

## Chapter 10

# Planning and Scheduling Operations part 2

- Scheduling and Control Functions
- Facility Scheduling
- Scheduling Services
- Sequencing Jobs

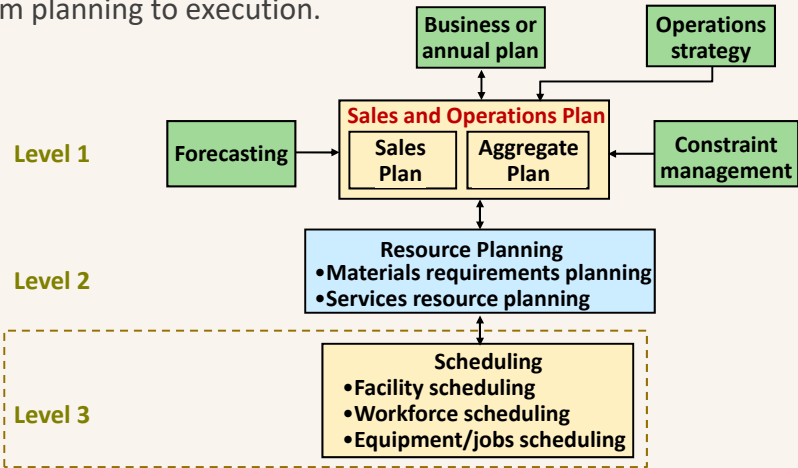
## Pilot Scheduling

- **Air New Zealand** has a combined fleet of 105 aircraft, with another 21 more on order.
- It serves 50 ports—26 domestic and 24 international within 15 countries. Its network incorporates flight times ranging from 15 minutes to 13 hours. 飛機大小與飛航距離差異大
- Pilots must be scheduled for no more than 35 hours in a 7-day week and no more than 100 hours in a 28-day cycle. They also must have a 36-hour break every 7 days and 30 days off in an 84-day cycle.
- Each pilot's tour of duty begins and ends at a crew base and consists of an alternating sequence of duty periods and rest periods, with duty periods including one or more flights. 每次出勤包括多段航線並回到出發點



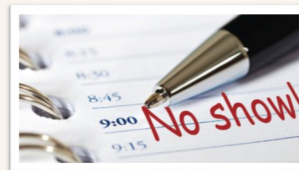
## Scheduling

The function that takes the operations and scheduling process from planning to execution.



### Scheduling customers (jobs)

- Appointment systems  
Controls customer arrivals for service
- Reservation systems  
Estimates demand for service
- Late arrivals and no-shows.



### Scheduling the workforce

Manages capacity for service 人員調度與排班

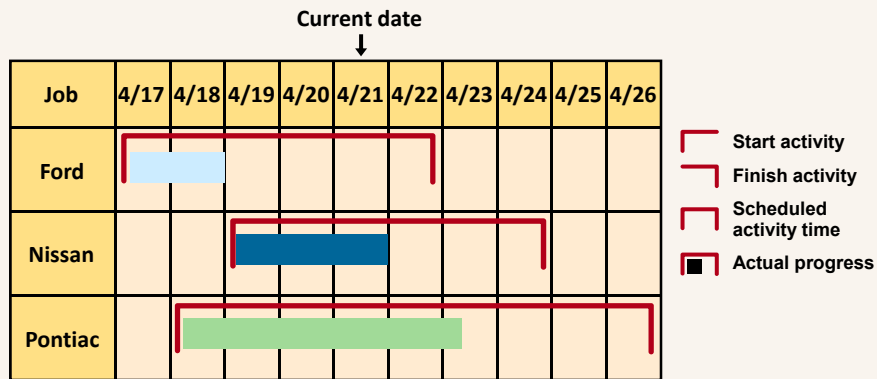
### Scheduling multiple resources

排課：教師 × 課程 × 時段 × 教室

航空公司：航線 × 飛機 × 機組 × 登機門/地勤

## Job and Facility Scheduling 1/2

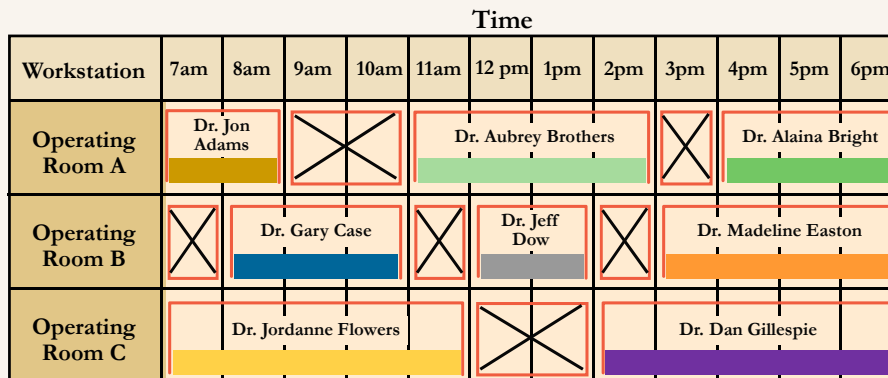
- Gantt progress chart displays the current status of each job or activity relative to its scheduled completion date.



## Job and Facility Scheduling 2/2

Gantt workstation chart shows the load on operating rooms and the nonproductive time. The chart can be used to identify time slots for emergency surgeries.

