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ONERA
THE FRENCH AEROSPACE LAB

CP Model for Assembly Line Balancing and Scheduling with Walking Workers and Parallel Stations

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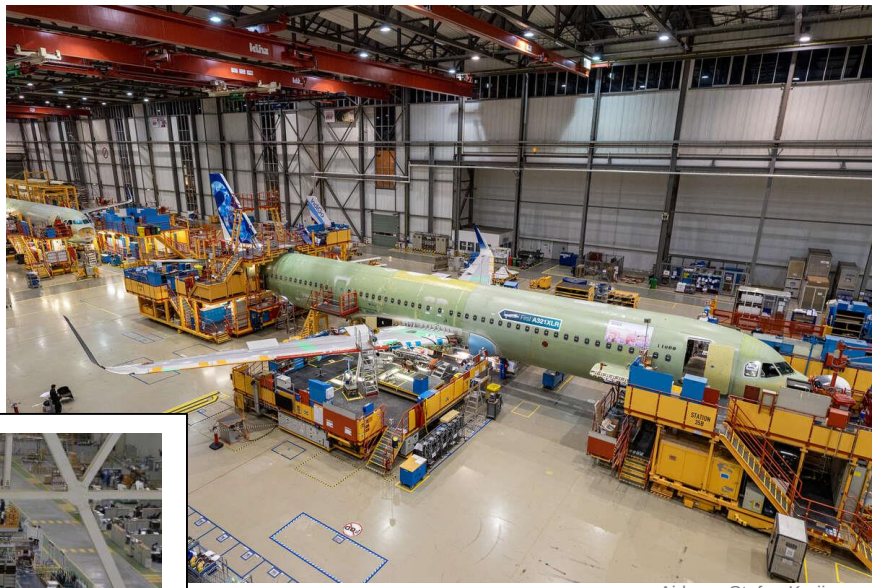
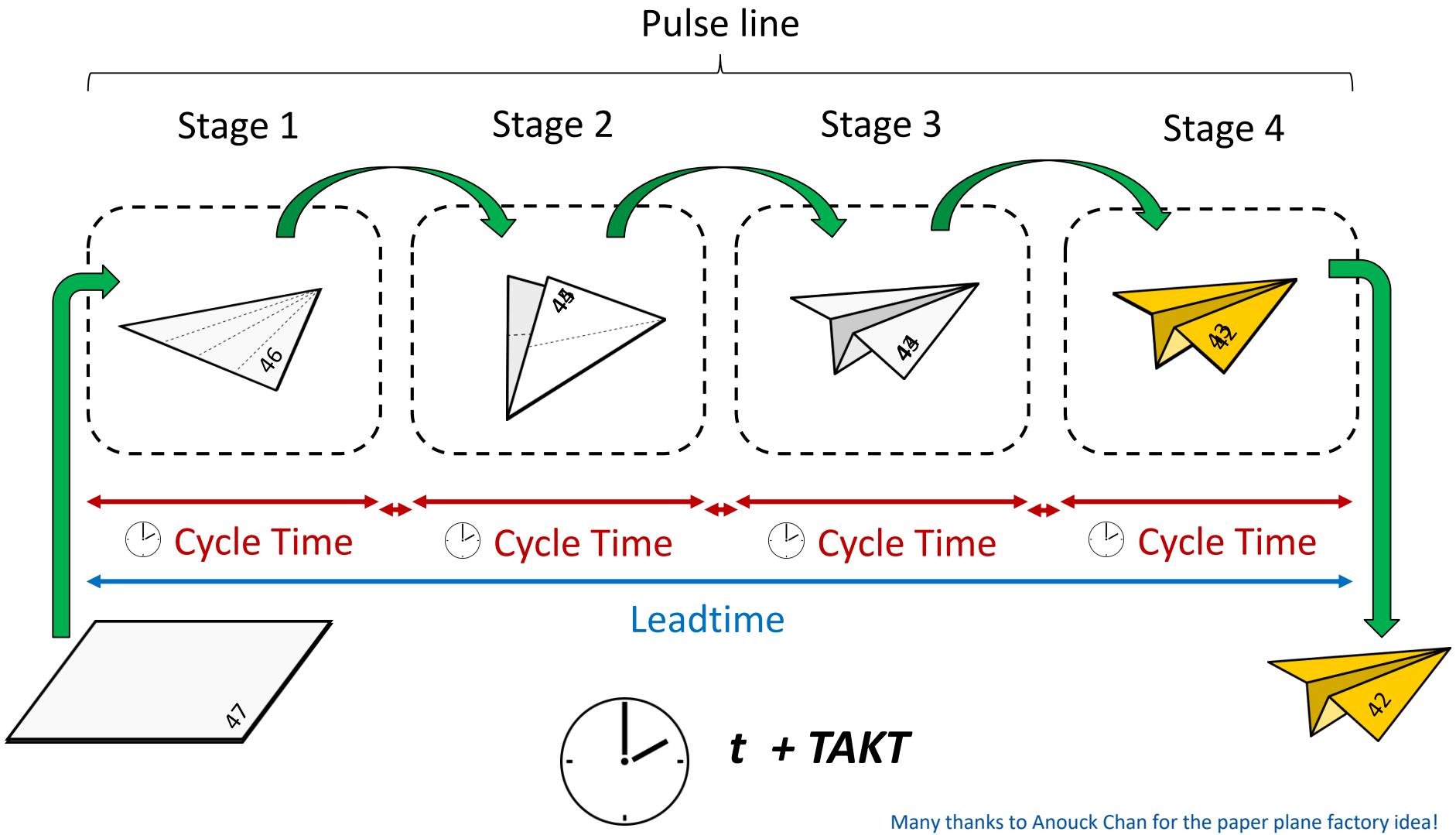
Application Track

Pulse Assembly Line – In Real Life


Airbus - Stefan Kruijer

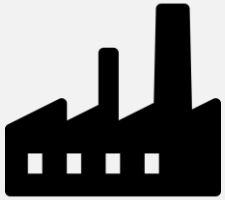

© Airbus Defence and Space SAU 2012

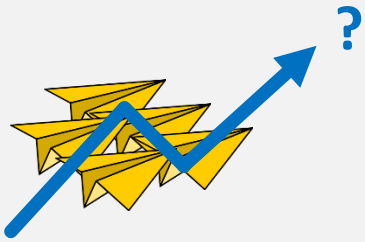
Pulse Assembly Line - Model

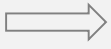


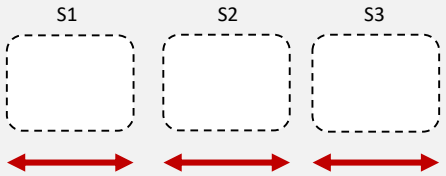
Many thanks to Anouck Chan for the paper plane factory idea!

