Airline Schedule Development Overview

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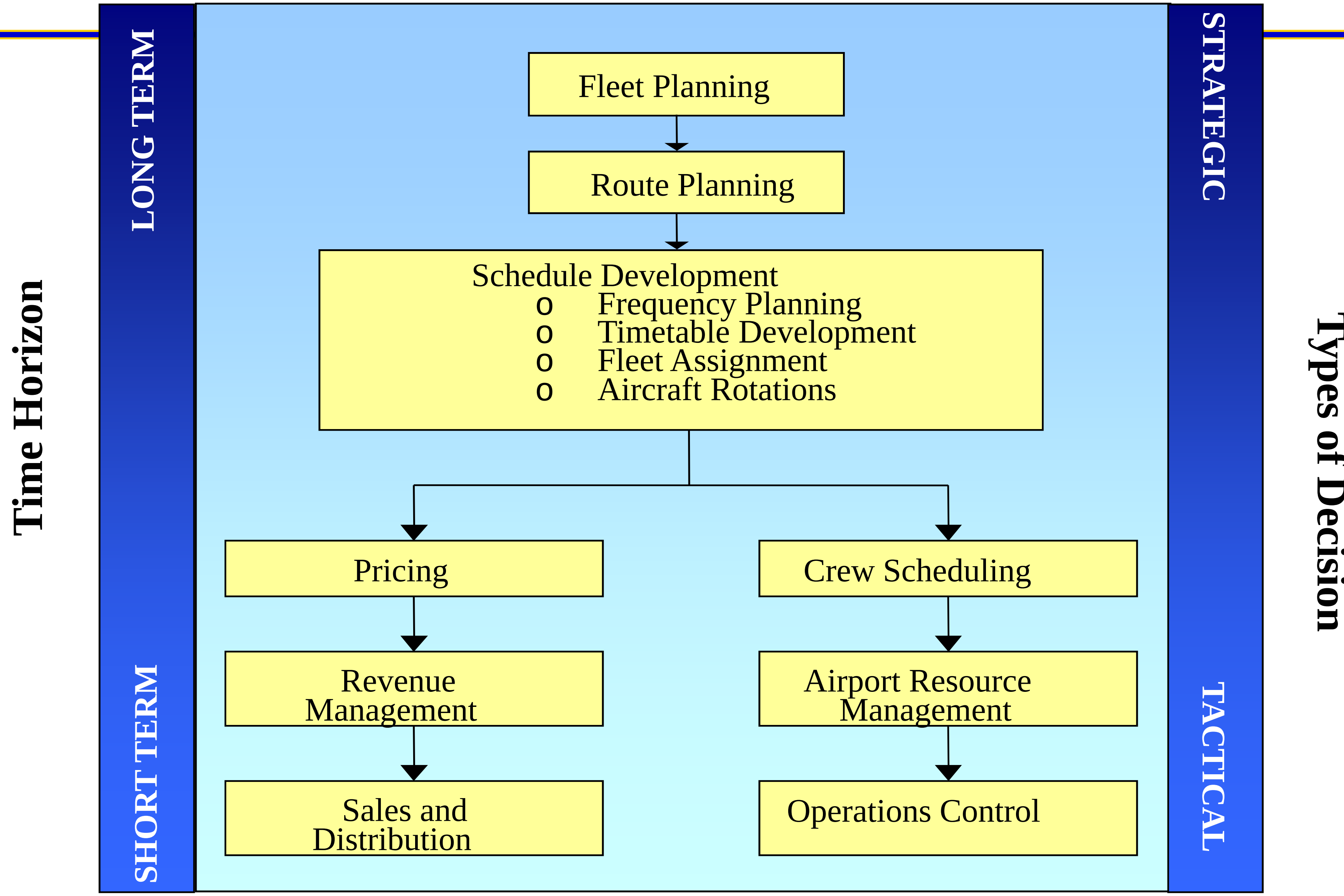
Lecture Outline

- **Schedule Development Process**
  - Principal decision steps
  - Airline supply terminology
  - Sequential schedule planning
- **Frequency Planning**
  - Frequency share vs. load consolidation
  - Additional frequency considerations
- **Timetable Development**
  - Time of day demand distributions
  - Operational and maintenance constraints
  - Scheduled block times
- **Schedule Map of Aircraft Rotations**



