



Scheduling Activities for the Patrol Boat Force

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Overview

- Introduction
- The scheduling tasks
- Problem-solving scheme
- Cost formulations
- The software
- Possible further development

Introduction

- CBM: scheduling **crews**, **boats**, **missions**... also maintenances and ports.
- Carried out by CSIRO with DSTO, for the Replacement Patrol Boats project.

Scheduling tasks – summary

- Main tasks:
 - ❖ Set timings for missions and maintenances
 - ❖ Determine assignments of crews to boats
 - ❖ Construct week-by-week schedule of activities for each boat and each crew.
- We assume a 12-month planning period, with one-week granularity of time.
- Multi-crewing makes for complexity and is a primary driver of the project.

Scheduling tasks - objectives

- 1 Spread timings evenly in each mission-group
- 2 Regular operational cycles for crews
- 3a Leave during school holidays
- 3b At least one leave during school holidays
- 3c Spread leave evenly in year
- 3d Desired leave block sizes
- 5 Minimise hand-overs
- 6 Minimise remote hand-overs

Scheduling tasks – constraints₁

- 1 Include UUC
- 2 Include all planned missions
- 3 Limited boats
- 4 Limited mission-time
- 5 Boats available for surge
- 6 Restricted maintenance facilities in ports
- 7 All missions assigned to crews
- 8 One activity at a time per crew
- 9 Operational workload limit
- 10a Leave quota per crew
- 10b Minimum leave block size