Our Problem

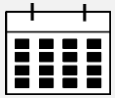








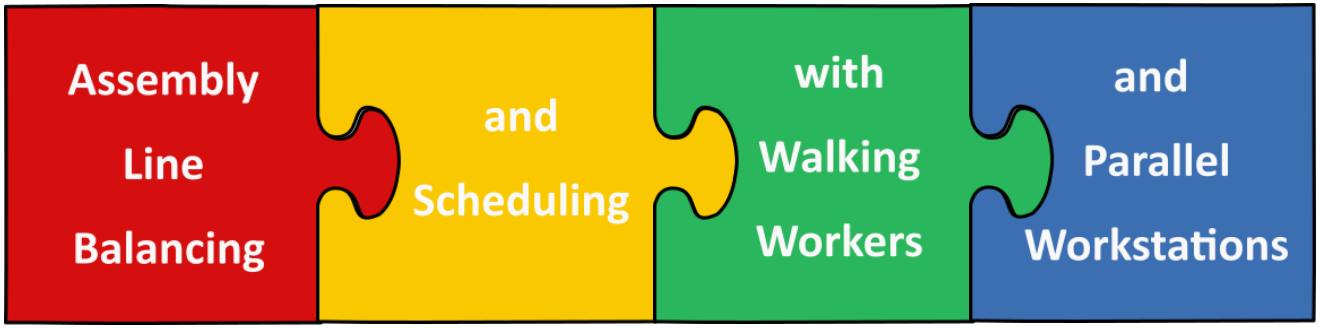
Minimize cycle time



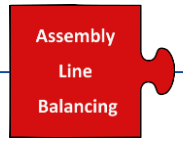
8 working hours/day

18 working days/month

takt (h)	#aircraft/month
14,4	10
12	12

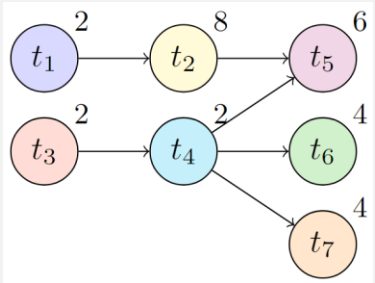


AL Balancing (ALB)