SOURCE: Prof. C. Barnhart

SCHEDULE DEVELOPMENT

- **Given a set of routes to be operated in a network, and a fleet of aircraft, schedule development involves**
  - Frequency planning (how often?)
  - Timetable development (at what times?)
  - Fleet assignment (what type of aircraft?)
  - Aircraft rotation planning (network balance)
- **The process begins a year or more in advance and continues until actual departure time:**
  - Frequency plans established first, based on routes and aircraft
  - Timetables and aircraft rotations defined 2-6 months in advance
  - Final revisions and “irregular operations” until the flight departs

Schedule Development Decisions

- **Involves several interrelated decisions, which to date have not been fully integrated:**

Frequency Planning: Number of departures to be offered on each route, non-stop versus multi-stop

Timetable Development: Flight departure and arrival times, including connections at airline hubs

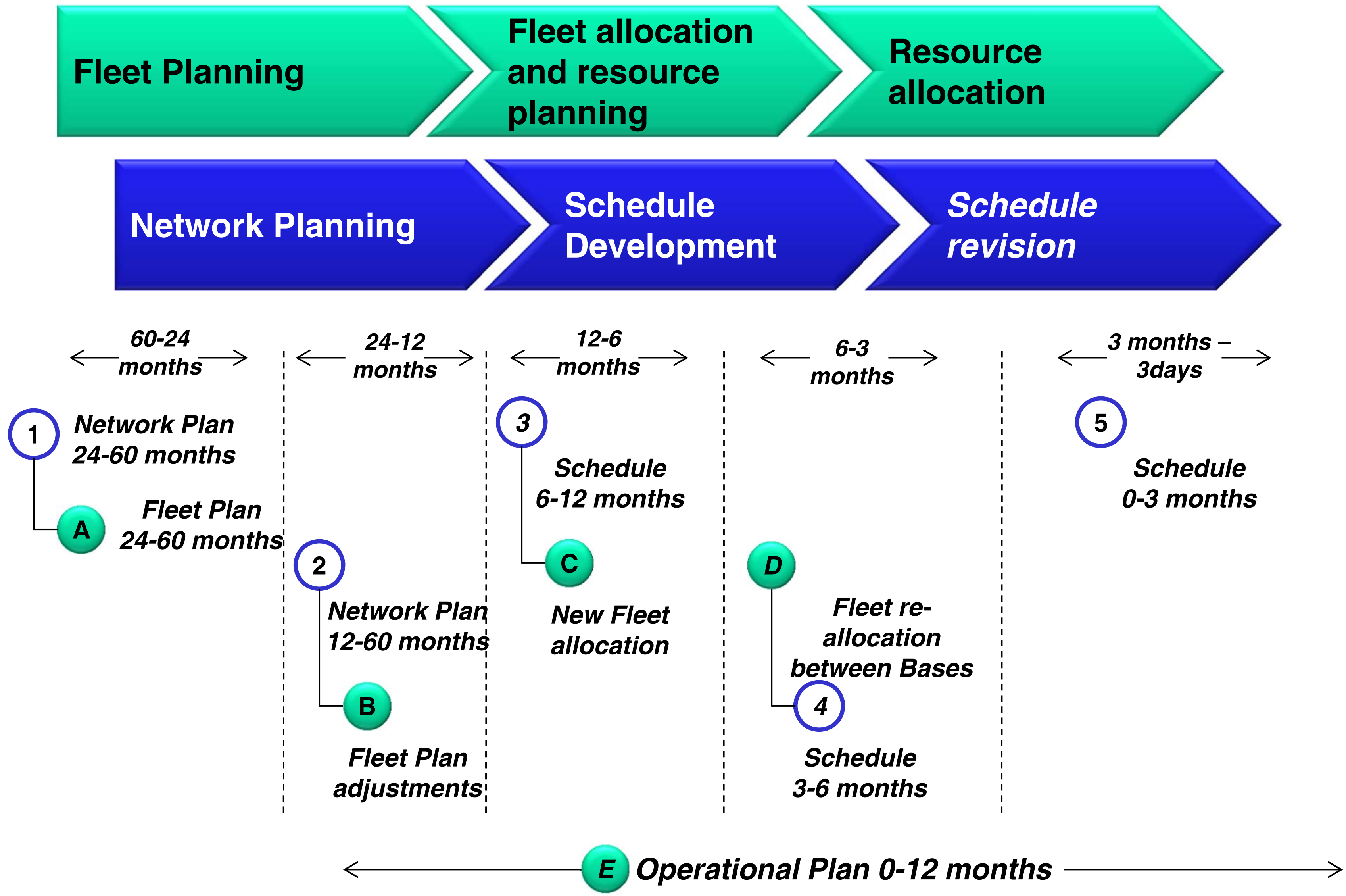
Fleet Assignment: Aircraft type for each flight, based on demand and operating cost estimates

Aircraft Rotation Planning: Links consecutive flights to ensure balanced aircraft flows on the network.

