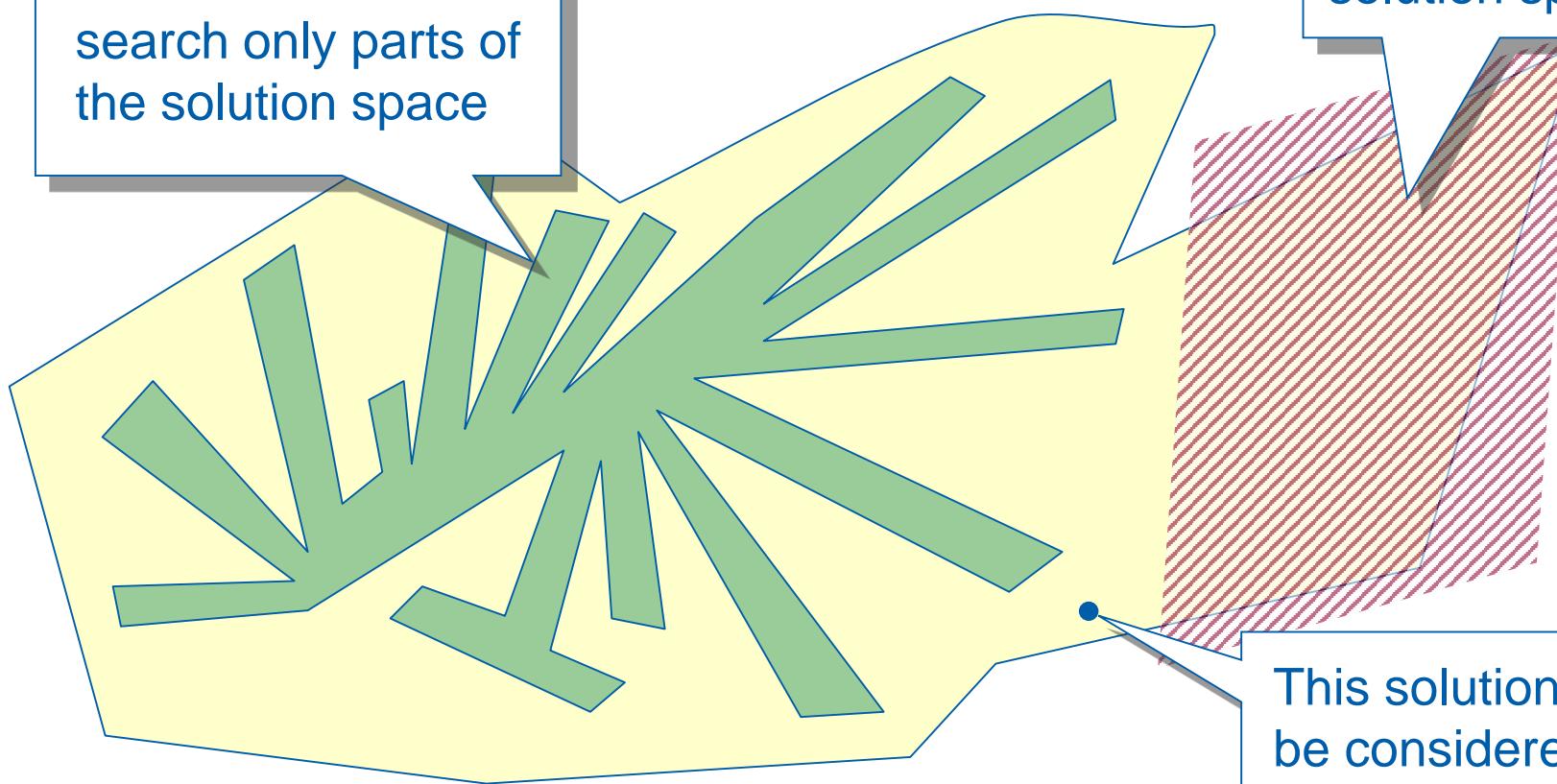
- quality rules limit the solution space
- optimization methods limit the solution space search.

# Optimization

The used methods search only parts of the solution space

A quality rule limits solution space

This solution will not be considered

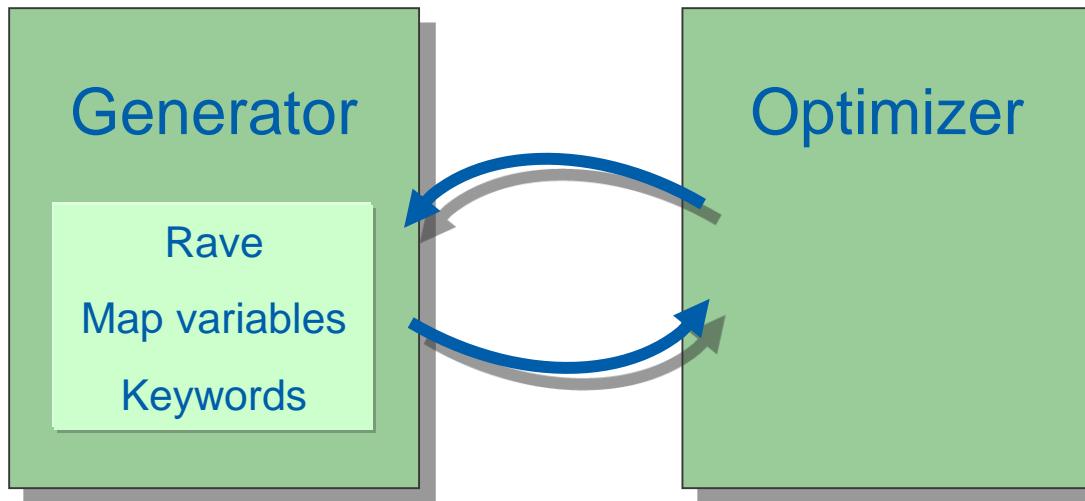


# Optimization

## Optimization process:

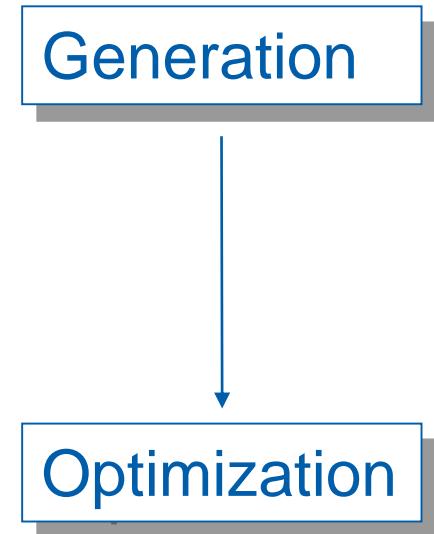
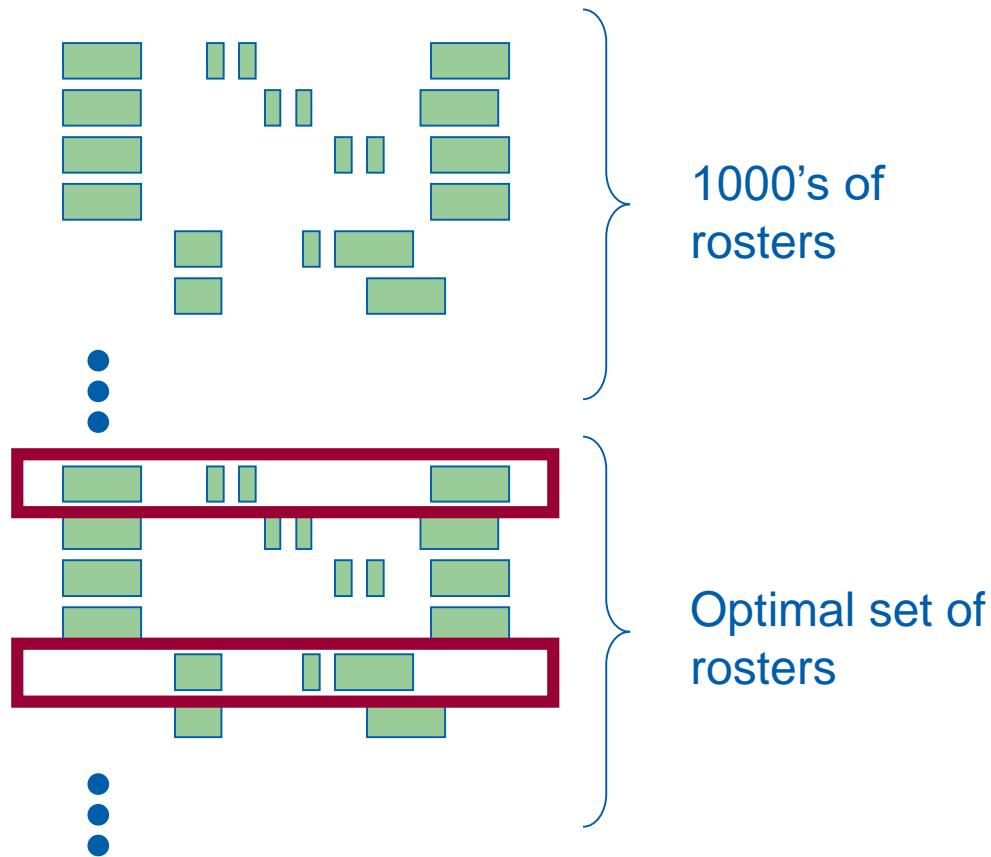
1. the generator produces a lot (typically tens of thousands) of legal candidate rosters
2. the optimizer then selects the best subset of candidate rosters constituting a solution.

# Optimization



1. generator generates legal subsets
2. optimizer finds the cheapest combination.

# Optimization



The optimization methods allow a global approach — total cost is important.

(Individual extreme cases can of course still be avoided.)

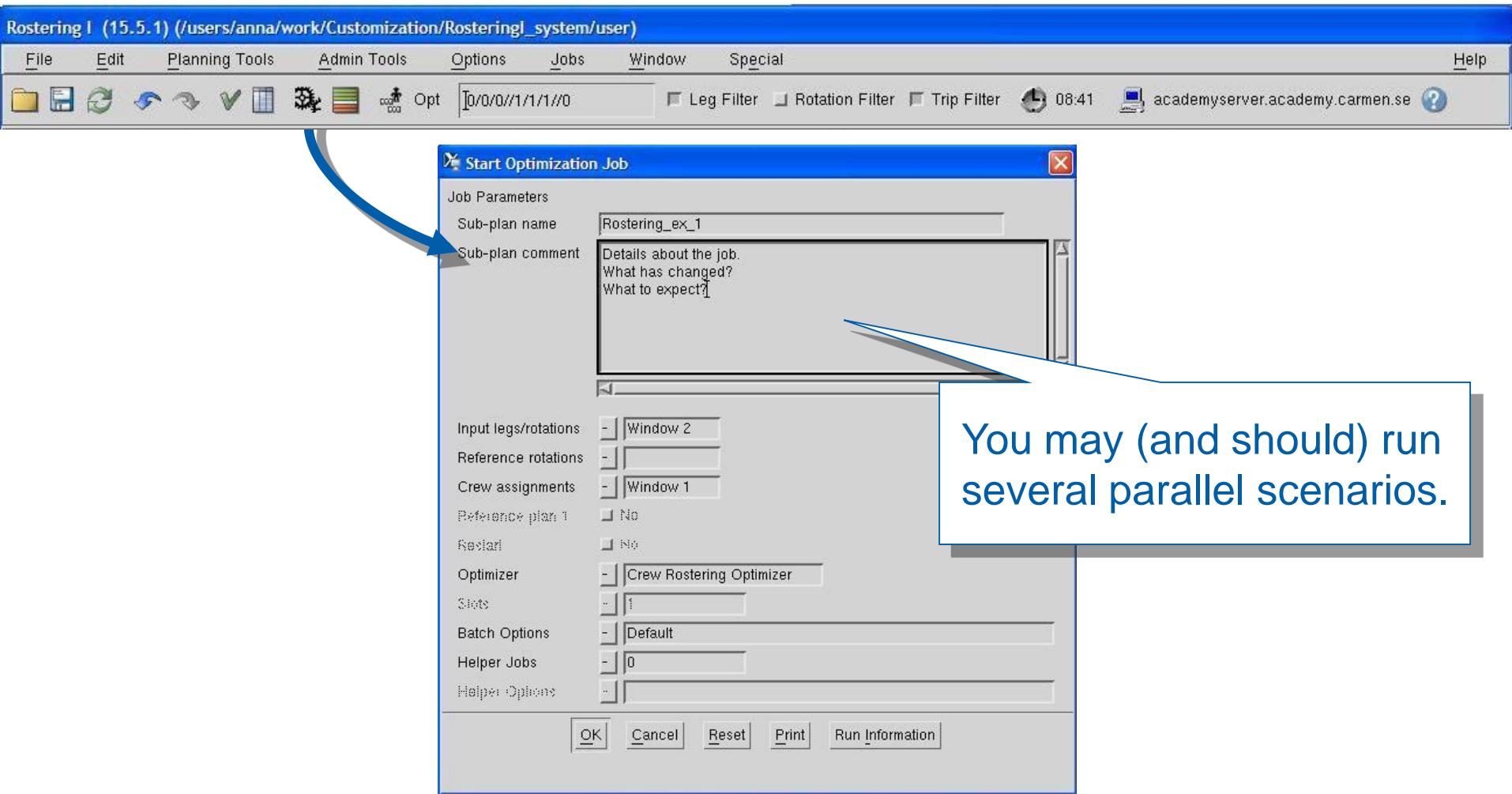
# Optimization

**Keep in mind that the cost function depends on penalty parameter settings. Hereby the planner controls solutions produced by the optimizer.**

# Using the optimizer – walkthrough

- 1. Start a job.**
- 2. Monitor progress using:**
  - Batch Job Manager
  - Plan Manager.