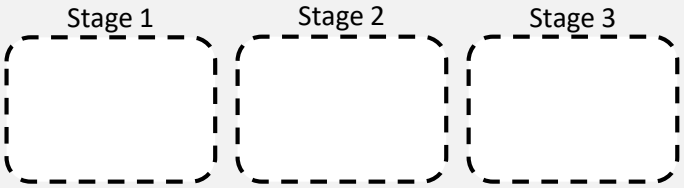


Input

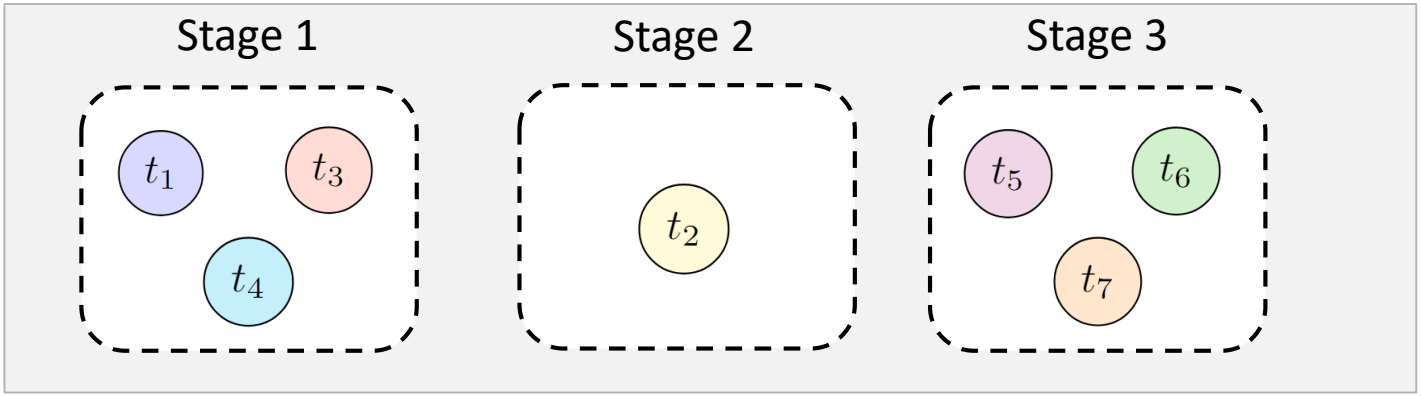
Tasks, duration and precedence



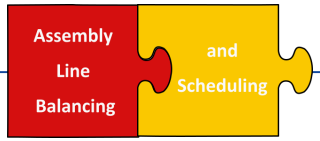
Layout



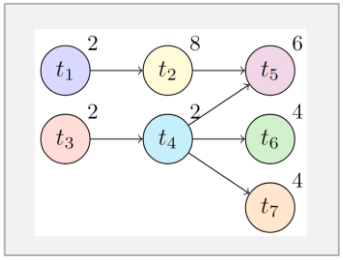
Solution

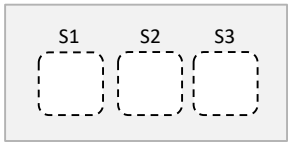


ALB & Scheduling

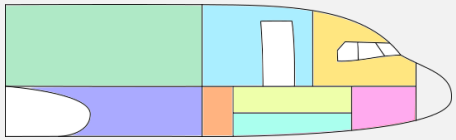


Input



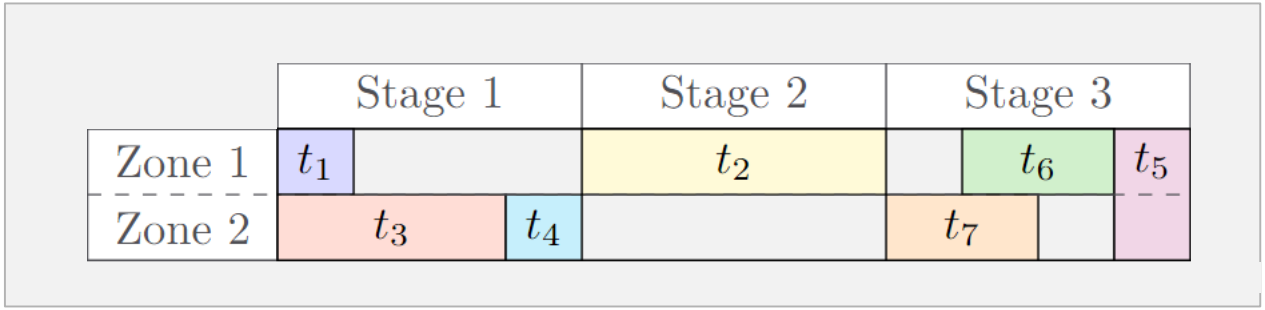


Zones with max. capacity

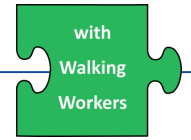


One cumulative resource per zone

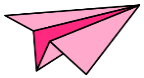
Solution

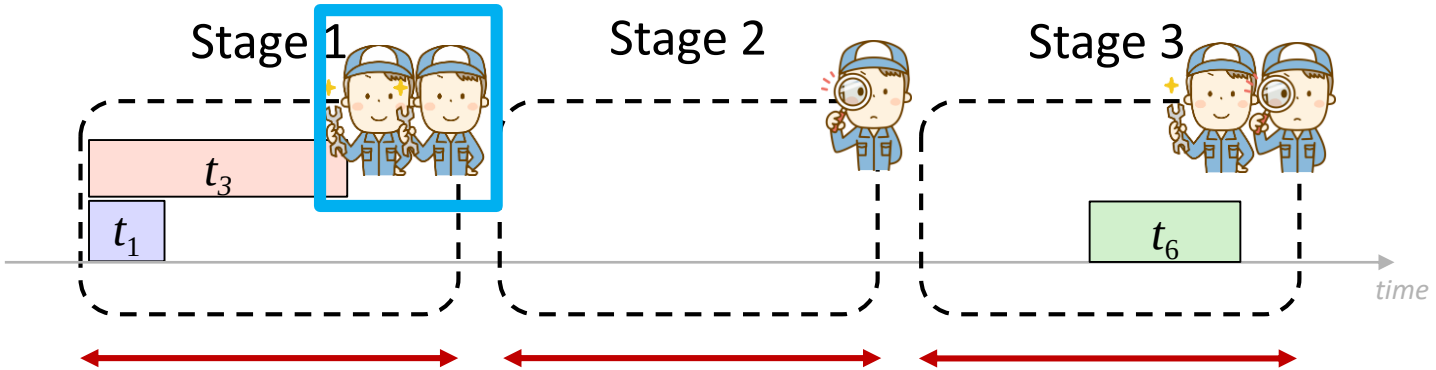


(Non Walking) Workers