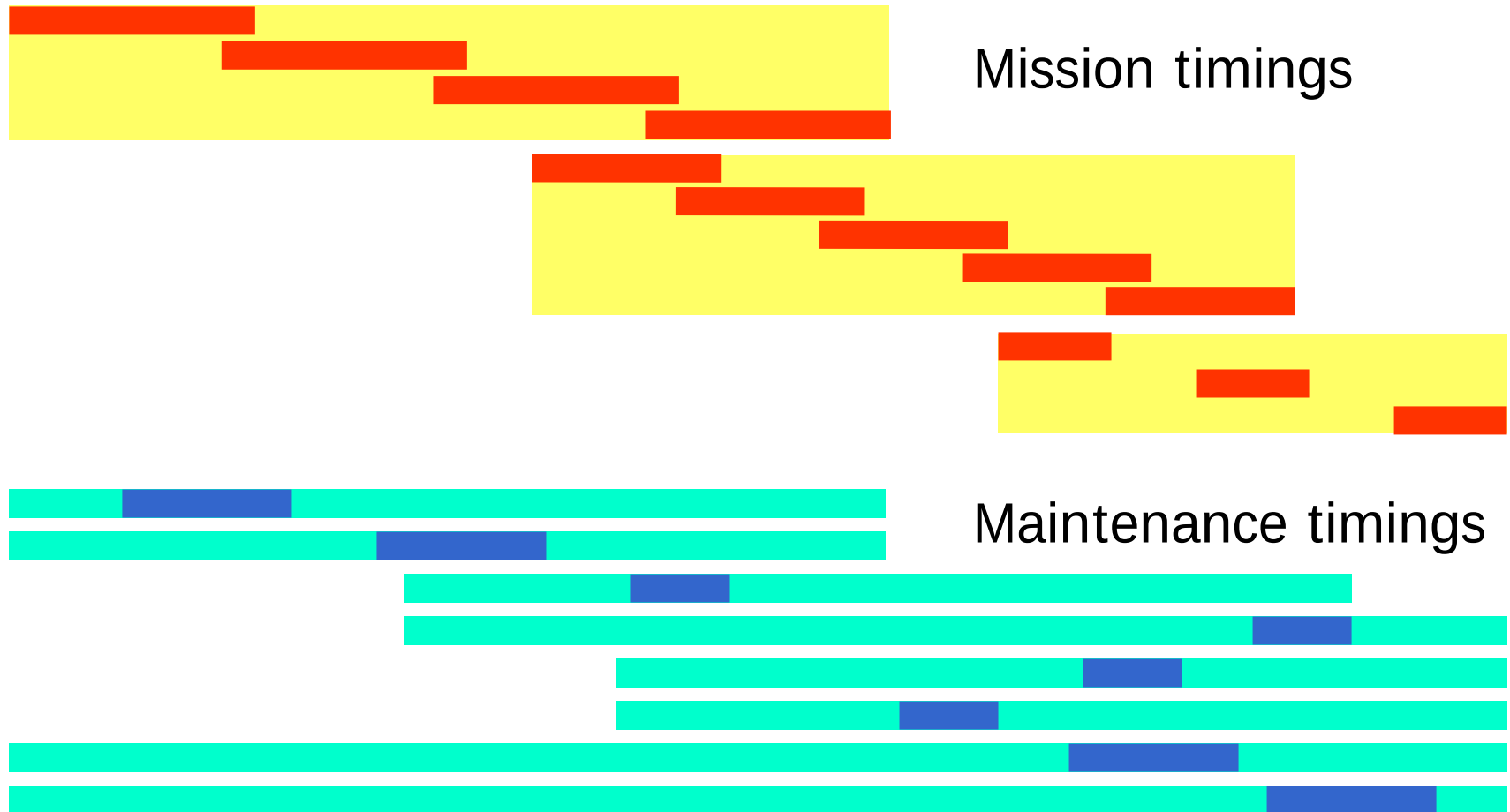
Scheduling tasks – constraints₂

- 12 At most one workup mission per crew
- 13 Training every operational cycle
- 15 All boat activities assigned to boats
- 16 One activity at a time per boat
- 17 Boat must have crew assigned
- 18 Limit no. of crews assigned to a boat
- 19 Limit no. of boats a crew is assigned to
- 20 Maintenance at crew's home port
- 21 Workup follow-up

Problem-solving scheme

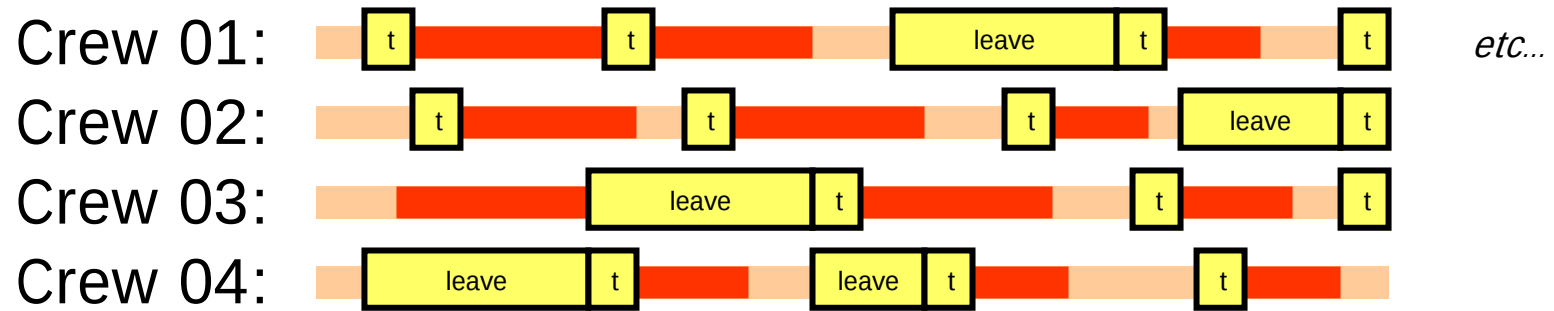
1. Generate a Fleet Activity Schedule (FAS), with timings for all maintenances and missions.
2. Generate a Combined Operations Plan (COP), with maintenances and missions assigned to crews, boats and ports.
3. Define details of leave and training for each crew in the COP.