# Using the optimizer



# Using the optimizer

Rostering I (15.5.1) (/users/anna/work/Customization/RosteringI\_system/user)

File Edit Planning Tools Admin Tools Options Jobs Window Special Help

Opt 0/0/0//1/1/1/0 Leg Filter Rotation Filter Trip Filter 08:41 academyserver.academy.carmen.se ?

Grid Engine Batch Viewer – Julia Niklasson

File Show Help

Job ID	Submitted by	Submitted on	Status	Location	Job ID
INTERACTIVE	mirsada (Mirsada Kasum)	Nov 01 15:26:22	running	login(connellserville.carmen.se)	JobId: 1589293
INTERACTIV	mirsada (Mirsada Kasum)	Nov 01 14:04:10	running	login(covelo.carmen.se)	JobId: 1587855
INTERACTIV	ingmari (Ing-Mari Nordborg)	Oct 31 09:07:13	running	login(madisonville.carmen.se)	JobId: 1574733
INTERACTIV	helen (Helen Carlsson)	Oct 04 11:11:05	running	login(covelo.carmen.se)	JobId: 1316639
INTERACTIV	helen (Helen Carlsson)	Sep 27 16:35:42	running	login(quaqtaq.carmen.se)	JobId: 1257069
sp_test_op	rodelius (Martin Rodelius)	Nov 10 09:54:10	s on opt	(oroville.carmen.se)	JobId: 1657599
v12_constr	govert (Martin Govert Helmer)	Oct 21 10:18:24	s on opt	(connellserville.carmen.se)	JobId: 1481684
carmen_TRA	nightjob (Nightshift at Carmen)	Nov 20 22:07:47	pending		JobId: 1748326
carmen_TRA	nightjob (Nightshift at Carmen)	Nov 20 22:07:46	pending		JobId: 1748322

Close



# Using the optimizer

Grid Engine Batch Viewer – Julia Niklasson

File Show

INTERACTIVE running on login/covelo.cam  
Submitted by: mirsada (Mirsada Kasum) on: Nov 01 15:26:22

INTERACTIV running on login(covelo.cam)  
Submitted by: mirsada (Mirsada Kasum) on: Nov 01 14:04:10 JobId: 15

INTERACTIV running on login/madisonville.cam  
Submitted by: ingmari (Ing-Mari Nordborg) on: Oct 31 08:45:15 \* Course Rostering Dated Rostering\_ex\_4\_opt best\_s

INTERACTIV  
Submitted by: helen (Helen Carlsson) on: Oct 04 11:11:15

INTERACTIV  
Submitted by: helen (Helen Carlsson) on: Sep 27 16:35:15

sp\_test\_op  
Submitted by: rodelius (Martin Rodelius) on: Nov 10 09:55:15

v12\_constr  
Submitted by: govert (Martin Govert Helmer) on: Oct 21 10:15:15

carmen\_TRA  
Submitted by: nightjob (Nightshift at Carmen) on: Nov 20 10:15:15

carmen\_TRA  
Submitted by: nightjob (Nightshift at Carmen) on: Nov 20 10:15:15

**Solution\_19 information**

**Solution analysis ▾**

Cost	1820000
Cost of rosters	0
Cost of unassigned slots	1820000
Cost of unassigned crew	0
Cost of broken trip constraints	0
Cost of broken leg constraints	0
Cost of broken global constraints	0
Assignment percentage	97

**Solution details ▾**

**PDL report ▾**

**Optimization info ▾**

Method	ImproveMethod
Generation ▾	
Optimization ▾	
CPU usage ▾	

Plot against CPU time Compare  Solution range from 1 to 9999

Expand all Collapse all Print Close

Batch viewer allows monitoring of optimization jobs.  
Click right > Status (only on jobs that are still running)

# Using the optimizer

**Course Rostering Dated Rostering\_ex\_4\_opt best\_solution**

**Solution\_75 information**

**Solution analysis**

Cost

- Cost of rosters: 0
- Cost of unassigned slots: 0
- Cost of unassigned crew: 0

Graphs display development of solution quality, e.g. total cost.

**Optimization info**

Method

Generation >

Optimization >

CPU usage >

Plot against CPU time

Compare

Solution range from 1 to 9999

ImproveMethod

Plot graph

Print graph

Print

**Gnuplot**

"\_\_Total\_cost\_of\_plan"

2.0e+07  
1.8e+07  
1.6e+07  
1.4e+07  
1.2e+07  
1.0e+07  
8.0e+06  
6.0e+06  
4.0e+06  
2.0e+06  
0

0 10 20 30 40

Solution Number

Intermediate solutions may be loaded and analyzed.

**Timetables**

Course

**Versions**

RosteringI

Dated

**Local Plans**

**Sub-plans**

Rostering\_ex\_1  
Rostering\_ex\_3  
Rostering\_ex\_4  
Rostering\_ex\_4\_opt

**Solutions**

best\_solution  
input  
Solution\_78  
Solution\_77  
Solution\_76  
Solution\_75  
Solution\_74  
**Solution\_73**  
Solution\_72

**Buttons**

Close Open Plan Load as Env Load as Ref Access Unlock Delete Copy Select Deselect Keep Best Solutions View Opt. Report Properties

# Using the optimizer

The Scenario Analyzer can be used for comparing solutions

The screenshot shows the Rostering I application window. The main menu bar includes File, Edit, Planning Tools, Admin Tools, Options, Jobs, Window, Special, and Staff. A toolbar below the menu contains various icons for file operations and tools. The central workspace displays a 'Rosters' grid for two dates: 2004 Aug and 2004 Aug. To the right of the grid is a 'Views' tree view showing a hierarchy of courses and rostering scenarios. A large callout box highlights the 'Scenario Analyzer' feature. The 'Scenario Analyzer' window contains three main sections: 'KPIs' (Key Performance Indicators), 'Graphs', and 'Logs'. The 'KPIs' section is currently active, showing a table comparing three scenarios: 'Rostering\_ex\_6\_3\_1 [86\*]', 'Rostering\_ex\_7\_3\_ref [99\*]', and 'Rostering\_ex\_7\_7\_1 [86\*]'. The table includes columns for Overview, Custom KPIs, and various performance metrics like Quality, Stability, and Fairness. The 'Graphs' section displays two line charts showing the evolution of rostering costs over CPU time for the three scenarios. The first chart shows 'Penalty for Rosters: FAIRNESS - 4.2 RESERVES (millions)' and the second shows 'Penalty for Rosters: QUALITY - Sum (thousands)'.

KPI name	Rostering_ex_6_3_1 [86*]	Rostering_ex_7_3_ref [99*]	Rostering_ex_7_7_1 [86*]
Overview	[1]	[1]	[1]
Solution nr	86	99	86
Custom KPIs	[2]	[2]	[2]
Module Name	kpi.roster_cost	kpi.roster_cost	kpi.roster_cost
Penalty for Rosters	[16]	[14]	[16]
QUALITY - 2.1 P	40000	500	5000
QUALITY - 2.2 P	80000	3100	34000
QUALITY - 2.3 P	148000	5800	63000
QUALITY - 2.4 P	1020000	15150	93500
QUALITY - 2.5 P	3760000	37000	980000
QUALITY - Sum	5048000	61550	1175500
STABILITY - 3.1	47200	590	7600
STABILITY - Sum	47200	590	7600
FAIRNESS - 4.1 I	9330900	250640	11982000
FAIRNESS - 4.2 I	3147600	45210	2583600
FAIRNESS - Sum	12477500	295850	1455500

Graphs X

Penalty for Rosters: FAIRNESS - 4.2 RESERVES (millions)

Penalty for Rosters: QUALITY - Sum (thousands)

# Exercise 4

## Using optimization



### Purpose

Start and monitor an optimization job

**~20 mins**

# Exercise 4 summary

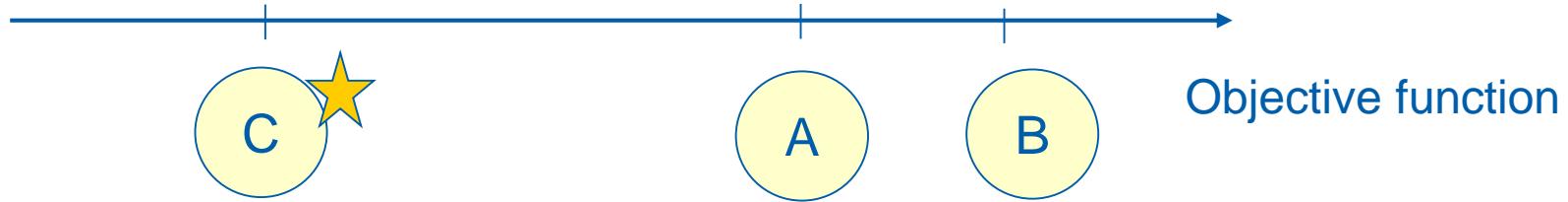


# Influence the solution

# Objective function

When you solve problems automatically, all crew rostering solutions should be uniquely ordered.

This is the only way to identify the best solution.



Solution A is better than solution B, but solution C is better than both and therefore the best.

# Objective function

The objective function:

- guides the optimizer when generating solutions
- is modelled in Rave
- returns a value for every solution.

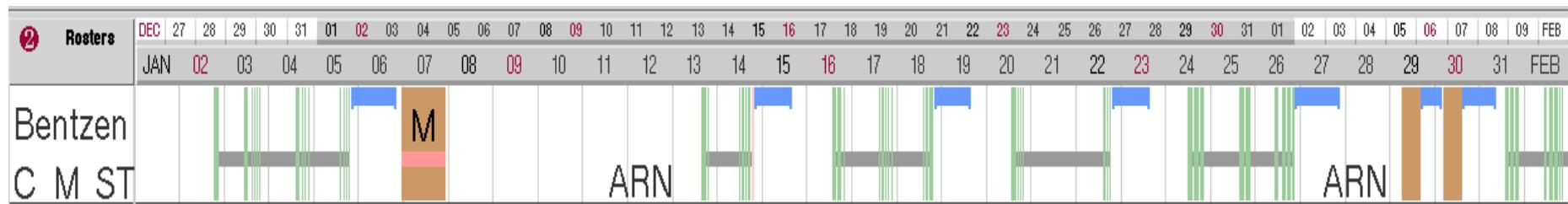
# Objective function

**The objective function contains two parts:**

- real costs (e.g. overtime costs)
- penalties for lacking quality (e.g. lack of fairness).