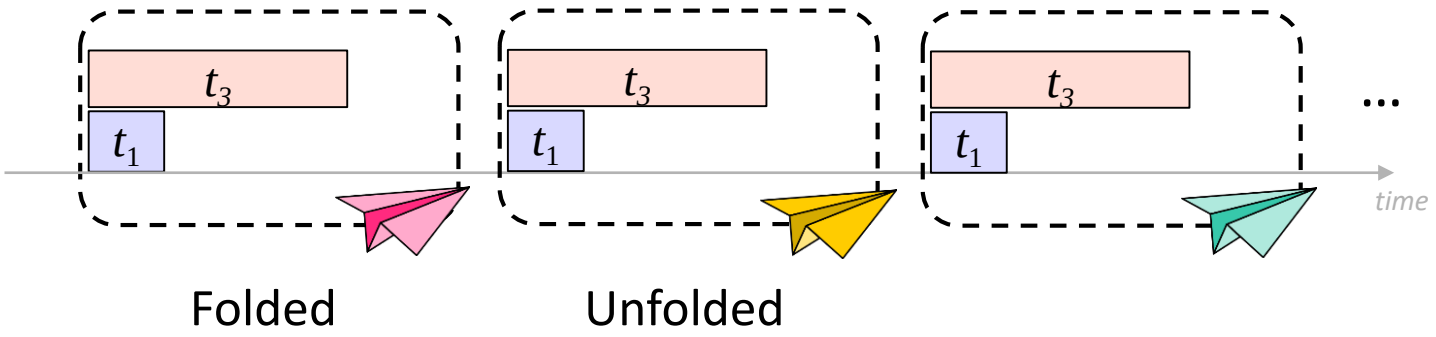


Aircraft schedule

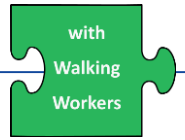




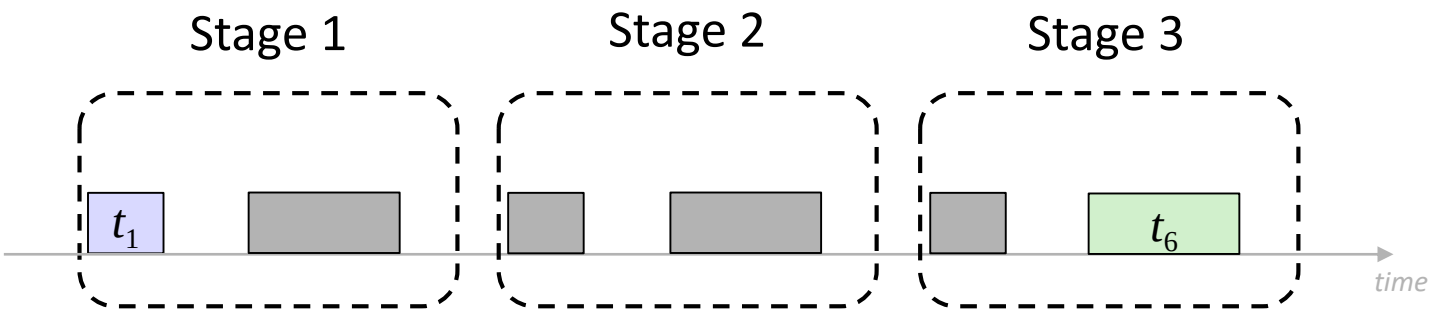
Workers schedule

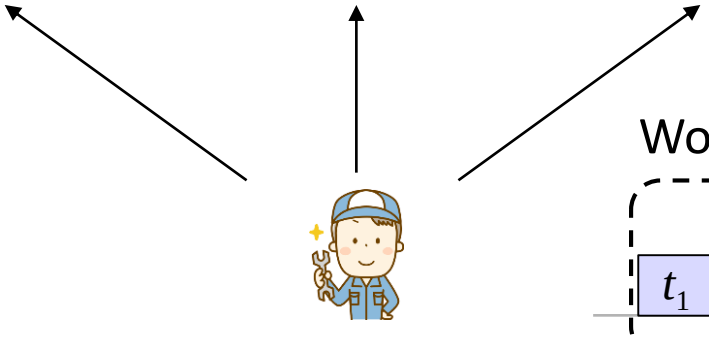


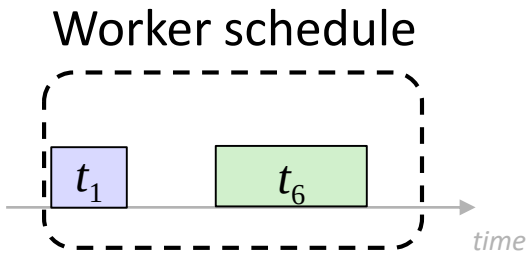
Walking Workers



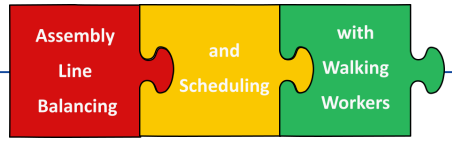
Aircraft schedule







ALB & Scheduling with Walking Workers



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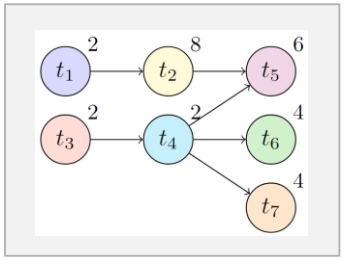
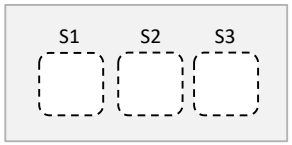
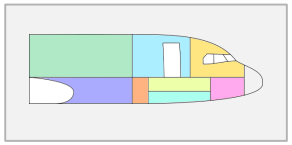
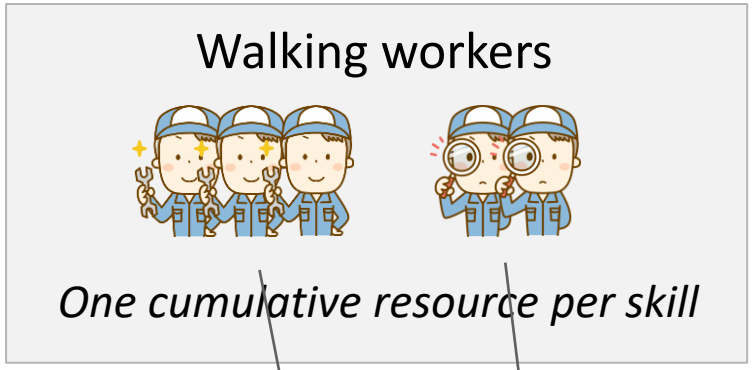
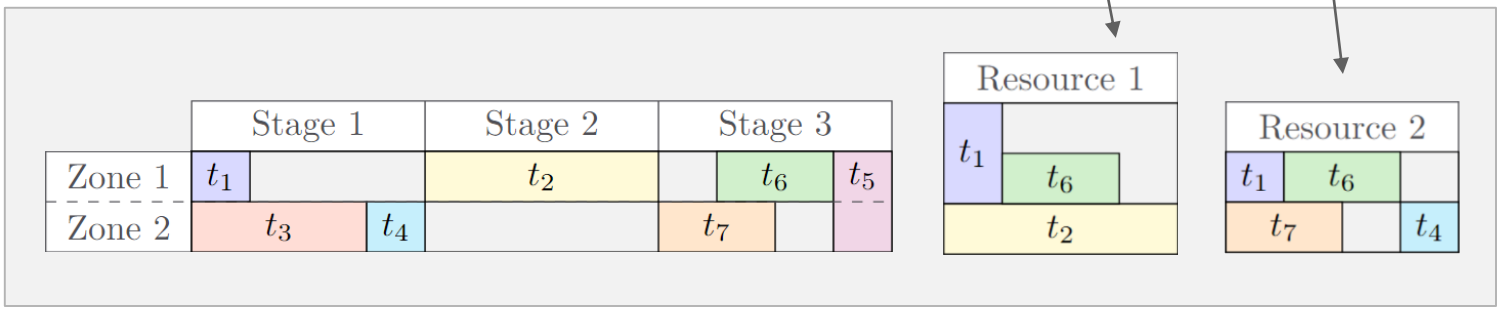