- ┌ Scheduled activity time
- Actual progress
- X Nonproductive time



## Workforce Scheduling

- A type of scheduling that determines when employees work
- Constraints
  - Technical: meet workforce requirements 人力需求
  - Legal and behavioral considerations: laws, regulations, and labor contracts 法律與工會
  - Psychological needs of workers: preferences of the employees 員工偏好
- Goals: minimize slack capacity or cost
- Scheduling Options
  - Rotating schedule vs. Fixed schedule 輪值班表

## Example 10.2 each employee with 2 consecutive days off

- From all the pairs of consecutive days, excluding the busiest day (or days), find the pair with the lowest total requirements. 由連續兩天人力需求最少的日期開始排假
- To break ties in the selection of off days, the scheduler gives preference to Saturday and Sunday if it is one of the tied pairs.

Day	M	T	W	Th	F	S	Su
Required no. of employees	6	4	8	9	10	3	2

Day	M	T	W	Th	F	S	Su
Required no. of employees	3	1	5	6	7	3	2
Schedule 4	off	off	x	x	x	x	x
	3	1	4	5	6	2	1
Schedule 5	x	x	x	x	x	off	off
	2	0	3	4	5	2	1
Schedule 6	off	off	x	x	x	x	x
	2	0	2	3	4	1	0
Schedule 7	x	x	x	x	x	off	off
	1	0	1	2	3	1	0
Schedule 8	x	x	x	x	x	off	off
	0	0	0	1	2	1	0
Schedule 9	off	x	x	x	x	x	off
	0	0	0	0	1	0	0
Schedule 10	x	x	x	x	x	off	off

tie-breaking

## Sequencing Jobs at a Workstation

- Priority Sequencing Rules
  - First-Come, First-Served (FCFS)
  - Earliest Due Date (EDD)
  - Smallest Processing Time (SPT)
  - Smallest Slack = 距離交期天數 - 訂單處理所需天數
  - Critical Ratio = 距離交期天數 / 訂單處理所需天數
  - Rush or Emergency First
  
- Performance Measures
  - Flow Time: time from job arrival to completion
  - Past Due (Tardiness): amount of time by which a job missed its due date
  - Makespan: 從第一個訂單開始到最後一個訂單完成

### Example 10.3

- Determine the schedule by using the FCFS rule, and calculate the average days past due and flow time.
- How can the schedule be improved, if average flow time is the most critical?

Customer	Time Since Order Arrived (days ago)	Processing Time (days)	Due Date (days from now)
A	15	25	29
B	12	16	27
C	5	14	68
D	10	10	48
E	0	12	80

FCFS: A-B-D-C-E    EDD: B-A-D-C-E    SPT: D-E-C-B-A

### Example 10.3: FCFS

假設現在日期=0

15+25=40

Customer Sequence	Start Time (days)		Processing Time (days)		Finish Time (days)	Due Date	Days Past Due	Days Ago Since Arrival	Flow Time (days)
A	0	+	25	=	25	29	0	15	40
B	25	+	16	=	41	27	14	12	53
D	41	+	10	=	51	48	3	10	61
C	51	+	14	=	65	68	0	5	70
E	65	+	12	=	77	80	0	0	77

$$\text{Average Tardiness} = \frac{0 + 14 + 3 + 0 + 0}{5} = 3.4 \text{ days}$$

$$\text{Average Flow Time} = \frac{40 + 53 + 61 + 70 + 77}{5} = 60.2 \text{ days}$$

### Example 10.3: SPT

Customer Sequence	Start Time (days)		Processing Time (days)	=	Finish Time (days)	Due Date	Days Past Due	Days Ago Since Arrival	Flow Time (days)
D	0	+	10	=	10	48	0	10	20
E	10	+	12	=	22	80	0	0	22
C	22	+	14	=	36	68	0	5	41
B	36	+	16	=	52	27	25	12	64
A	52	+	25	=	77	29	48	15	92

$$\text{Average Tardiness} = \frac{0 + 0 + 0 + 25 + 48}{5} = 14.6 \text{ days}$$

$$\text{Average Flow Time} = \frac{20 + 22 + 41 + 64 + 92}{5} = 47.8 \text{ days}$$

	A	B	C	D	E	F
加工時間	2	8	4	10	5	12
距離交期	7	16	4	17	15	18
CR	7/2	16/8	4/4	17/10	15/5	18/12

$$\text{Critical Ratio} = \frac{\text{time to due date}}{\text{processing time remaining}}$$

	A	B	D	E	F
加工時間	2	8	10	5	12
距離交期	7-4	16-4	17-4	15-4	18-4
CR	3/2	12/8	13/10	11/5	14/12

	A	B	D	E
加工時間	2	8	10	5
距離交期	3-12	12-12	13-12	11-12
CR	-9/2	0/8	1/10	-1/5

	B	D	E
加工時間	8	10	5
距離交期	0-2	1-2	-1-2
CR	-2/8	-1/10	-3/5

	B	D
加工時間	8	10
距離交期	-2-5	-1-5
CR	-7/8	-6/10

dynamic and based on slack

## Johnson's rule for 2-station flow line



從尚未安排之工單中選擇單站作業時間最短者  
若該站為第一站，安排該工單於最前的空位  
若該站為第二站，安排該工單於最後的空位

1	2	3	4	5	6
D					

	work center 1	work center 2
A	5	5
B	4	3
C	8	9
D	2	7
E	6	8
F	12	15

排除剛加入之工單，重新挑選單站作業時間最短者  
該站為第二站，安排該工單於最後的空位

1	2	3	4	5	6

重複以上步驟，直到所有工單均排入，總工作時間(makespan)最短

1	2	3	4	5	6

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## Software Support

LEKIN Scheduling System