**The best solution is uniquely identified as the one with lowest value of the objective function.**

# Objective function – example



Given a certain objective function, the value of the objective function (often called **total cost**) for the roster above is:

Real costs  
Penalties

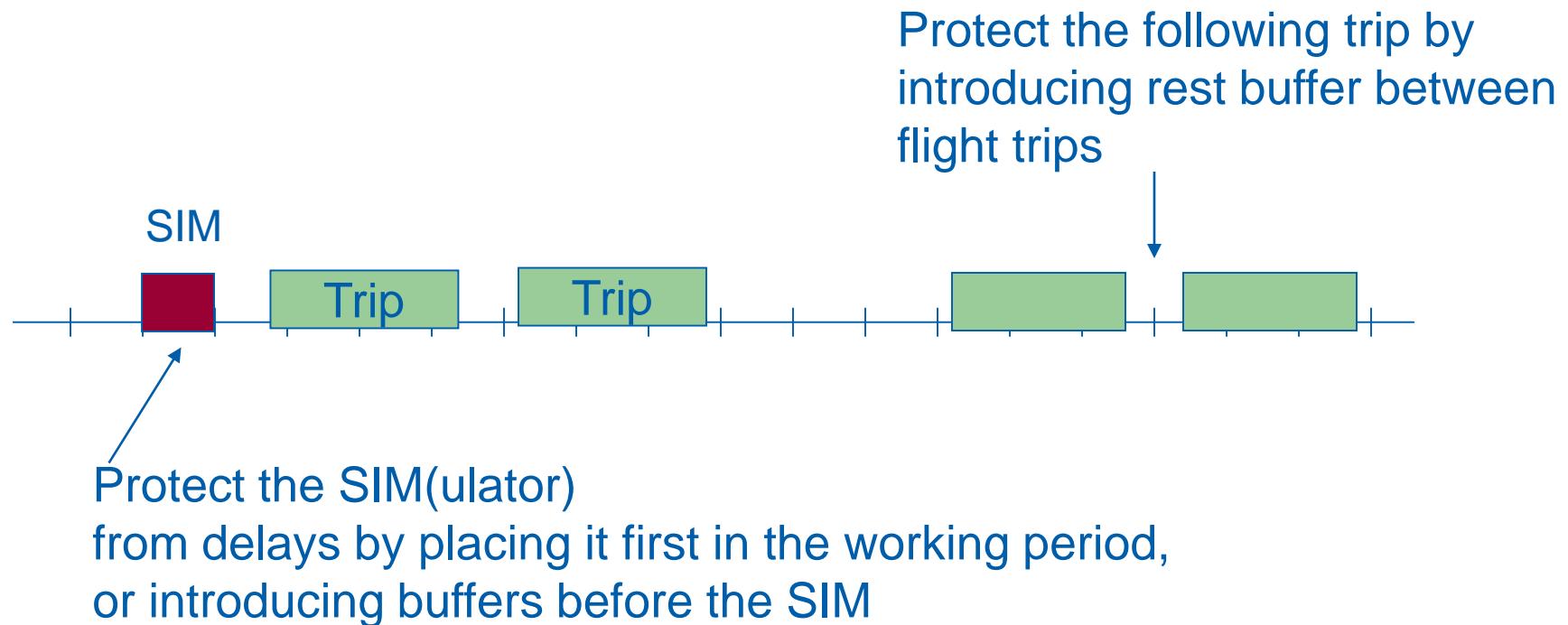
1,870 Jeppesen\$  
4,652 Jeppesen\$

Total costs

6,522 Jeppesen\$

# Objective function – stability

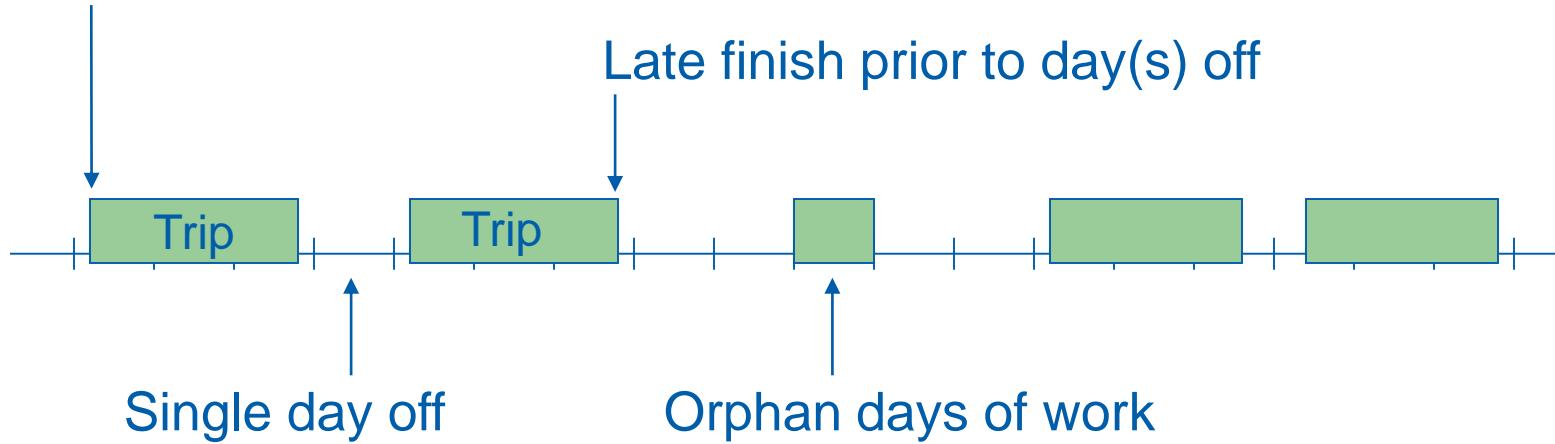
Make the roster less sensitive to delays and disturbances.



# Social quality

Combinations of trips in a roster result in bad properties.

Early start following day(s) off



# Quantifying quality

Defining penalties (and hereby quantifying quality) is always difficult, but often a very rewarding process.

It forces planning departments to:

- prioritize quality issues
- decide how much quality is worth.

# Rules vs. cost function

If a rule may be violated in certain cases, this should be considered as a quality issue. A penalty should be given to be used as a backup when the rule is off.

## Example

**Rule:** “Do not allow more than 5 layovers in the same station per month.”

**Penalty:** “Every layover after the 3rd cost 1000.”

# Objective function – penalties

Setting priorities between objective groups

**Cover production**

**Bid ratio**

**Stability**

**Quality**

...

Planners have full control over solution goals.

# Parameter interface

**Prioritization between objective groups**

**Detailed penalties**

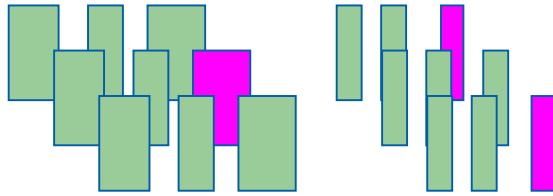
The screenshot shows the 'Rule Parameters' dialog box with several tabs at the top: BASIC VALUES, Visualization, ROSTER RULES, ROSTER COST (which is selected), BIDS, STD, Reports, and Matador. The main area displays various parameters with their current values:

- General Penalty Function Parameters:**
  - 1.0 Weight of UNASSIGNED..... 1000
  - 2.0 Weight of QUALITY..... 0
  - 3.0 Weight of STABILITY..... 0
  - 4.0 Weight of FAIRNESS..... 0
  - 5.0 Weight of PBS..... 0
- 1.0 Parameters for control of unassigned penalties:**
  - 1.1 Limit (days) for long flight duty..... 3
  - 1.2 Long flight duty, daily..... 10
  - 1.2.1 Long Flight duty (quadratic on days), daily..... 10
  - 1.3 Reserve pairing, daily..... 10
  - 1.4 Short flight, daily..... 10
- 2.0 Parameters for control of quality penalty:**
  - 2.1.1 Limit for a late finish before day off..... 21:00

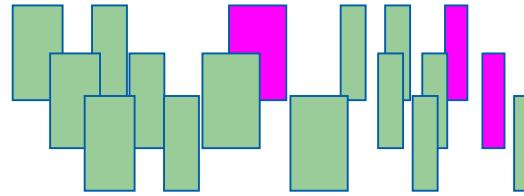
At the bottom of the dialog are buttons for OK, Cancel, Load from File, Load from Sub-plan, Save to File..., Reset, Print, Default diff, Search, and Help. The status bar at the bottom shows 'Default value: 10' and 'Name: unassigned\_factor'.

# Objective function – parameters

To compare solutions we often look at the costs:



Total cost: 35,670\$



24,770\$

# Objective function – parameters

Parameters are changed to influence the solution:

Fairness	1000	10	100
Quality	10	10	1000
Stability	10	100	50

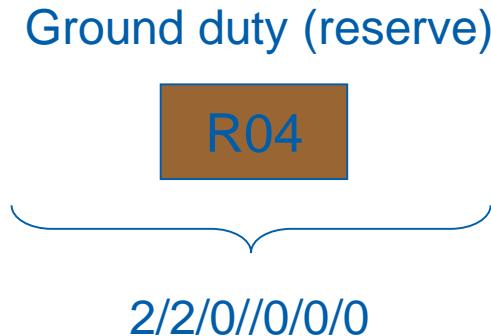
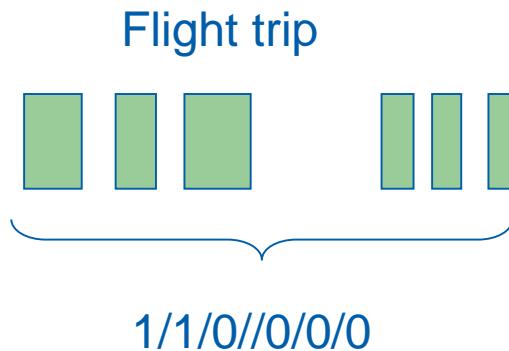
...

When penalties are changed the same solution will get a different cost and appear better (or worse).

# Ground duties

Ground duties are like flight trips:

- they have a crew complement
- they may be assigned to anyone who is qualified.



# Ground duties

Rostering I (15.5.1) (/users/anna/work/Customization/RosteringI\_system/user) Course/RosteringI/Dated/Rostering\_ex\_4Anna2 default\_ccr

File Edit Planning Tools Admin Tools Options Jobs Window Special Help

Trips 2004Aug Sep Oct Nov

	Sep 04	Thu 2	Fri 3	Sat 4	Sun 5	Mon 6	Tue 7	
0/0/0/1/1/1/0 LHR	R1							
0/0/0/1/1/1/0 LHR		R1	LHR					
0/0/0/1/1/1/0 LHR		LHR	R4	LHR				
0/0/0/1/1/1/0 LHR		LHR	R1	LHR				
0/0/0/1/1/1/0 LHR		LHR	R4	LHR				
0/0/0/1/1/1/0 LHR		LHR	R1	LHR				
0/0/0/1/1/1/0 LHR		LHR	R4	LHR				
0/0/0/1/1/1/0 LHR		LHR	R1	LHR				
0/0/0/1/1/1/0 LHR		LHR	R4	LHR				
0/0/0/1/1/1/0 LHR		LHR	R1	LHR				
0/0/0/1/1/1/0 LHR		LHR	R4	LHR				
0/0/0/1/1/1/0 LHR		LHR	R1	LHR				
0/0/0/1/1/1/0 LHR		LHR	R4	LHR				
0/0/0/1/1/1/0 LHR		LHR	R1	LHR				
0/0/0/1/1/1/0 LHR		LHR	R4	LHR				
0/0/0/1/1/1/0 LHR		LHR	R1	LHR				
0/0/0/1/1/1/0 LHR		LHR	R4	LHR				
0/0/0/1/1/1/0 LHR		LHR	R1	LHR				
0/0/0/1/1/1/0 LHR		LHR	R4	LHR				
0/0/0/1/1/1/0 LHR		LHR	R1	LHR				
0/0/0/1/1/1/0 LHR		LHR	R4	LHR				
0/0/0/1/1/1/0 LHR		LHR	R1	LHR				
0/0/0/1/1/1/0 LHR		LHR	R4	LHR				
43 rows								

Leg Sets 2004Aug Sep Oct Nov Sun 12

	Sep 04	Thu 2	Fri 3	Sat 4	Sun 5	Mon 6	Tue 7	Wed 8	Thu 9	Fri 10	Sat 11	Sun 12
1234567 R1 RC1	R1	LHR	LHR	R1	LHR	R1	LHR	R1	LHR	R1	LHR	R1
...45.7 R4 RC4		LHR	R4	LHR	R4	LHR		R4	LHR	R4	LHR	R4
					R4	LHR			LHR	R4	LHR	R4
2 rows												

LHR – LHR R1 RC1  
U.T.C.: 0420 – 1420 Need: 0/0/0/1/1/1/0 Booked: 0/0/0/1/1/1/0 Assigned: 0/0/0/0/0/0/0  
Local: 0520 – 1520 Changes:

Time-point: 10Sep2004 1037 (U.T.C.)

29Jul2004 – 30Nov2004 0/0/0/1/1/1/0 On/Off/On ALL LHR Course/RosteringI/Dated/Rostering\_ex\_4Anna2 default\_ccr

Ground duty legs should match flights in the timetable.  
Thus, the local plan should contain ground duties.

# Ground duties

## Ground duty external tables

Table Editor - /users/anna/work/Customization/Rostering\_system/carmdata/GROUND\_DUTY\_FILES/Reserves.etab

File Edit

SeqNo main\_code attribute suffix station category start\_time end\_time length traffic\_days period\_start

SeqNo	main_code	attribute	suffix	station	category	start_time	end_time	length	traffic_days	period_start
1	1 R1	RC1		LHR		05:20	15:20	10:00	1234567	01Jan1986 00:00
2	4 R4	RC4		LHR		12:30	22:30	10:00	45 7	01Jan1986 00:00

2 rows

# Exercise 5

## Influence the solution



### Purpose

- change priorities of the cost function
- add ground duties to the plan.