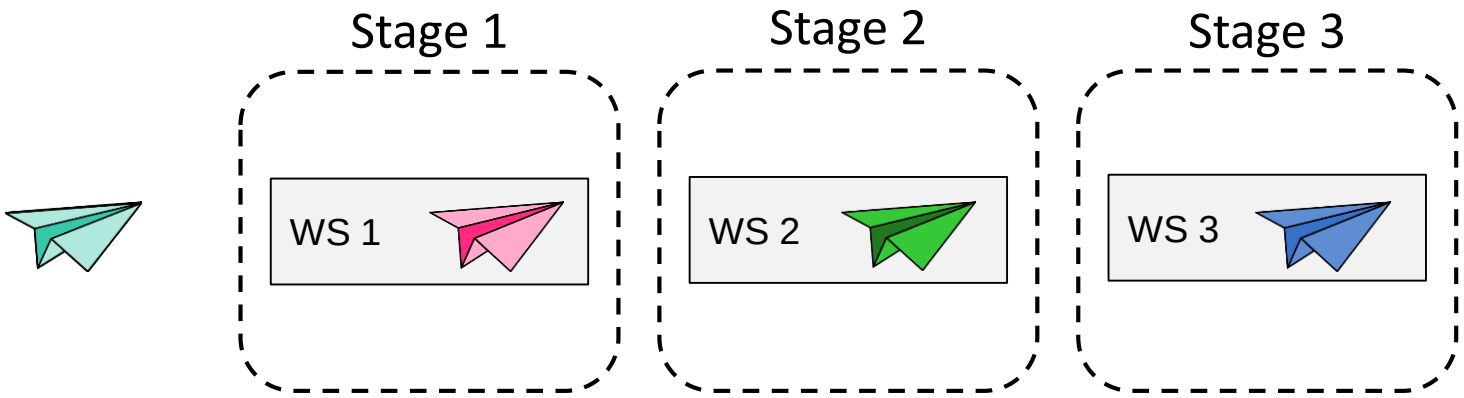


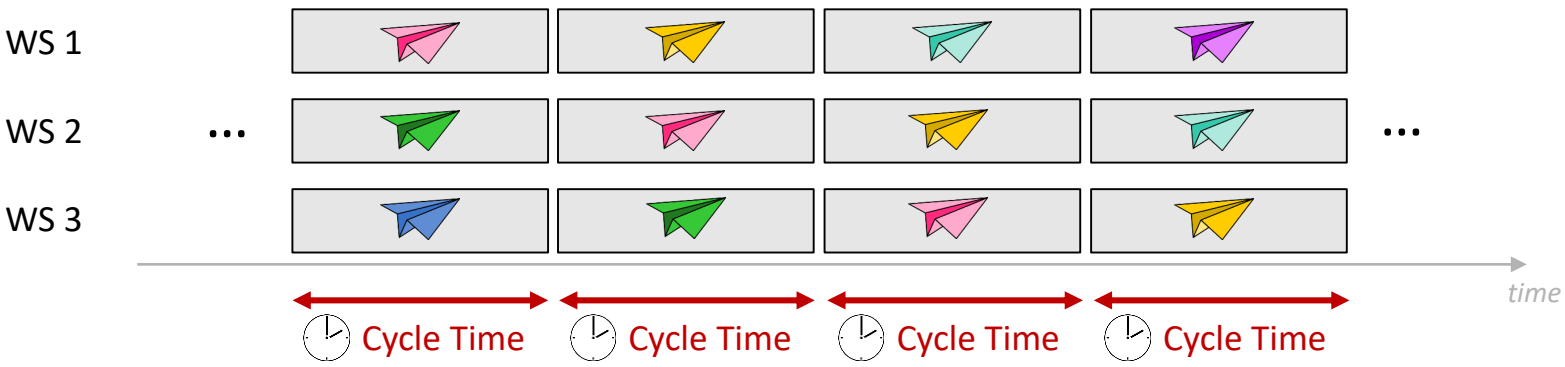


Solution

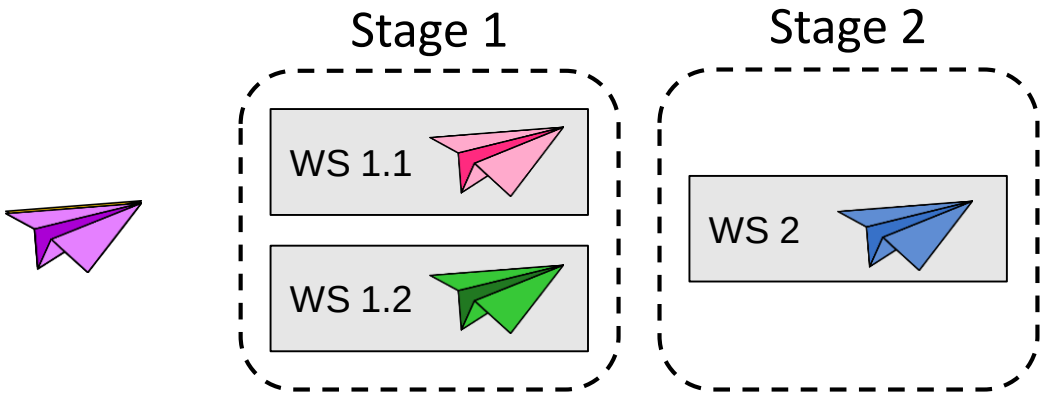


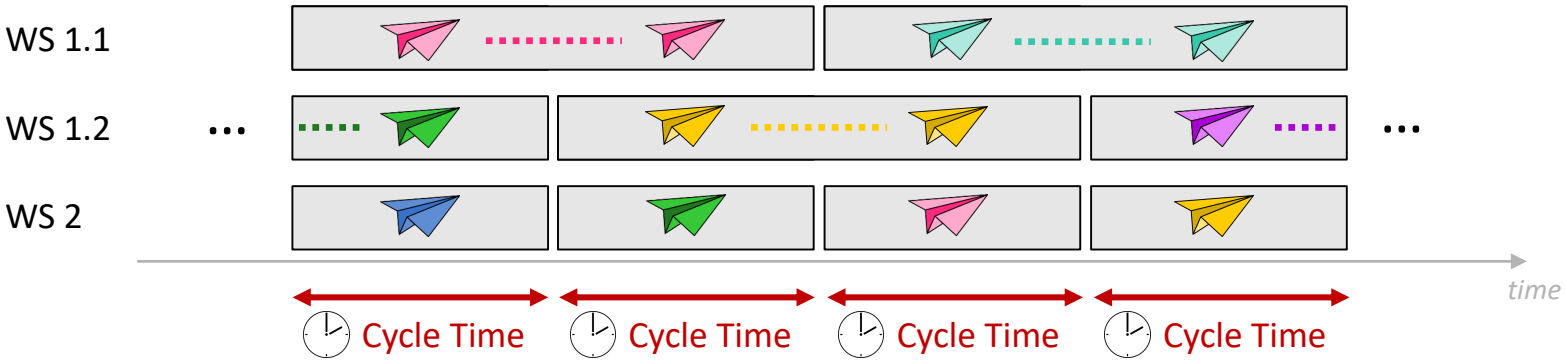
Parallel Workstations



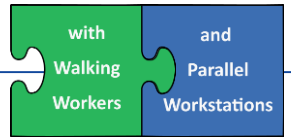


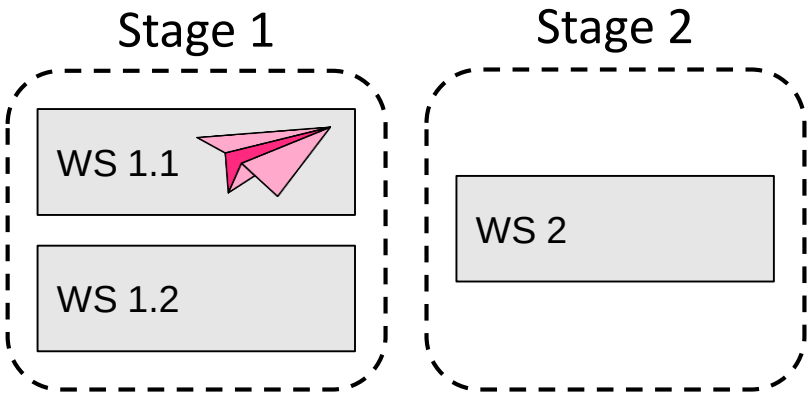
Parallel Workstations

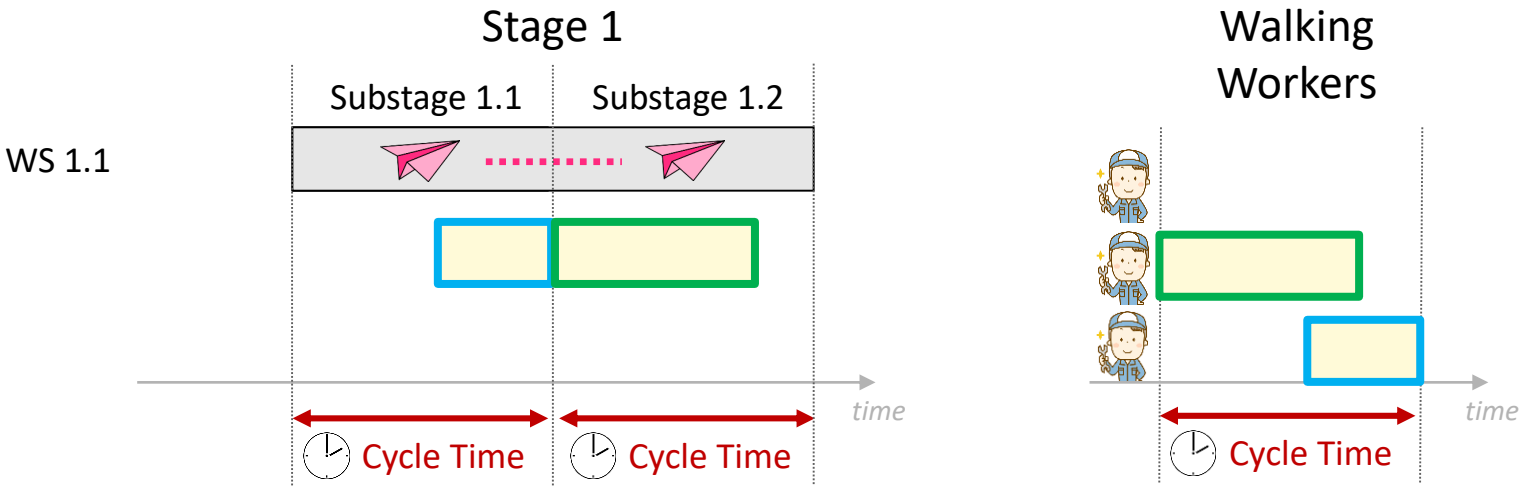