Problem-solving scheme: FAS



Problem-solving scheme: COP

Crews: week-by-week deployments, leave, training



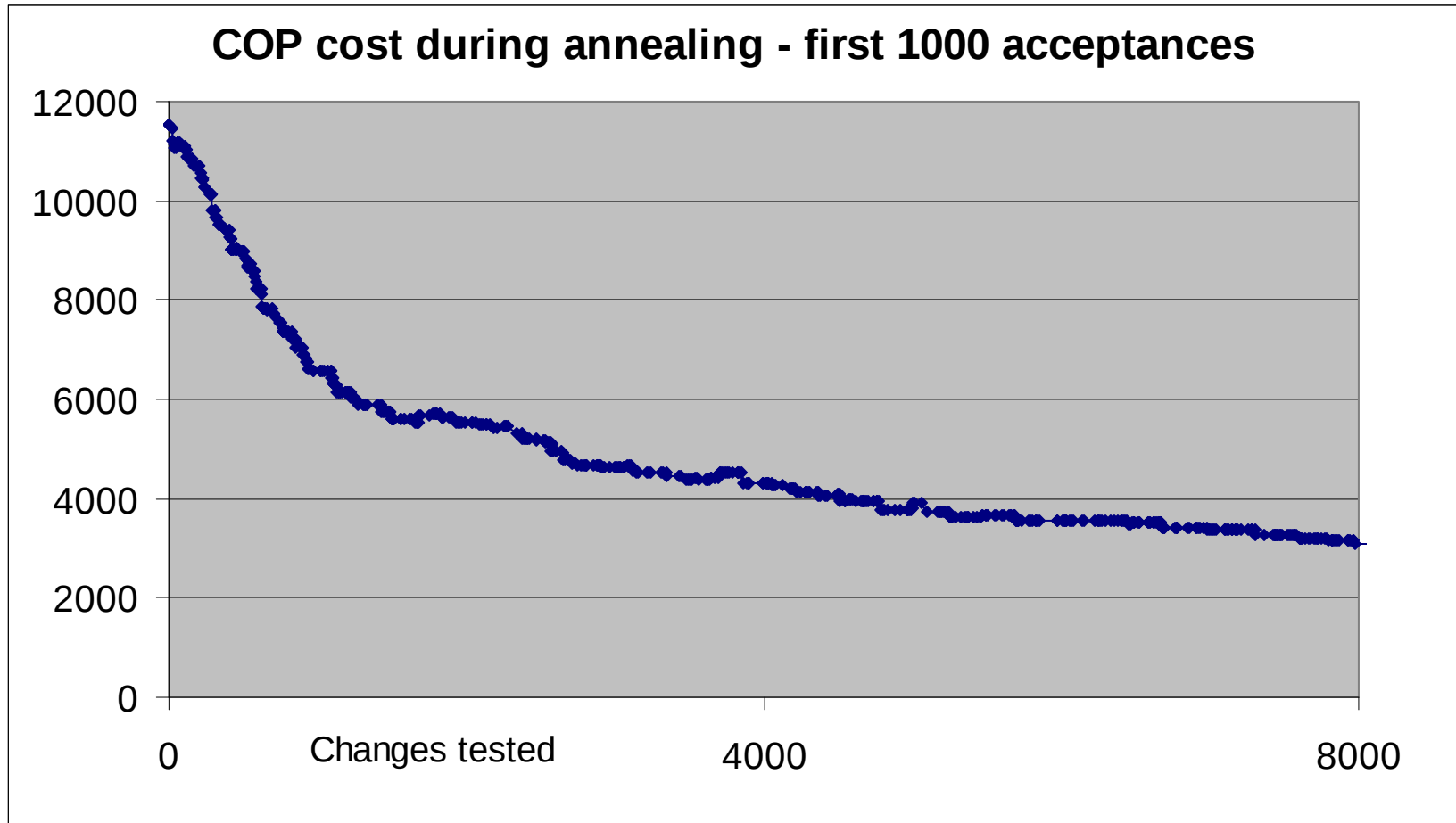
Boats: week-by-week deployments and maintenance



Local search techniques

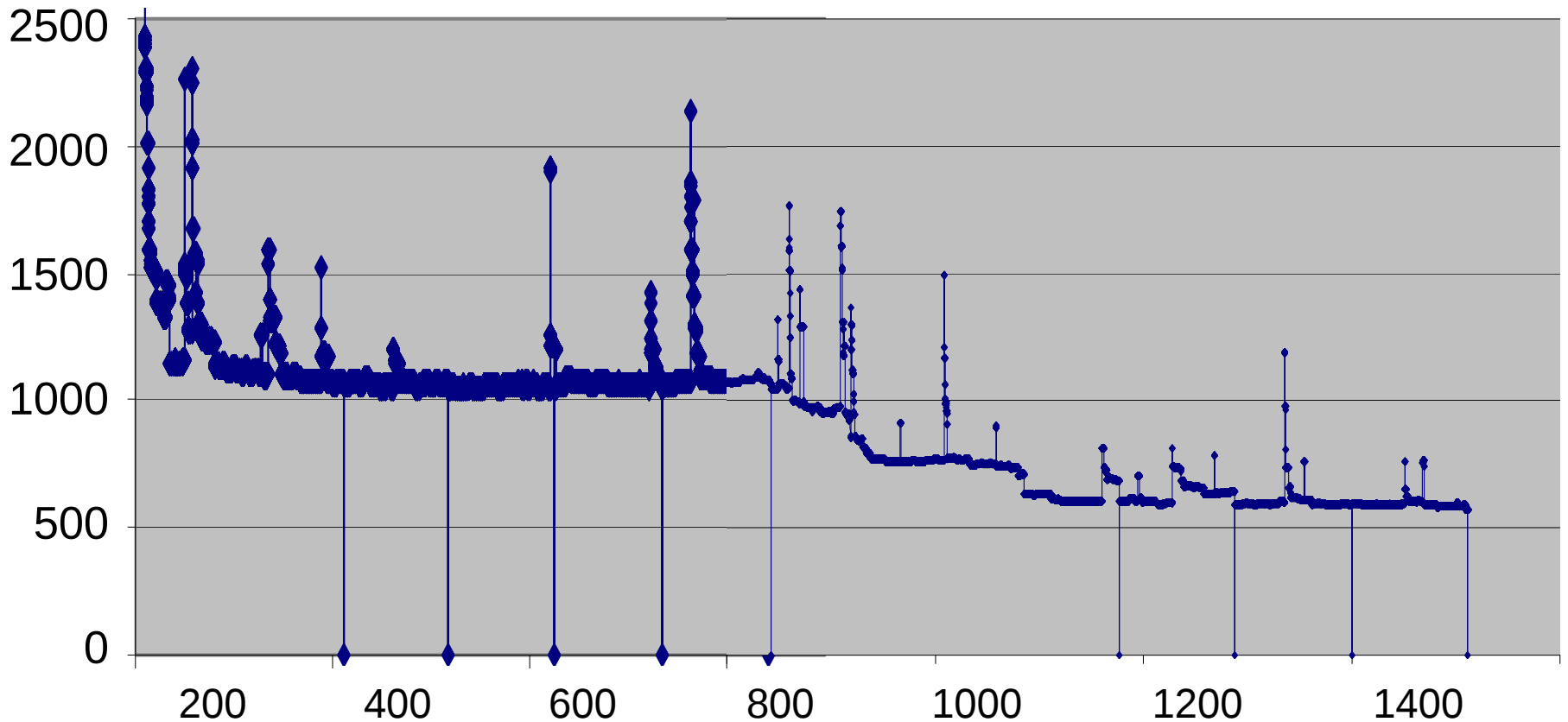
- **Steepest-descent improvement**: take an arbitrary starting plan and make the most-improving small change. Repeat until no further change is possible.
- **Simulated annealing**: like improvement, with temporary reductions in quality. We start “hot” (allowing random changes) and proceed slowly to a “cooled” state, aiming for an “well-ordered” outcome.