**~1 hour**

# Exercise 5 summary



# Fairness

# Cost elements

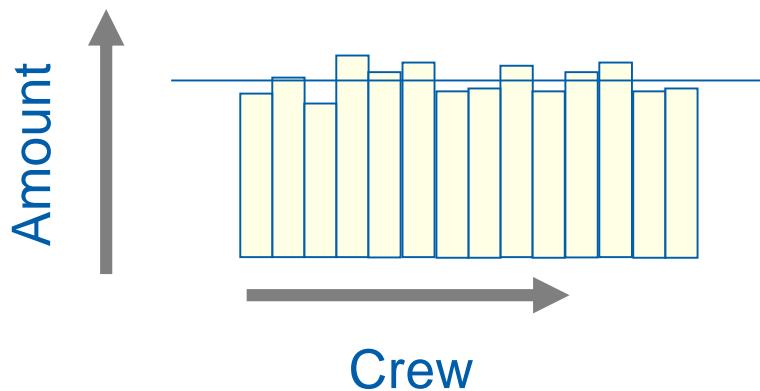
After all trips have been assigned, one of the major cost factors is to make crew happy. European and American planning strategies differ:

American – strict seniority, long-term  
European – fairness, short-term.

# Fairness

Often there are certain attributes that must be distributed equally among crew members.

For example, duty time per month should be distributed fairly



# Fairness

## A fairness element is:

- something interesting to distribute
- something crew members should have less of if they work less (or element of avg. type)
- something possible to calculate (or approximate) a target value and an actual value for.

# Fairness

**Common fairness elements are:**

- duty hours
- duty days
- early check-ins
- specific destinations
- standby duties.

# Fairness

---

The optimization supports a fair distribution of arbitrary roster aspects.

Rave penalizes deviations from fair distribution, forcing the optimizer to generate solutions with a high degree of fairness.

# Fairness

**Fairness calculation requires two steps:**

1. Calculate fairness target values before optimization job.
2. Calculate current deviation from target, and the cost of this.

# Fairness target values – examples

**A planning problem for April, three crew members (A, B and C):**

- A works full-time, has 10 days of vacation
- B works half-time, no absences
- C works on a 75 % contract, 10 days of leave.

**In total there are 8 night duties to be distributed among the three crew members.**

What is the full-time target?

What are the personal targets for A, B and C?

# Fairness target values – examples

## 30 days in April

A:  $(30-10) \times 100\%$  = 20 days available

B:  $(30) \times 50\%$  = 15 days available

C:  $(30-10) \times 75\%$  = 15 days available

**Total available days 50**

**Full-time equivalent  $50/30 = 1.67$  crew**

# Fairness target values – examples

**8 night duties gives a full-time target of  $8/1.67 = 4.8$**

## Personal target

$$\text{A: } 67\% \times 4.8 = 3.2$$

$$\text{B: } 50\% \times 4.8 = 2.4$$

$$\text{C: } 50\% \times 4.8 = 2.4$$

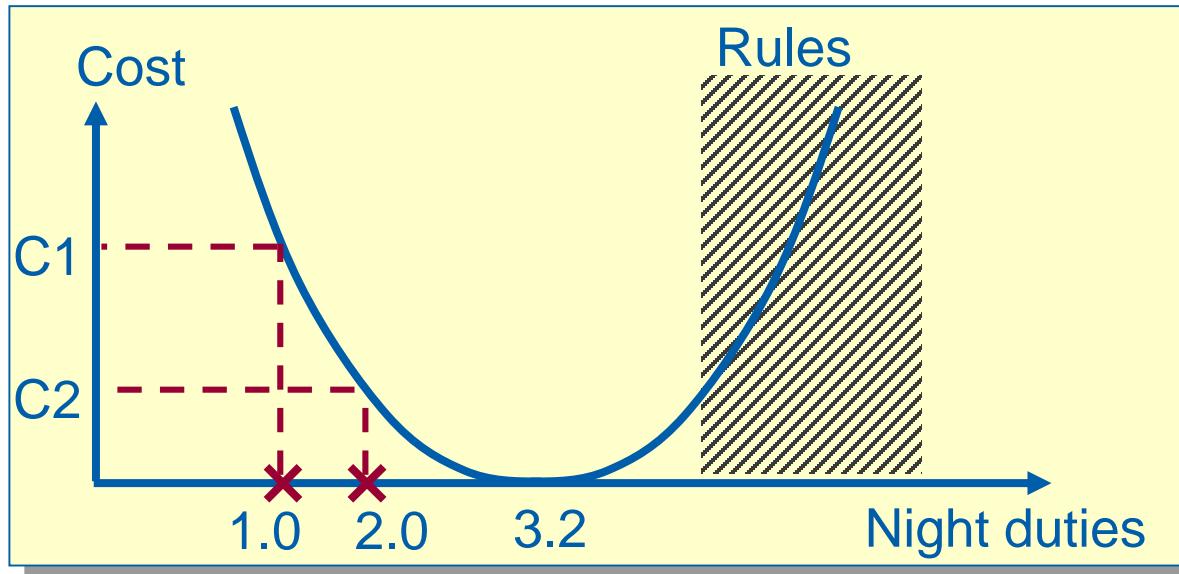
$$\text{Total night duties} \quad 8.0$$

# Fairness – the basic idea

Calculate a target for each crew member.

Penalize distance from target.

→ optimizer selects fair rosters



# Fairness

## Fairness Details

Planning Period: 01 - 29Sep2004

Rule Set Name: default\_ccr

Plan: Course / Rostering! / Dated / Rostering\_ex\_3

Crew	BLOCK TIME			RESERVES			Total Cost		
	Actual	Target	Cost	Actual	Target	Cost			
ASKINS	89:45	78:34	762	0	0.07	0	762		

Printed 30Sep2010 11:08:44 by magnusa

Fairness report for one crew member.

## Fairness Statistics

Planning Period: 01 - 29Sep2004

Rule Set Name: default\_ccr

Plan: Course / Rostering! / Dated / Rostering\_ex\_3

Group	Element	Avg Target	Avg Dev	Max Dev	Avg Cost	Total Cost
LHR-FA (16)	BLOCK TIME	75:16	11:01	21:11	912	14596
	RESERVES	0.06	0.06	0.07	0	0
LHR-AP (3)	BLOCK TIME	71:01	7:27	11:45	397	1193
	RESERVES	0	0	0	0	0
LHR-PU (1)	BLOCK TIME	77:01	3:44	3:44	84	84
	RESERVES	0	0	0	0	0

Printed 30Sep2010 10:53:39 by magnusa

Fairness report for several crew members.

JEPPESEN

1 ( 1 )

[Close](#) [Search](#) [Print](#) [Save As](#)

# Exercise 6

## Fairness



### Purpose

- create fairness target values
- run optimization with fairness.

~20 mins

# Exercise 6 summary



# Bidding

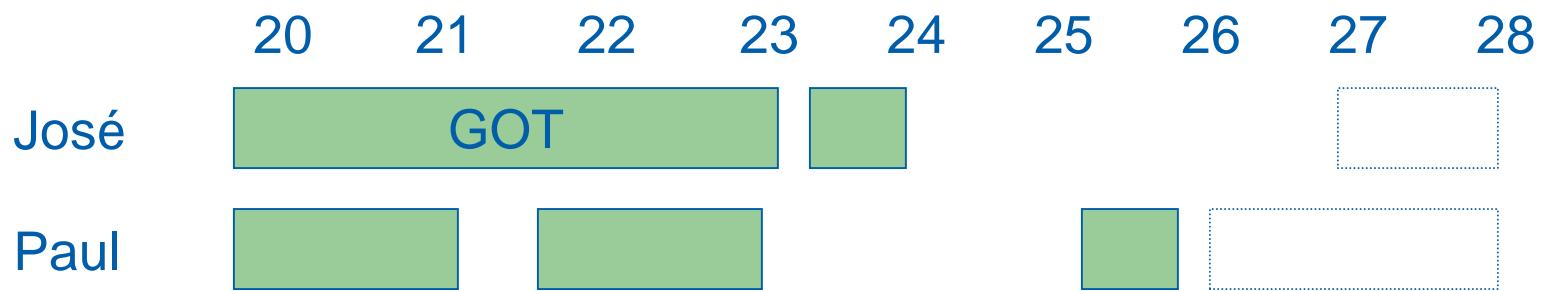
# Preferential bidding

A bidding system enables crew to influence working hours, working tasks and time off.

- based on the fact that people have different needs and lifestyles
- if everybody wants the same things, PBS will not work.

# Bidding – example

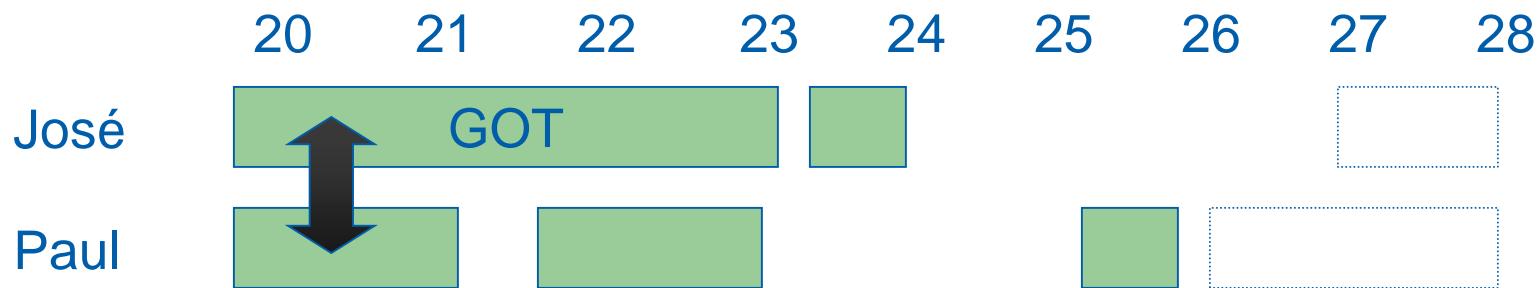
Captains José and Paul are planned to fly:



# Bidding – example

José just had a child and therefore prefers short trips.  
Furthermore, it is his birthday on the 24th.

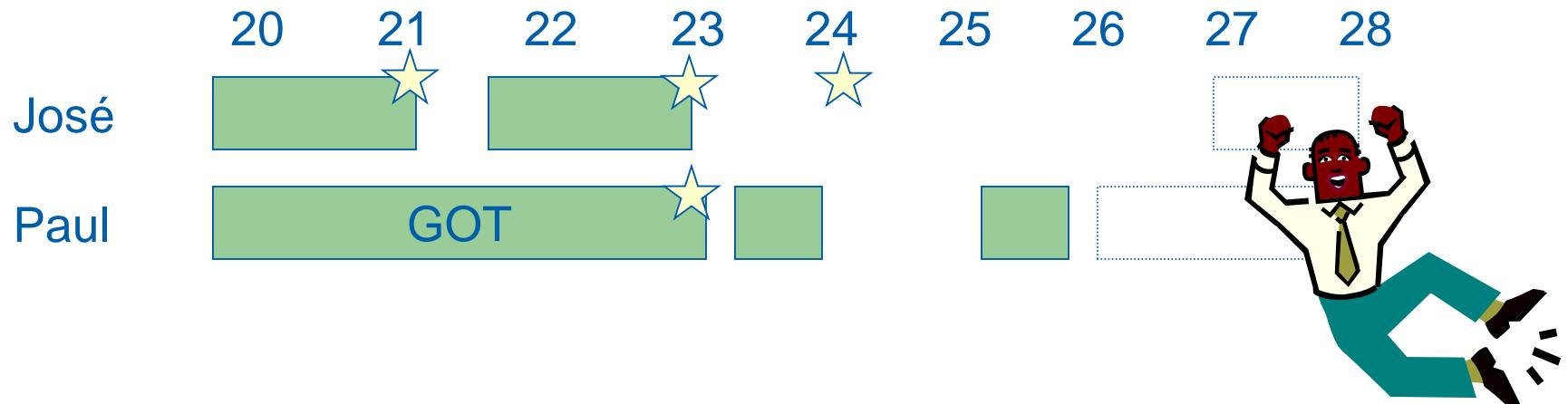
Paul is a bachelor living in Göteborg. He likes long trips.



...so we shift their schedules

# Bidding – example

The result has the same overall stability and the same overall cost but it is better adapted to real life crew requests.



# Bid types

## Time-off bids

"I wish to be off the 17th"

"I wish to be off on Tuesdays"

## Trip bids

"I wish to check-in before 8 am"

"I wish trips longer than 3 days"

"I wish trips shorter than 4 days with a layover in PAR and check-ins after 8 am"

## Ground duty bids

"I would like my reserve block between the 20-28th"

## Buddy bids

"I would like to fly with Hansen"

# Bidding models

There are two main bidding models:

- bid ratio/reference roster
- strict seniority.

# Strict seniority model

---

With strict seniority the system strives to maximize scheduled points for each individual in seniority order.

# Bid ratio model

- strives for a fair distribution of bid fulfillment
- crew seniority may influence the bid fulfillment
- allows each crew member to decide exactly which bids that mean the most to him/her
- creates individual rosters based on individual bids.

In this course we work with the bid ratio model.