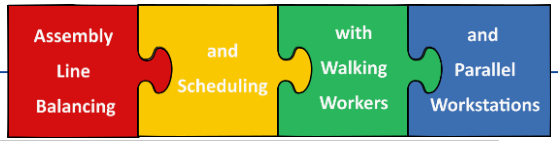
Parallel Workstations







ALB & Scheduling with Walking Workers and Parallel Workstations



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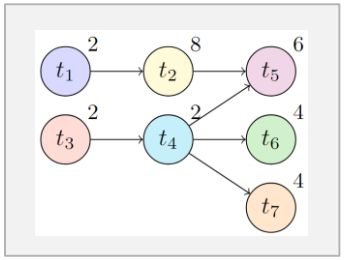
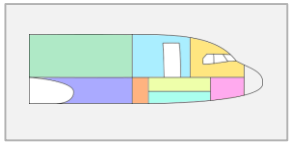
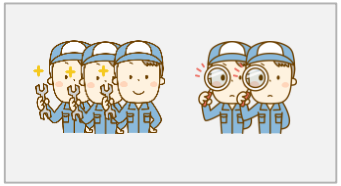
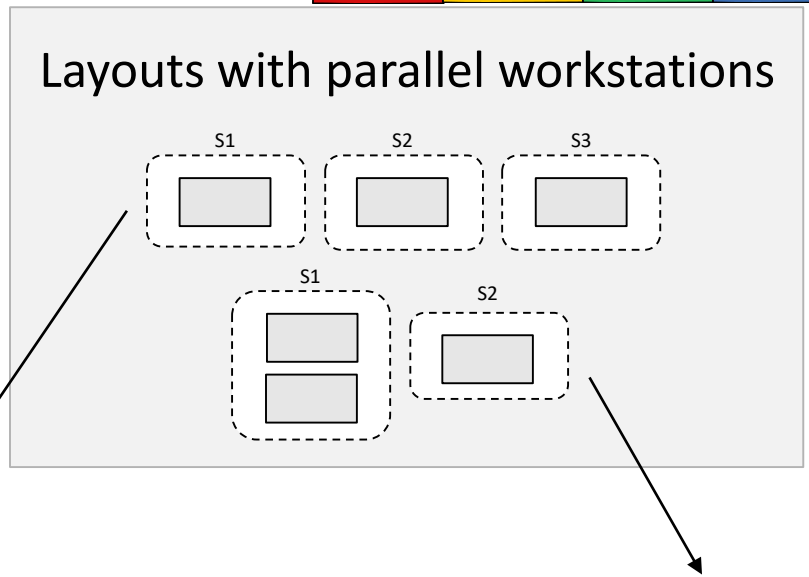