COP annealing (11B18CSA01-CopSA-2)



COP annealing (11B18CSA01-CopSA-2)

Cost over 1433718 tries, 65536 acceptances



Cost formulation

- A scheduling plan comprises a FAS and a COP based on the FAS timings.
- For both FAS and COP, overall solution quality is measured as total cost:
 - ❖ Costs due to objectives, e.g. deviations from equal-spaced timings for missions.
 - ❖ Costs due to violations of constraints, e.g. boat-weeks in violation of the surge condition. Some constraints are *hard*, some *soft*.

Cost formulation – FAS

FAS-01: cost 309.86 (O: 289.86, S: 20.00, H: 0.00) . . .

[01]	Mission-group devs:	169.86	x	1.00	x	1	=	169.86	
[03a]	Avoid school hols:	120	x	1.00	x	1	=	120.00	
[C3]	Total boats used:	0	x	20.00	x	1	=	0.00	[0 weeks]
[C4]	Monthly miss-times:	0.00	x	10.00	x	1	=	0.00	[0 mths..]
[C5]	Surge available:	2	x	10.00	x	1	=	20.00	[2 weeks]
[C6a]	Maintenance cap:	0	x	20.00	x	1	=	0.00	[0 weeks]

Cost formulation – COP

COP-01: cost 524.0 (0: 384.0, S: 140.0, H: 0.0) . . .

[02] Regular op cycles: 105 x 1.0 x 1 = 105.0

[03b] School holidays: 0 x 1.0 x 9.0 = 0.0

[05] Total handovers: 21 x 1.0 x 9.0 = 189.0

[06] Remote handovers: 2 x 5.0 x 9.0 = 90.0

[C6b] Port capacities: 0 x 20.0 x 1 = 0.0

[C8*] One act per crew: 0 x 150.0 x 1 = 0.0

[C9] Total opnal weeks: 0 x 10.0 x 1 = 0.0

[C12] Workup/crew <= 1: 0 x 10.0 x 1 = 0.0

[C13] Training/cycle: 14 x 10.0 x 1 = 140.0

[C16*] One act per boat: 0 x 150.0 x 1 = 0.0

[C18] Crews per boat: 0 x 10.0 x 9.0 = 0.0

[C19] Boats per crew: 0 x 10.0 x 9.0 = 0.0

[C21] Workup followup: 0 x 10.0 x 9.0 = 0.0

The software

- CBM runs on a Windows PC, in a command-prompt window.
- I/O is mainly Excel spreadsheets.
- Good solutions for difficult problems can be obtained in 15-60 minutes.
- Technical awareness is required of users.

Possible further development – as an operational tool?

1. Make CBM more user-friendly, with GUI.
2. Allow scheduling over a given calendar period instead of a “standard year”.
3. Accept existing commitments, e.g. at beginning of planning period.
4. Mission prioritization.
5. More fairness for crews
6. Handle new scheduling conditions (squadrons?).