# Bid ratio process

## Run #1: Reference roster

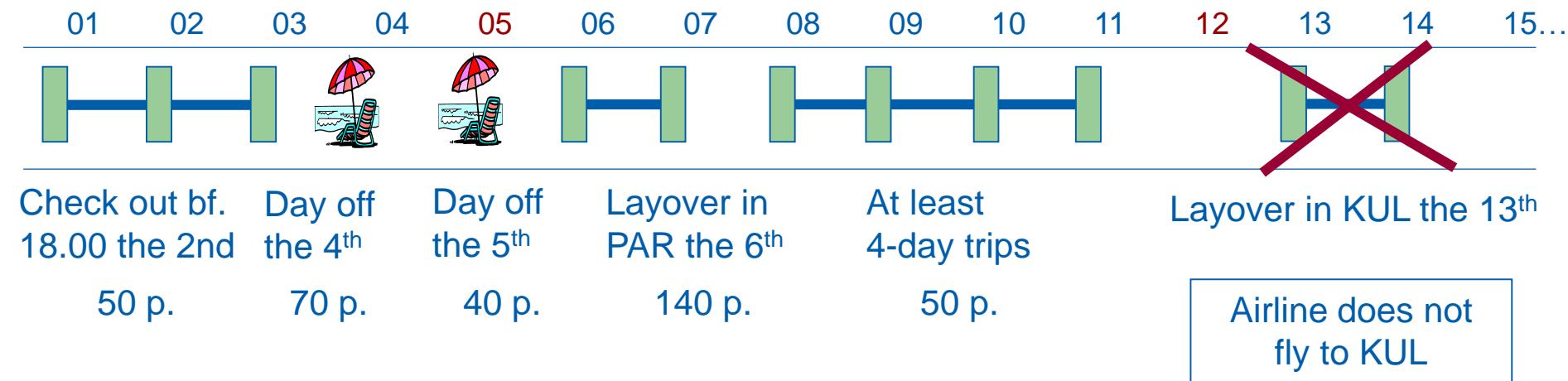


## Run #2: Production (bid ratio)



# Reference roster

Try to build the best possible roster for each crew, with all the trips available as if he was the only one bidding.



Totally 350 points

# Reference roster

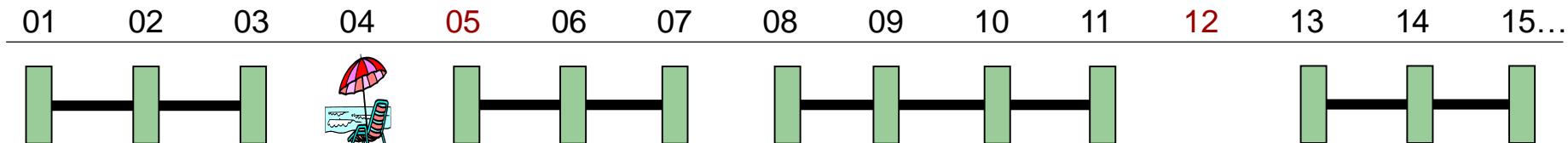
Blue indicates overbooked

1 Rosters	2004		AUG			SEP			OCT			2004														
	AUG 30	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	SEP 25
778128-A 68:40	BA	LHR	JNB	JNB	BA	LHR	LHR	LHR	LAX	LAX	LHR	LHR	LHR	LHR	GRU	GRU	GRU	LHR	LHR	LHR	LHR	PHX	PHX	B	LHR	
747177-A 78:10	BA	LHR	JNB	JNB	BA	LHR	2300	MBT	2259	LHR	JNB	JNB	LHR	LHR	BA	BA	BA	LHR	LHR	LHR	LHR	PHX	PHX	B	LHR	
771078-A 78:10	BA	LHR	CAT	CAT	LHR	LHR	JNB	BA	LHR	JNB	JNB	LHR	LHR	LHR	ABV	ABV	ABV	LHR	LHR	LHR	LHR	LAX	LAX	LAX	LAX	
862847-A 74:05	BA	LHR	CAT	CAT	LHR	LHR	2300	MBT	2259	2300	2300	2259	2300	2259	YUL	LHR	LHR	YYZ	LHR	LHR	LHR	LHR	SIN	SIN	SIN	B
830145-A 78:45	BA	LHR	JNB	JNB	BA	LHR	2300	MBT	2259	BA	MEX	MEX	MEX	MEX	LHR	LHR	LHR	MEX	MEX	MEX	MEX	LHR	LHR	BA	LHR	
818851-B 57:44	BA	LHR	JNB	JNB	BA	B	B	B	B	LHR	JFK	JFK	JFK	JFK	PHX	PHX	PHX	LHR	LHR	LHR	LHR	2300	AL	AL	AL	
749265-A 79:05	BA	LHR	MBT	2300	2259	B	B	B	B	LHR	LHR	LHR	LHR	LHR	GRU	GRU	GRU	LHR	LHR	LHR	LHR	HKG	HKG	BA	LHR	
870077-A 59:55	MBT	2300	FL7	2300	2259	B	B	B	B	CCS	CCS	CCS	CCS	CCS	LHR	LHR	LHR	PHL	PHL	PHL	PHL	B	B	B	ORD	
832528-A 72:35	AL	MBT	B	YYZ	B	YYZ	YYZ	YYZ	YYZ	LHR	LHR	LHR	LHR	LHR	YYZ	YYZ	YYZ	LHR	LHR	LHR	LHR	YYZ	YYZ	YYZ	LHR	
103240-A 76:35	MBT	2300	2259	B	YYZ	LHR	YYZ	YYZ	YYZ	LHR	LHR	LHR	LHR	LHR	GRU	GRU	GRU	LHR	LHR	LHR	LHR	HKG	HKG	BA	LHR	
864476-A 76:00	AL	MBT	LHR	ISB	B	ISB	ISB	ISB	ISB	LHR	LHR	LHR	LHR	LHR	YYZ	YYZ	YYZ	LHR	LHR	LHR	LHR	PHX	PHX	B	LHR	
871335-A 68:15	BA	LHR	P	LHR	ISB	ISB	ISB	ISB	ISB	LHR	CAT	CAT	LHR	LHR	ABV	ABV	ABV	ABV	2300	AL	2259	B	EWR	B	B	
75 rows																										

The same trip may occur for all crew that have the same wishes

# Bid ratio

## Final roster



Check out bf.  
18.00 the 2nd  
50 p.

Day off  
the 4<sup>th</sup>  
70 p.

Layover in  
PAR the 6<sup>th</sup>  
140 p.

At least  
4-day trips  
50 p.

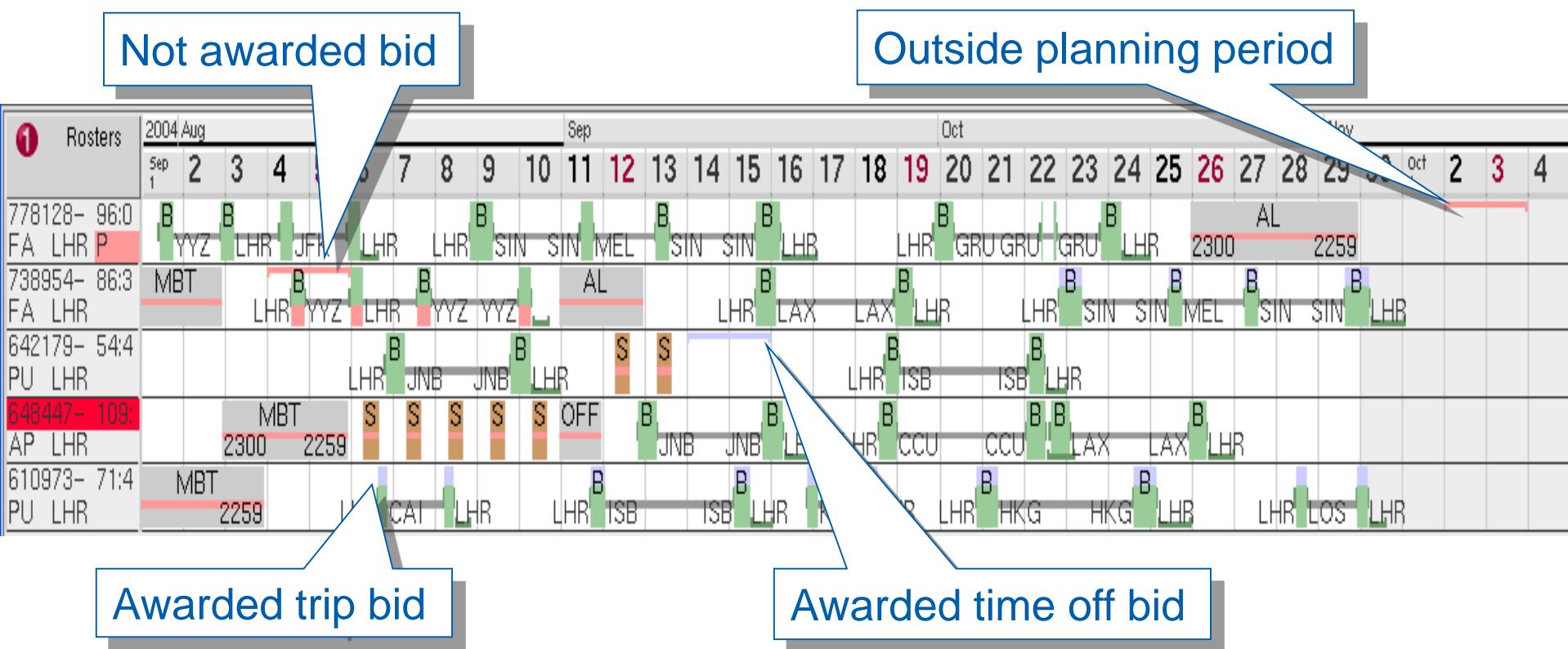
A three day trip  
(not according to bid)

No day off  
on the 5<sup>th</sup>

Totally 310 points  
Bid ratio = 89% (310/350)

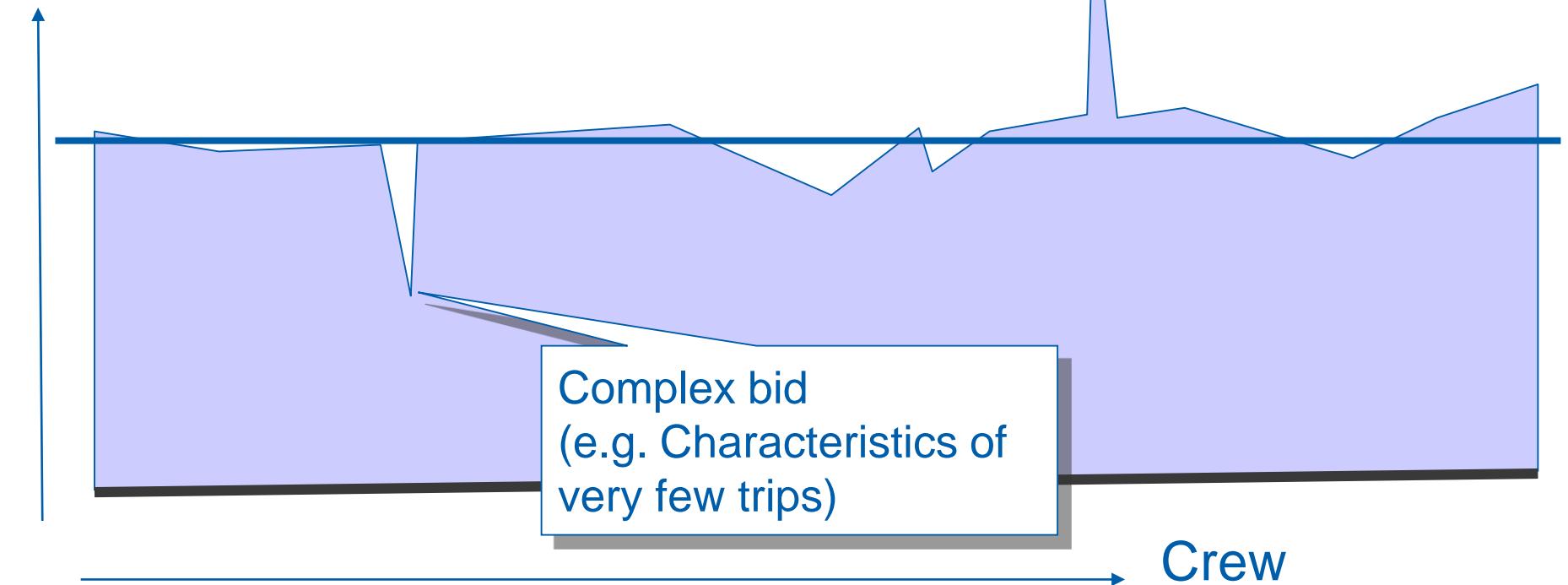
Bid ratio is always in the interval 0% to 100%.