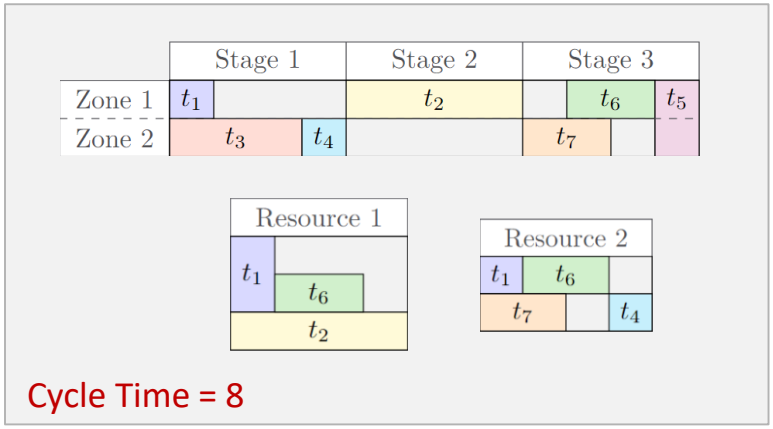


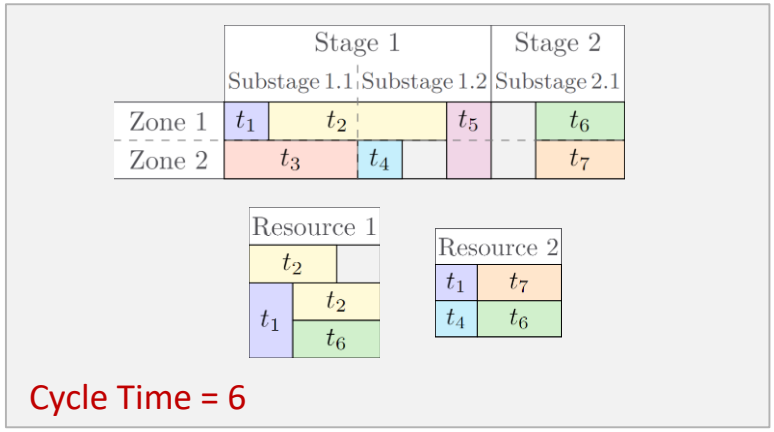


Layouts with parallel workstations

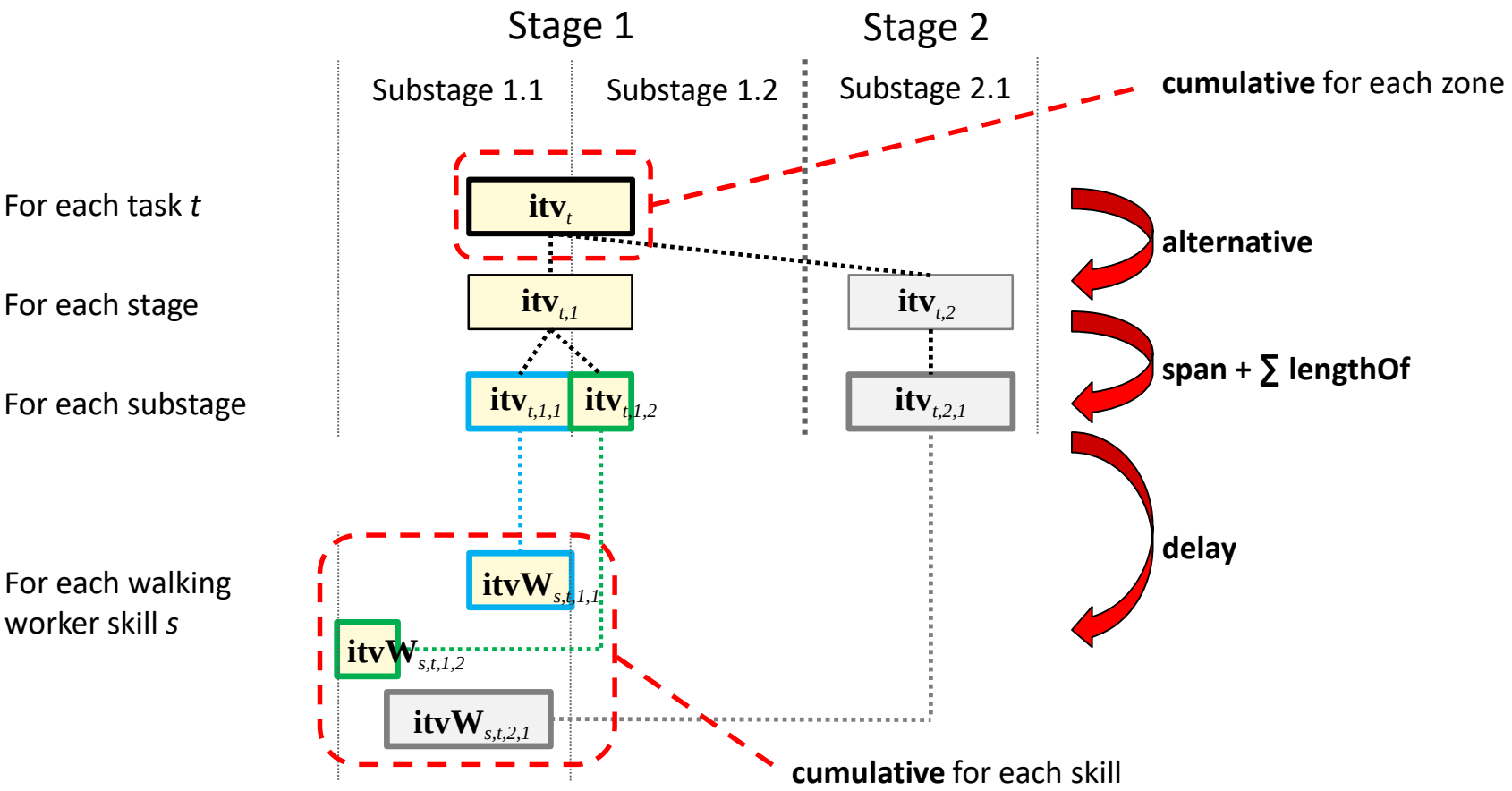


Solution





Constraint Programming Encoding – Overview



Experiments – Overview

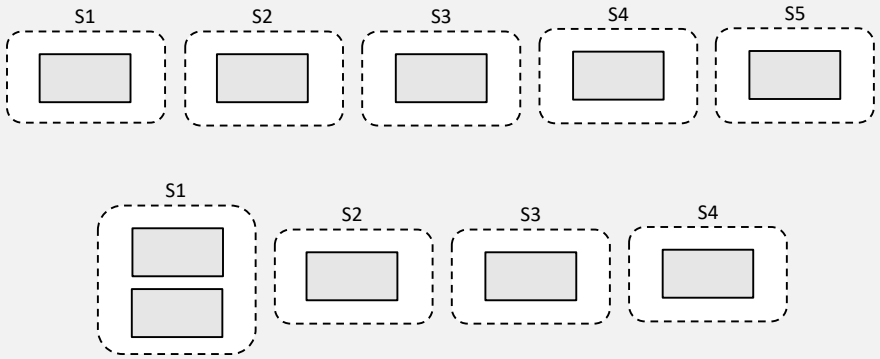
- 3 sets of benchmarks:
  - original industrial dataset (anonymous)
  - adapted industrial dataset (public)
  - generated academic dataset (public)

- IBM CP Optimizer 20.1.10

Experiments – Original Use Case (anonymous)

Aircraft Manufacturer – Small Aircraft Assembly Line

- 51 tasks
- 93 precedence constraints
- 12 work zones
- 23 walking workers
- 2 layouts

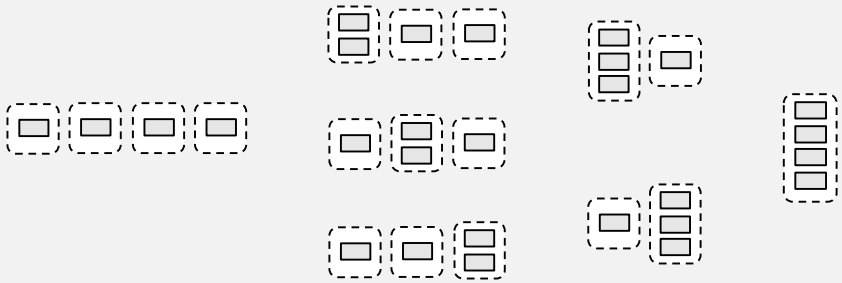


- 30 minutes time-out
- best solution found in a few seconds
- no optimality proof

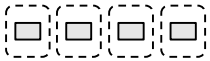
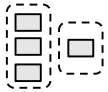
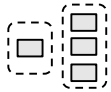
Experiments – Second Dataset (public)

Aircraft Manufacturer – Aircraft Assembly Line

- **21 instances**
- 3 original datasets
- 178 tasks / 628 tasks
- 48 work zones
- 6 walking workers types
- 7 layouts (4 WS)



