

Chapter 10

Planning and Scheduling Operations part 2

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

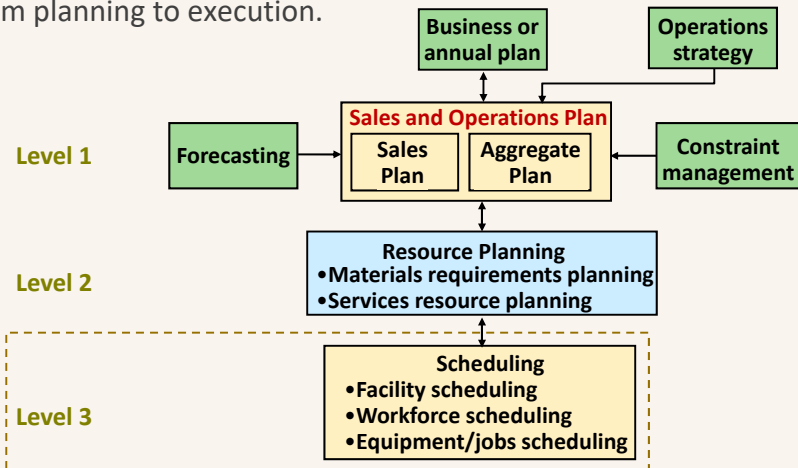
Pilot Scheduling

- **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



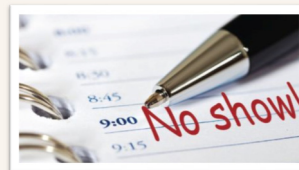
Scheduling

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

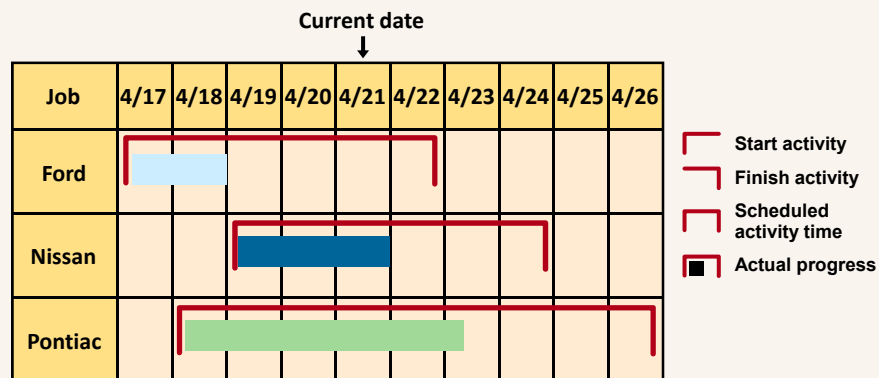
Scheduling multiple resources

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.



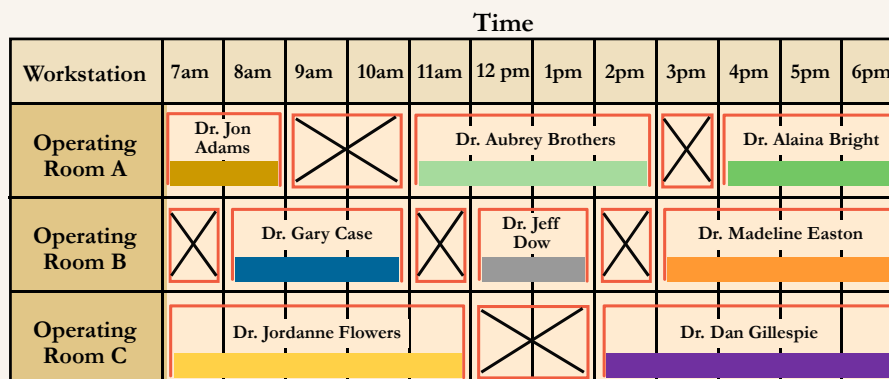
Job and Facility Scheduling 2/2

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

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

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

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