# Bidding – visualization

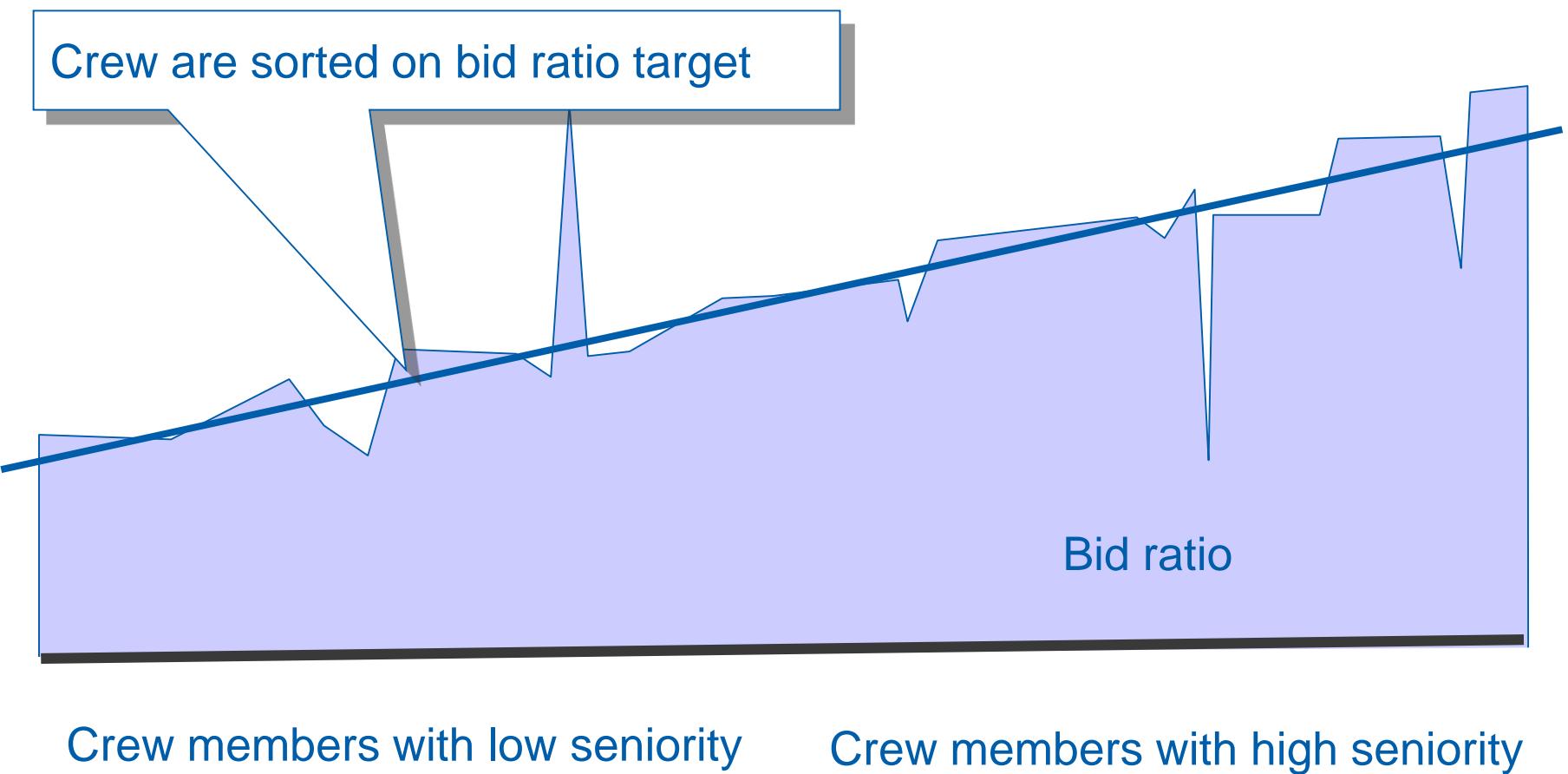


# Bidding – fairness

Bid  
Ratio



# Bidding – fairness



# Bid ratio

---

Not all bids are granted:

## Productivity

*(Production not covered if everybody had this bid satisfied)*

## Attractive bid

*(Limited number of certain properties)*

## Bad quality

*(The bid generates a roster that is not robust)*

## Illegal bid

*(The bid is illegal or impossible to combine with other bids)*

## Bid has low priority

*(There are other combinations that are more advantageous)*

## Impossible bid

*(e.g. A night stop at a destination where there are no night stops)*

## Not realistic

*(The roster would become unrealistic if the bid is granted)*

# Crew Bid

Crew Bid is a web application that makes it possible for crew to enter their bids using mobile devices.

Crew may see pre-assignments for the coming rostering period.

- Training
- Holiday
- ...

It is possible to filter out trips from Studio and to run reports.

The screenshot shows the 'Bids' section of the Crew Bid application. On the left, there are three calendar grids for July 2016, August 2016, and September 2016. The July grid shows various flight segments (e.g., DU8, OOT, AAR) with green and blue bars indicating duty and rest periods. The August and September grids show the start of the month. To the right of the calendars is a form for creating a bid. The 'Activity' section includes fields for 'From' (08/01/2016) and 'to' (08/31/2016), and dropdowns for 'Operating days from' and 'to'. Below this are sections for 'TRIP DETAILS' (Length: 5 days, Duty time: 5 hours), 'CHECK-IN & CHECK-OUT', and 'LAYOVER'. Under 'Layover', there is a dropdown for 'Max times/roster'. The 'Bid points' dropdown is set to '10 p'. At the bottom, there are 'Cancel' and 'Place bid' buttons, and a message stating '278 matching trips available'. A detailed trip summary is shown at the bottom right: 'AUG 01 01:40 - AUG 05 13:30 (+1 08:30)', 'DXB KUL MEL KUL', 'Duty 24:10h 24:05h 23:55h 29:40h', and a checkmark icon.

# Exercise 7

## Bidding



### Purpose

- produce a bid ratio solution
- combine bids with other considerations (such as ground duties, fairness).

~1 hour

# Exercise 7 summary



# The planning process

# Planning process – walkthrough

- 
- set up data
  - create sub-plan from file
  - load crew table
  - fetch trips
  - load rule set and parameters
  - do manual planning
  - run optimization
  - analyze the solution
  - publish.