Airline Supply Terminology

- **Flight Leg (or "flight sector" or "flight segment")**
  - Non-stop operation of an aircraft between A and B, with associated departure and arrival time
- **Flight**
  - One or more flight legs operated consecutively by a single aircraft (usually) and labeled with a single flight number (usually)
  - DL945 is a two-leg flight BOS-MSP-SEA operated with a B757
- **Route**
  - Consecutive links in a network served by single flight numbers
  - DL operates 2 flights per day on one-stop route BOS-MSP-SEA
- **Passenger Paths or Itineraries**
  - Combination of flight legs chosen by passengers in an O-D market (e.g., BOS-SEA via connection at DTW)

Integrated Scheduling Planning Process: Key Decisions



Aircraft and Crew Schedule Planning: Sequential Approach

Schedule Design
↓
Fleet Assignment
↓
Aircraft Routing
↓
Crew Scheduling

Select optimal set of *flight legs* in a schedule

A flight specifies origin, destination, and departure time

Contribution = Revenue - Costs

Assign crew (pilots and/or flight attendants) to flight legs

Frequency Planning

- **Frequency of departures on a route reduces total trip times for passengers and increases market share:**
  - In competitive markets, airline frequency share is most important to capturing time sensitive business travelers
  - Frequent departures reduce schedule displacement or "wait time" between flights
  - Frequency is more important in short-haul markets than for long-haul routes where actual flight time dominates "wait time"

- **Path Quality also affects market share**
  - Non-stop flights preferred over one-stop, one-connects, double-connects, interline connects
  - Frequency of departures can be as important as path quality (non-stop vs. connection) in many cases

Frequency Planning Process

- **Demand forecasts and competition drive the frequency of flights on a route:**
  - Estimates of total demand between origin and destination
  - Expected market share of total demand, which is determined by frequency share relative to competitors
  - Potential for additional traffic from connecting flights
- **"Load consolidation" affects frequency and aircraft size decisions:**
  - Single flight with multiple stops provides service to several origin-destination markets at the same time
  - Allows airline to operate higher frequency and/or larger aircraft
  - A fundamental reason for economic success of airline hubs