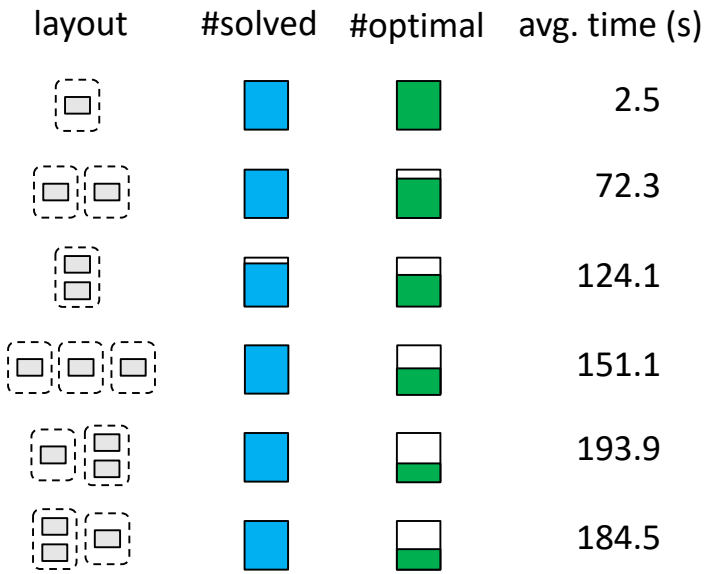
- 10 minutes time-out

instances	#tasks							
Ins. 1	178	1260	1260	1260	1260	1024	900	855
Ins. 2	178	1260	-------	1260	1260	-------	954	------
Ins. 3	628	1200	-------	900	1172	-------	1160	------

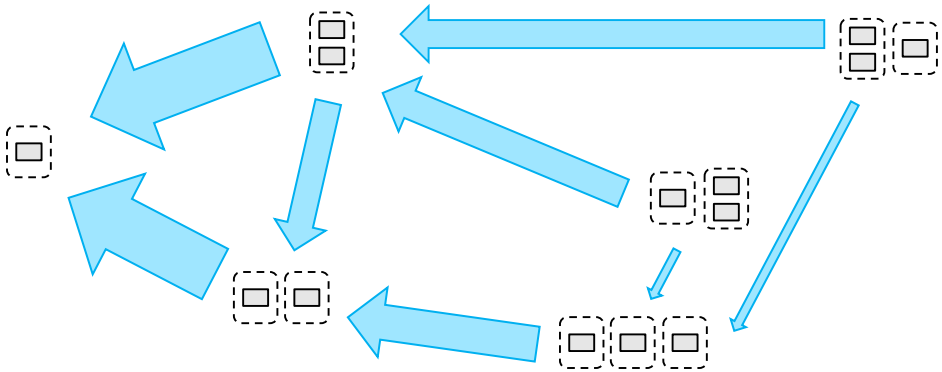
Experiments – Third Dataset (public)

Academic – PSP-based dataset

- **900 instances**
- 150 original j30rcp instances
- 30 tasks
- 0 work zone
- 4 walking workers types
- 6 layouts



- 5 minutes time-out



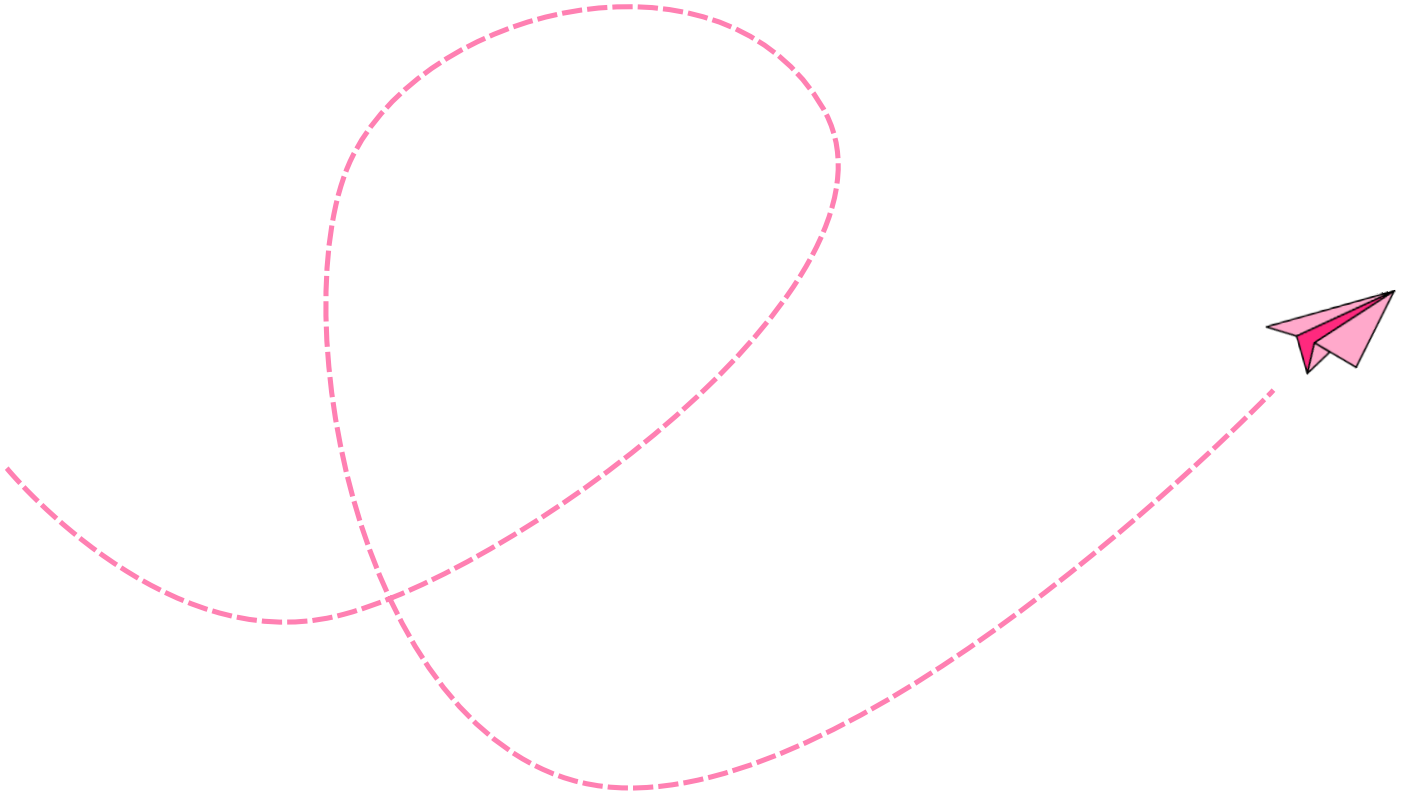
What's Next ?

Summary

- New problem and associated datasets
- CP approach

Perspectives

- Other heuristics / solvers / approaches
- Multi-criteria: cycle time and walking workers
- Several aircraft models in the same assembly line



Thank you for your attention

Many thanks to Anouck Chan for the paper plane factory idea!