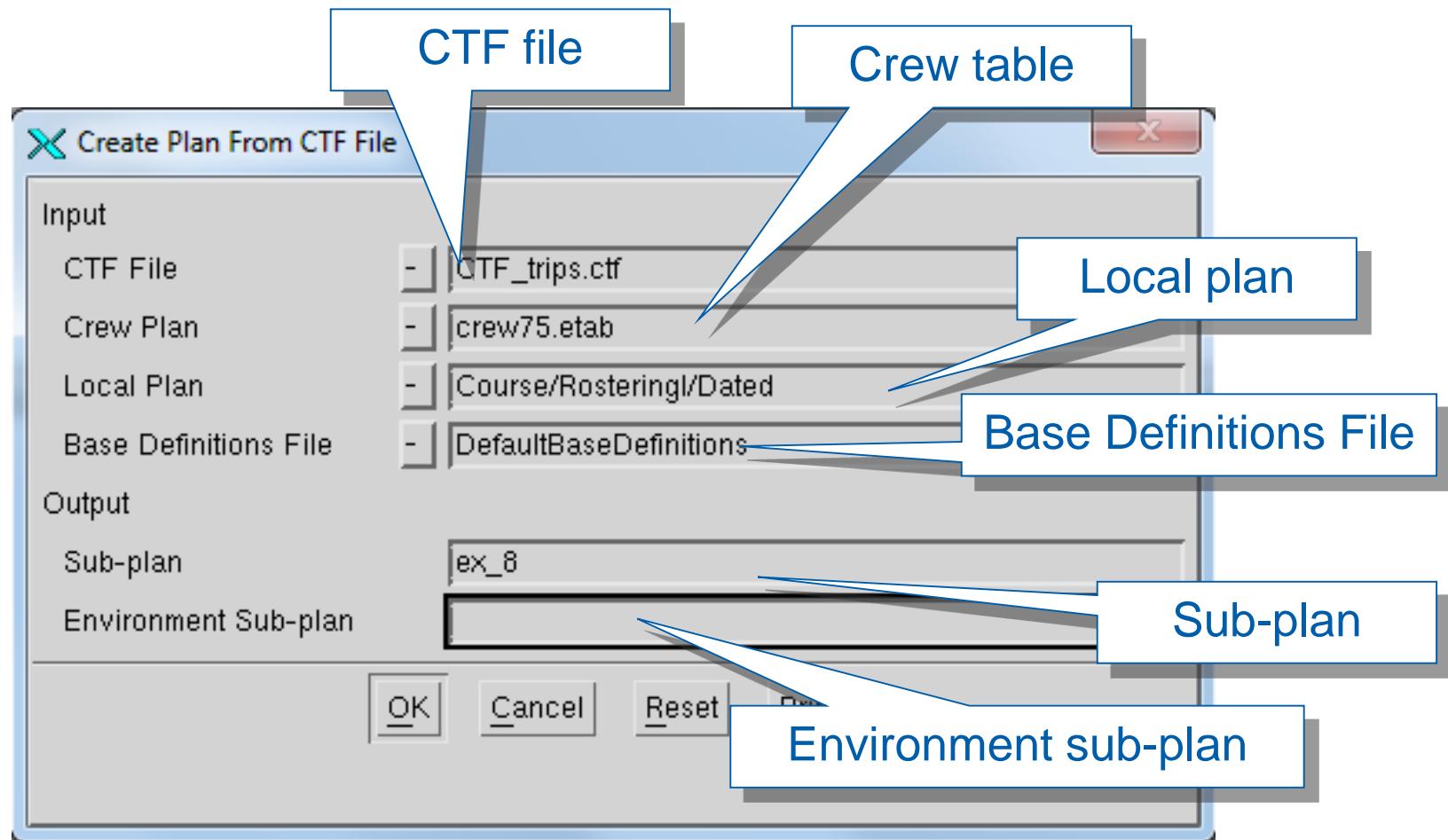
# Set up data

---

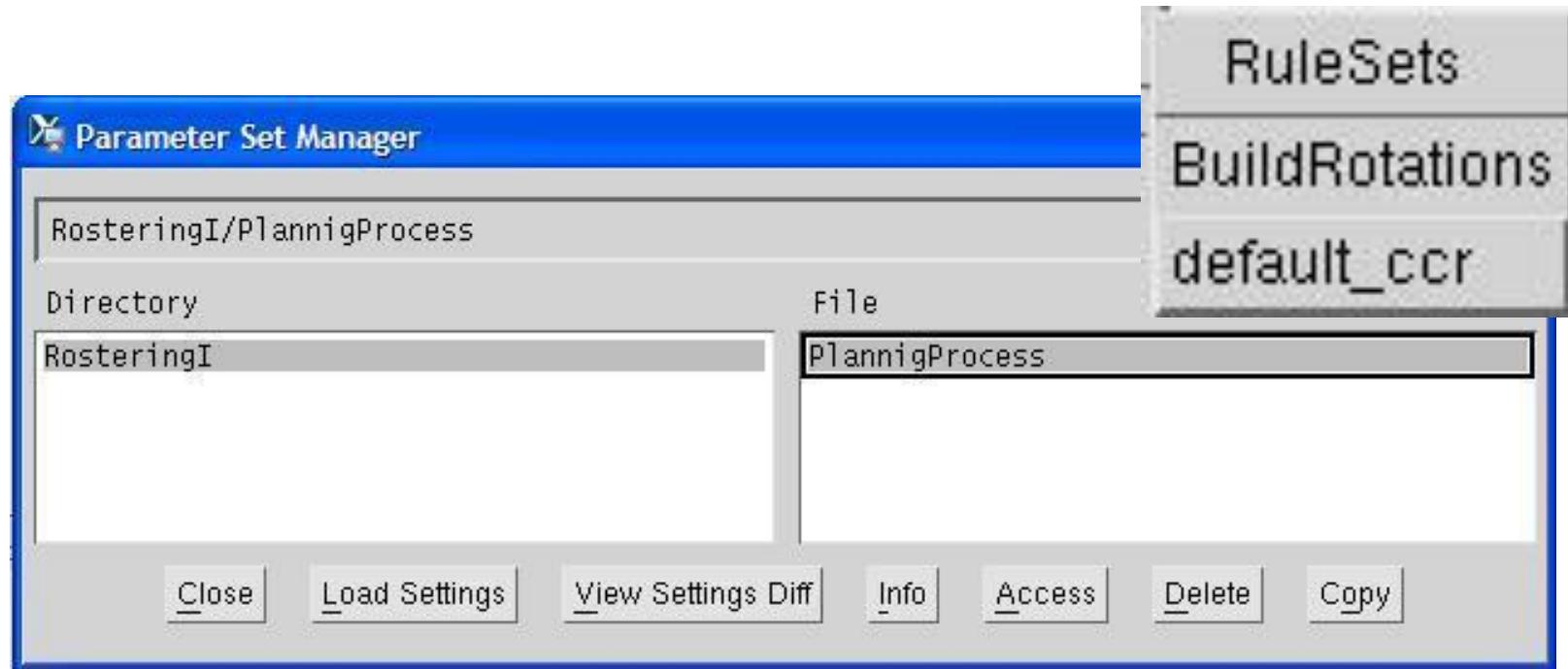
**For all your rostering problems**

**What data is needed?**

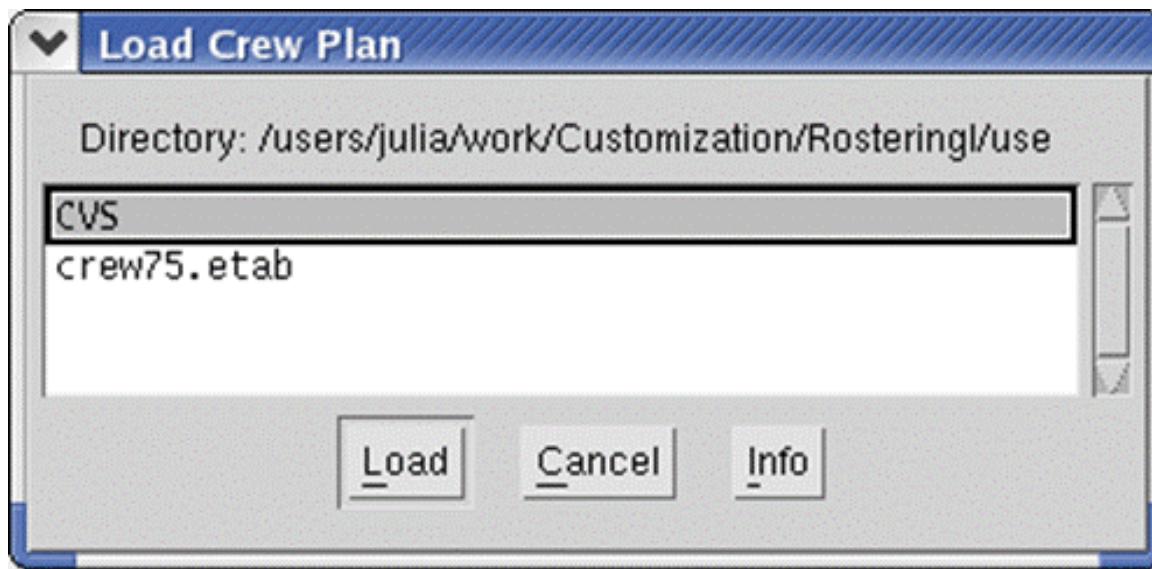
# Create sub-plan



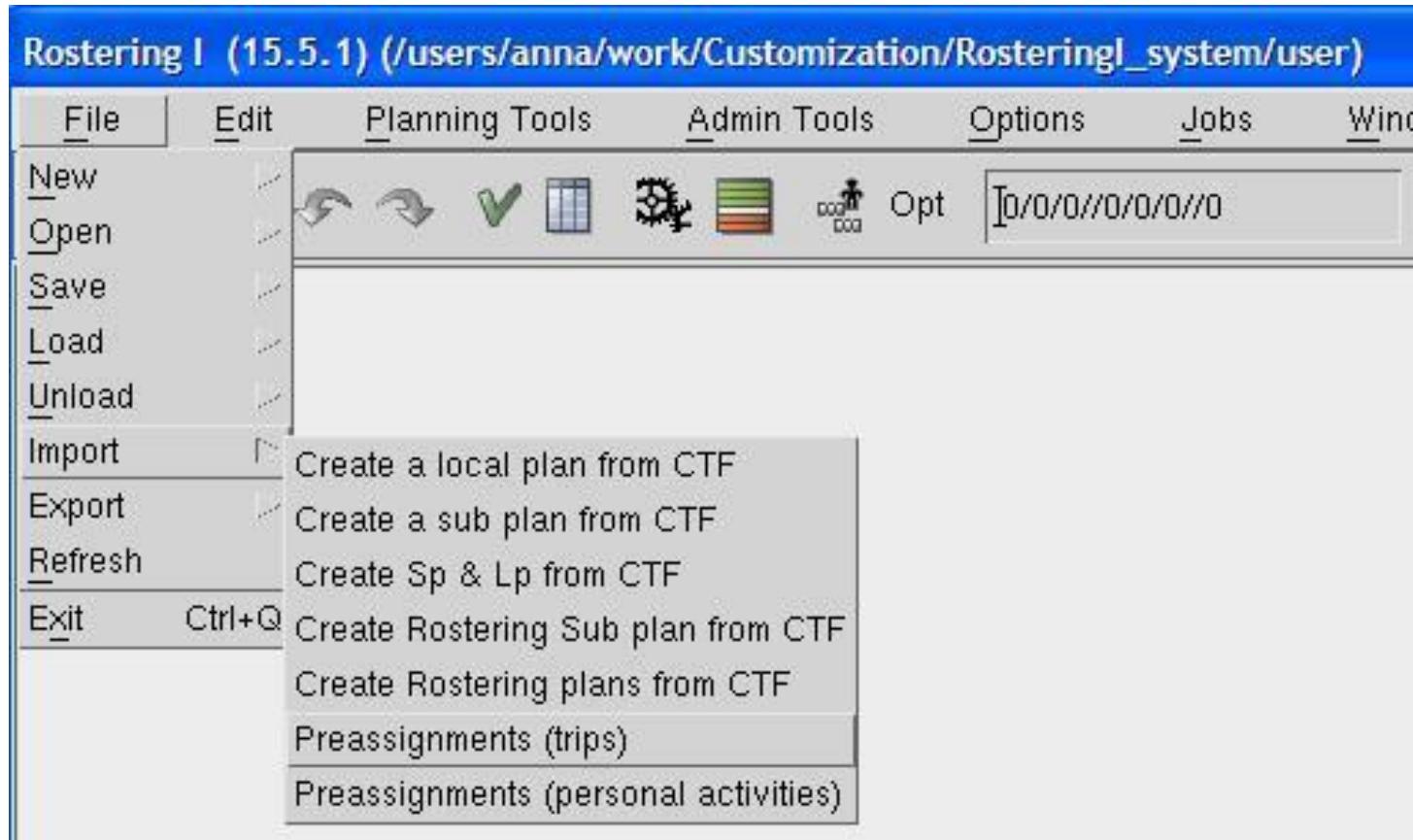
# Load rules and parameters



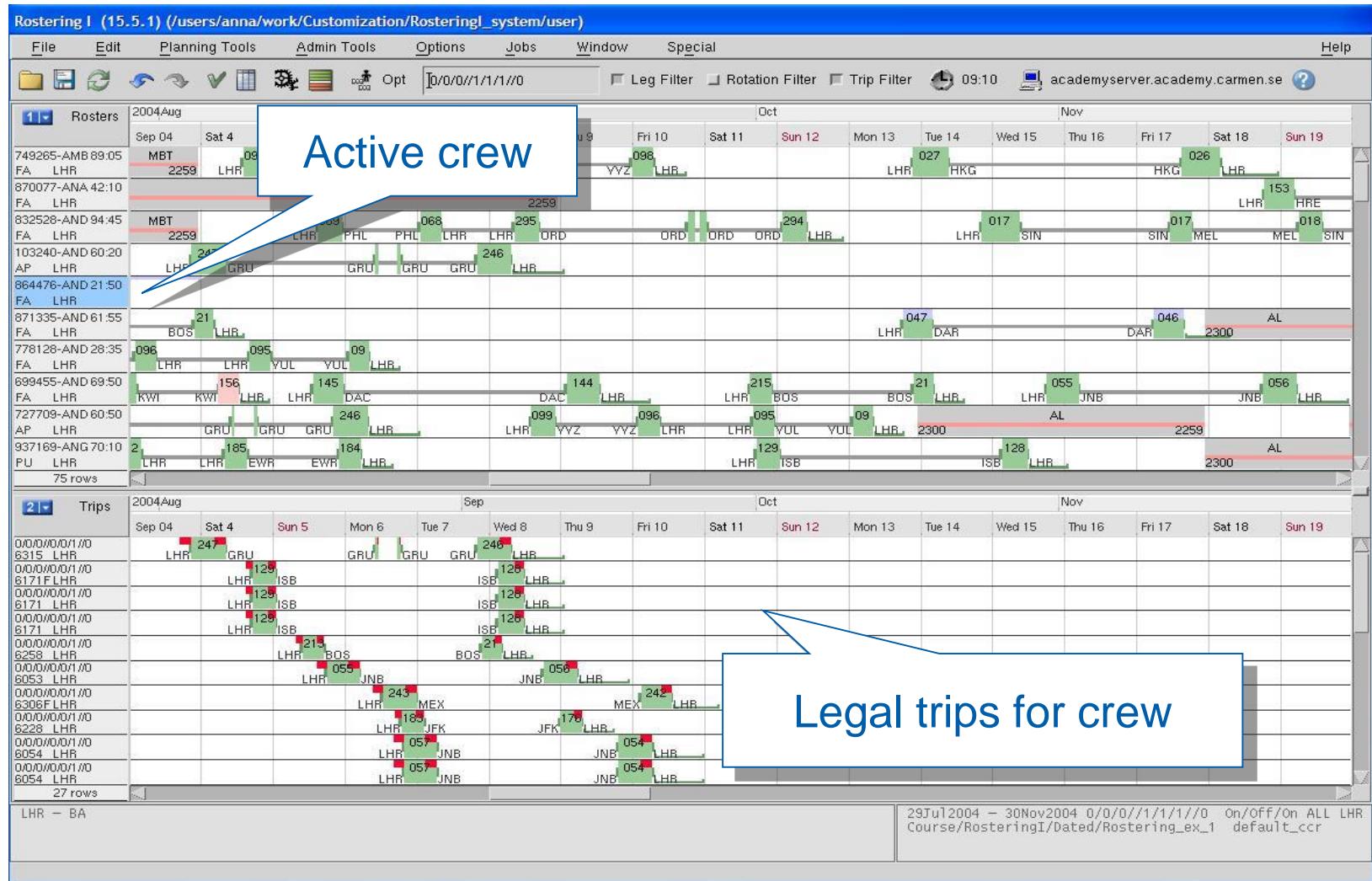
# Load crew table



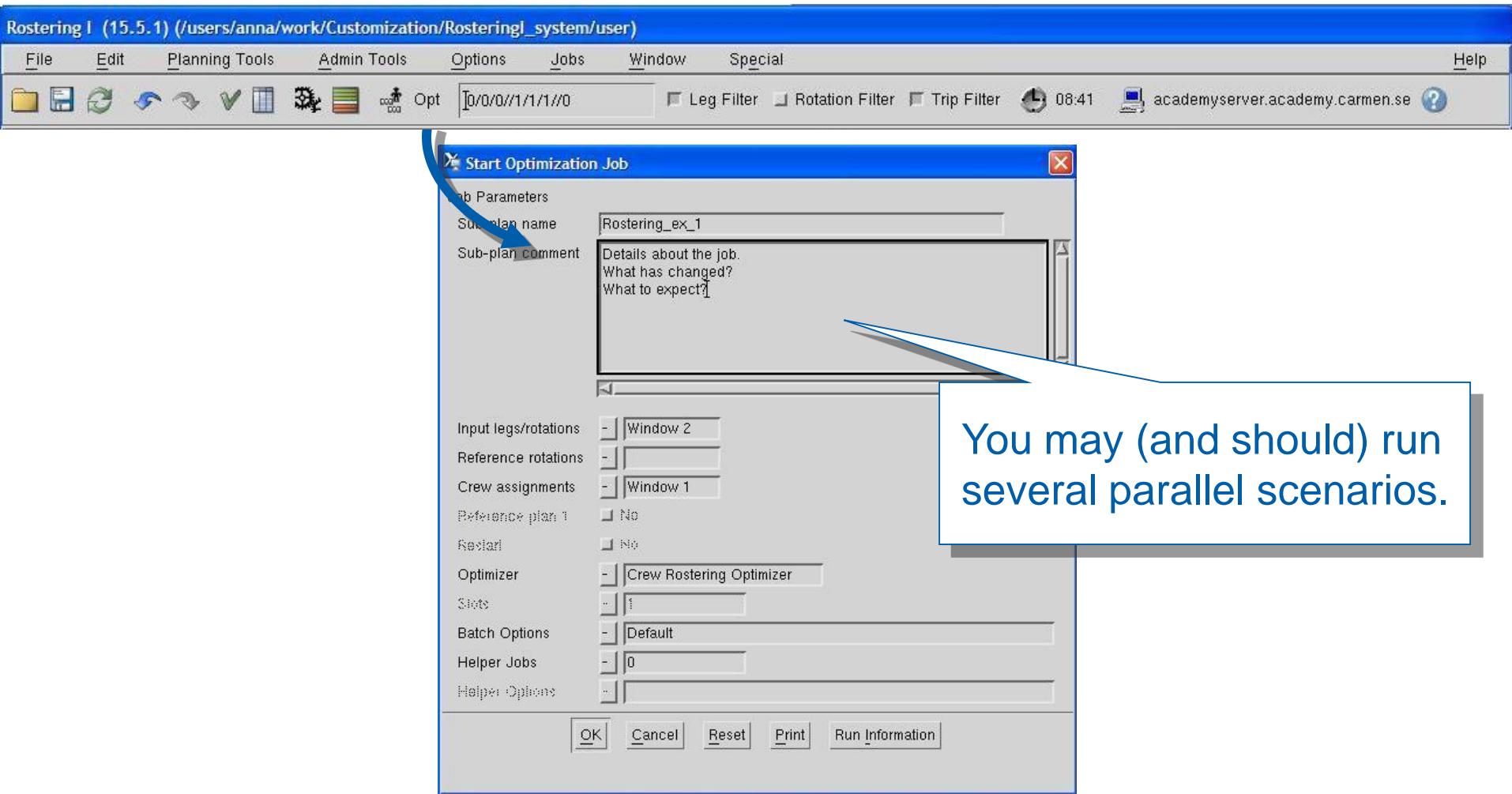
# Import trips and pre-assignments



# Manual assignment



# Start optimization job



# Analyze solution

**Bid Statistics**

Planning Period 01 - 29Sep2004  
Rule Set default\_ccr  
Plan Course/RosteringI/Dated/Rostering\_ex\_1\_01

**BID STATISTICS FOR BASE LMR**

Total Crew size	75
No of Crew with bids	43
Total no of bids	80

Roster Bids	#Bids (#Bidding Crew)	#Granted Bids
Days Off	32 (32)	28
Weekly Days Off	0 (0)	0

Trip Bids	#Bids (#Bidding Crew)	#Granted Bids
Flight Request	15 (14)	21

Combination Trip Bids	#Bids (#Bidding Crew)	#Granted Bids
Combination	6 (6)	6
Flight Request	6 (6)	6
Buddy	6 (6)	6

**FairnessStatistics**

Planning Period 01 - 29Sep2004  
Rule Set default\_ccr  
Plan Course/RosteringI/Dated/Rostering\_ex\_1\_01

Group	Element	Avg Target	Avg Dev	Max Dev	Avg cost	Total cost
LMR-FA (54)	BLOCK TIME RESERVES	69:41 0.05	7:49 0.13	10:38 3.95	365 7	20908 389
LMR-AP (17)	BLOCK TIME RESERVES	67:02 0	7:31 0	11:45 0	402 0	6835 0
LMR-PU (4)	BLOCK TIME RESERVES	74:30 0	7:47 0	10:11 0	395 0	1583 0

**RosterStatistics**

Printed 12De

Planning Period 01 - 29Sep2004  
Rule Set default\_ccr  
Plan Course/RosteringI/Dated/Rostering\_ex\_1\_01

**Key figures**

Single days off:	57
1 day wops:	0
2 days wops:	1
3 days wops:	9
4 days wops:	17

**Unassigned pairings**

Number of (1.1 Penalty for flight pairings >= 3 days) slots:	8
Number of (1.2 Penalty for reserve pairings) slots:	0
Number of (1.3 Penalty for short pairings) slots:	0
	8

# Exercise 8

## The planning process



### Purpose

Get a picture of the whole rostering process

**~30 mins**

# Exercise 8 summary



# Complicating factors

Crew composition

Training

Recency – to maintain qualifications

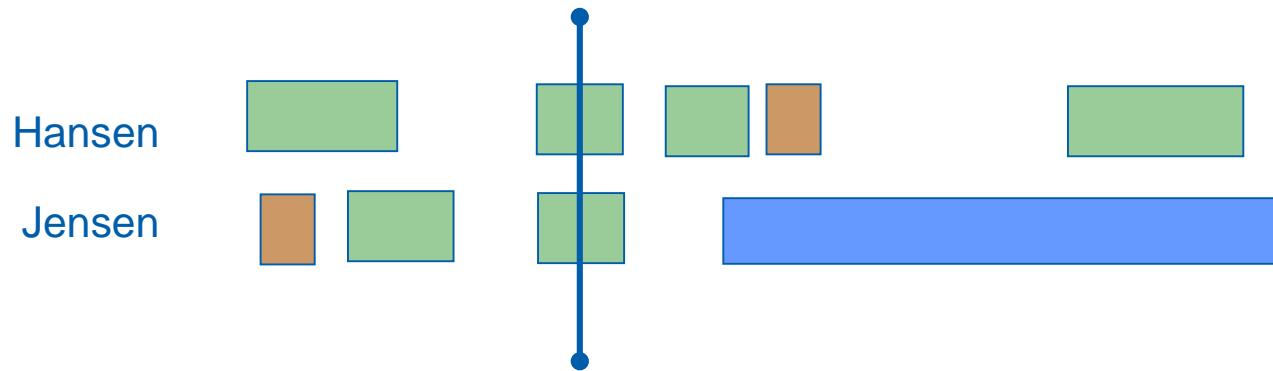
Fly below rank

Base variants

# Crew composition

When checking ordinary rules (e.g. "max duty time per month") only one crew member at a time is considered.

Some rules can be enforced only by taking several crew members into account. These rules are called vertical constraints.



# Training

Crew must go through different types of training:

- introduction training (new crew members)
- promotion training, e.g. first officer -> captain
- moving from one aircraft type to another
- approaching new or difficult airports
- yearly checks
- maintenance training after long absence.

# Training

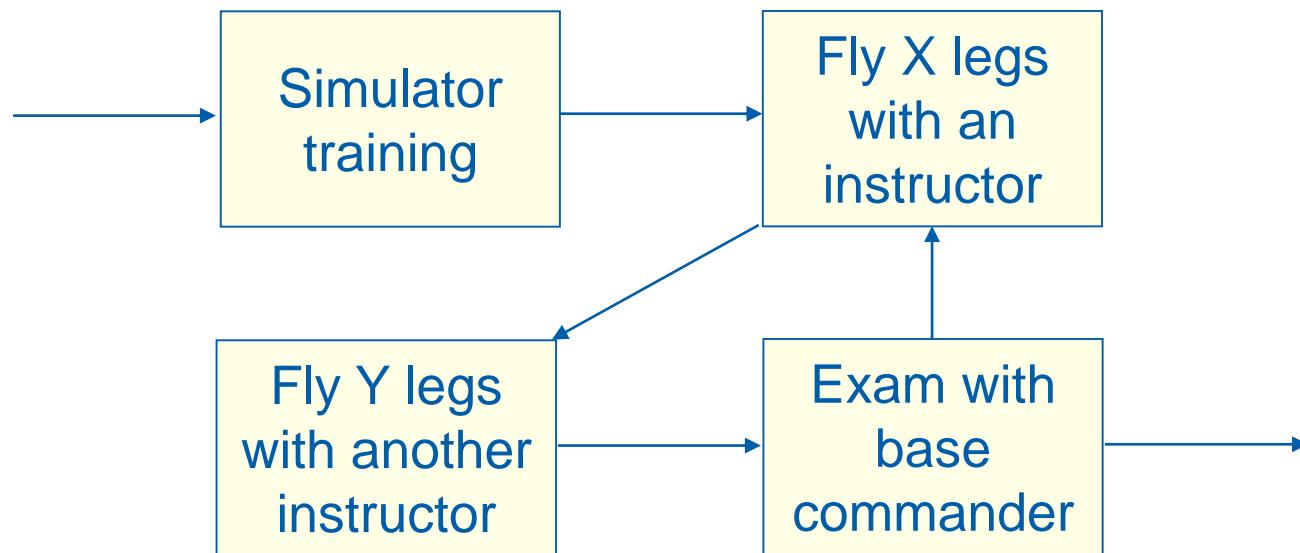
All training duties involve an instructor.

There are different types of training:

- fly with an instructor
- simulator training
- courses, meetings, conferences etc.

# Training

Complex training sessions involve several steps, for example:



# Training

From a planner point of view, training (especially complex training) is difficult to schedule optimally.

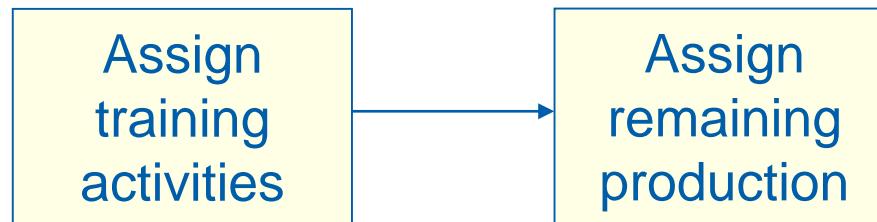
You have to make several choices:

- which instructor should fly with which student?
- which trips should be used for the training flights?

Often, instructors are scarce resources.

# Training

In many airlines, training activities are scheduled in a separate planning step (before normal production) to decrease complexity.



# Recency – maintain qualifications

Crew should not loose their qualifications: it must be maintained. This may involve flying certain trips and attending courses.

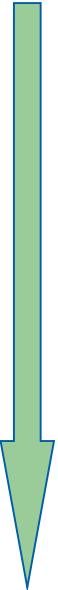
## Examples:

- crew must fly a certain aircraft type in any four consecutive months to keep their aircraft qualification.
- crew must attend a safety course once a year to be qualified to fly.

# Recency

The Jeppesen Crew Rostering system provides several mechanisms for maintaining qualifications:

Closer and  
closer  
expiry date

- 
- fairness on e.g. aircraft type
  - variation, quality penalties/rules
  - penalty for getting too close to expiry date without getting a trip with qualifying attributes
  - rule for getting really close to expiry date without getting a trip with qualifying attributes.

# Fly below rank

Crew may fly positions below (or above) their rank to cover production:

- captains fly as first officers
- pursers fly as cabin attendants.

The cost function determines if it is productive to fly in a different rank.

Usually only used during a transition period.

It increases the number of roster solutions significantly

# Pre-defined periods

**The optimizer may assign crew in pre-defined positions in pre-defined periods, for example:**

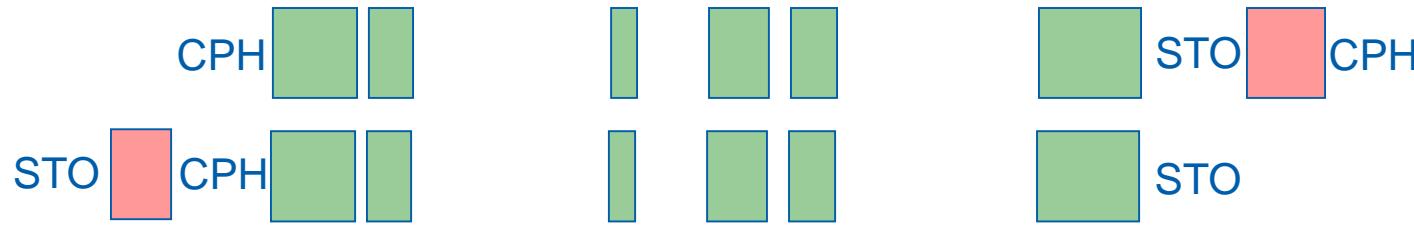
- work as flight attendant to the 15<sup>th</sup>
- work as purser from the 16<sup>th</sup>.

**The change in position may not depend on roster activities, for example:**

- Change position after 30:00 block hours in a month.

# Base variants

If an airline has several bases, you may easily make some trips flyable from several bases.



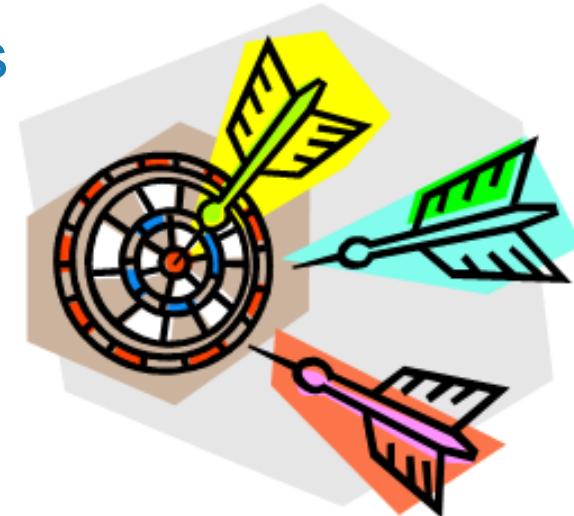
These sets of trips are called base variants.

The use of base variants eases accommodation of tight base constraints.

# Course summary

## You have learned about:

- manual planning in Studio
- using rule exceptions
- basic optimization
- using the Rostering Optimizer
- perform simple simulations
- distributing certain aspects using fairness
- preferential bidding.



# Course Evaluation

Please take a few minutes to complete the evaluation form, it will help us improve the courses for you and your colleagues:

## **Special> Academy> Course Evaluation**

Are the exercise definitions too vague (too real-life), would you like them to be more exact and straight forward?

Would you like to have even more info on slides (for self studying) or would you be stressed about the time constraint?

# The end

**This was Rostering I  
Welcome back to Jeppesen Crew Academy!**