Additional Frequency Considerations

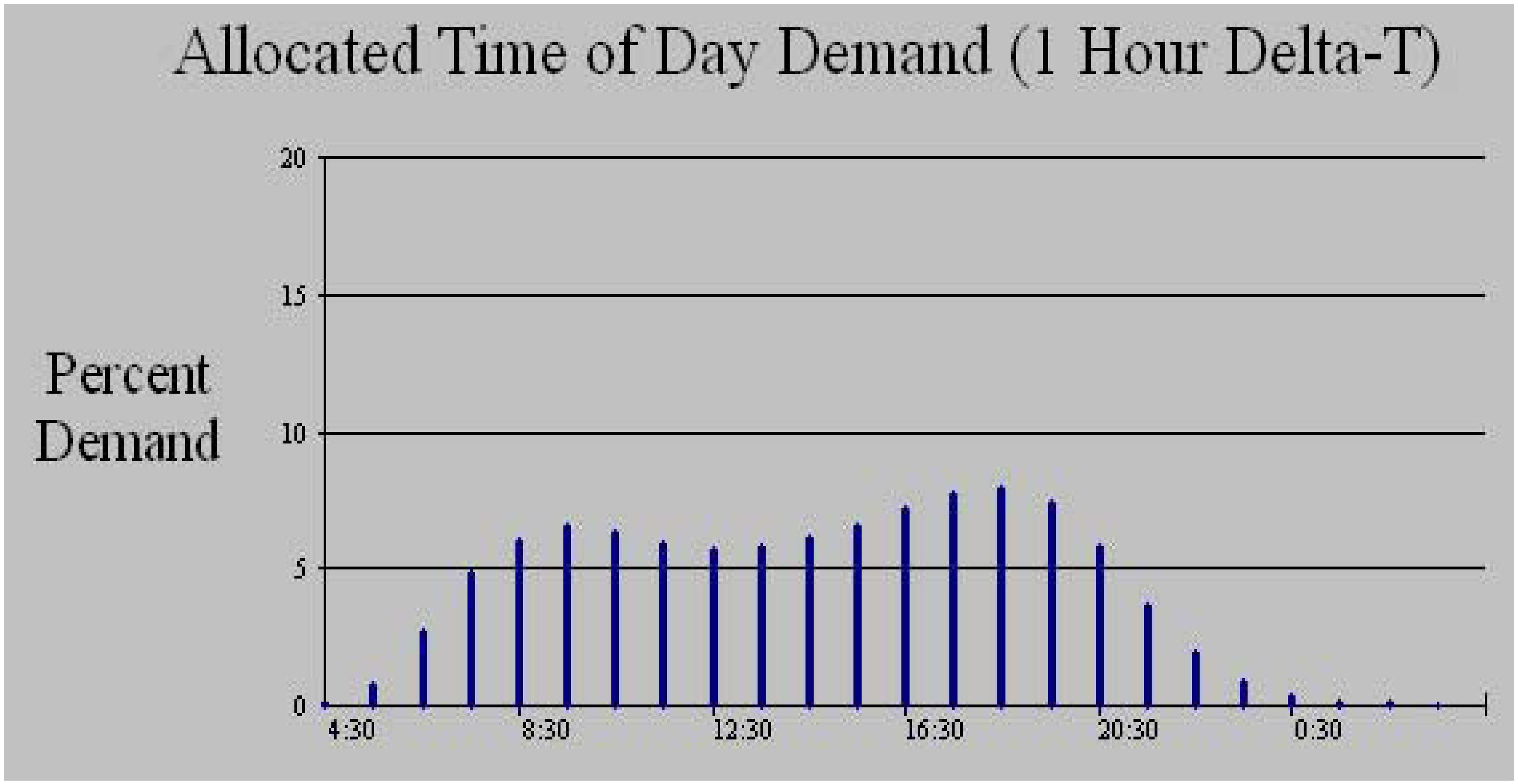
- **Seasonal variations in demand**
  - More frequent flights during peak seasons; require aircraft to be shifted from off-peak routes
  - Some routes might only be served during peak season
- **Business vs. leisure mix of demand**
  - Short-haul business routes typically require more frequency; usually with smaller aircraft
- **Hub connections and network considerations**
  - Number of flights affected by connecting banks at hub
  - Some flights provide one-stop service through hub

Timetable Development

- **For a chosen frequency of service on each route, need a specific timetable of flight departures:**
  - Goal is to provide departures at peak periods (0900 and 1700)
  - But, not all departures can be at peak periods on all possible routes, given aircraft fleet and rotation considerations
  - Minimum “turn-around” times required at each stop to deplane/enplane passengers, re-fuel and clean aircraft
- **Most airlines try to maximize aircraft utilization:**
  - Keep ground “turn-around” times to a minimum
  - Fly even off-peak flights to maintain frequency share and to position aircraft for peak flights at other cities
  - Leaves little buffer time for maintenance and weather delays

Time of Day Demand – Preferred Departure Times by Passengers

- **Two peaks of preferred departure times (0900 and 1800) in this short-haul (1-2 block hours) example.**



Source: Boeing Decision Window Model (DWM)

Timetable Development Constraints

- **Hub networks require that flights arrive/depart within a prescribed time range, for connecting banks**
- **Time zone differences limit feasible departure and arrival times**
- **Airport slot times, noise curfews limit scheduling flexibility**
- **Minimum turn times and gate availability at airports**
- **Crew scheduling – availability and layover rules differ for cockpit and cabin crew**
- **Routine maintenance requirements**

Maintenance Requirements

- **Most airlines have different maintenance capabilities at different stations on their network:**
  - Major Maintenance Bases perform virtually all types of maintenance, from minor to complete aircraft overhauls
  - Scheduled Maintenance Stations perform minor to intermediate scheduled maintenance
  - Some stations have the airline’s own mechanics on duty
  - Remaining stations limited to other airlines or sub-contractors

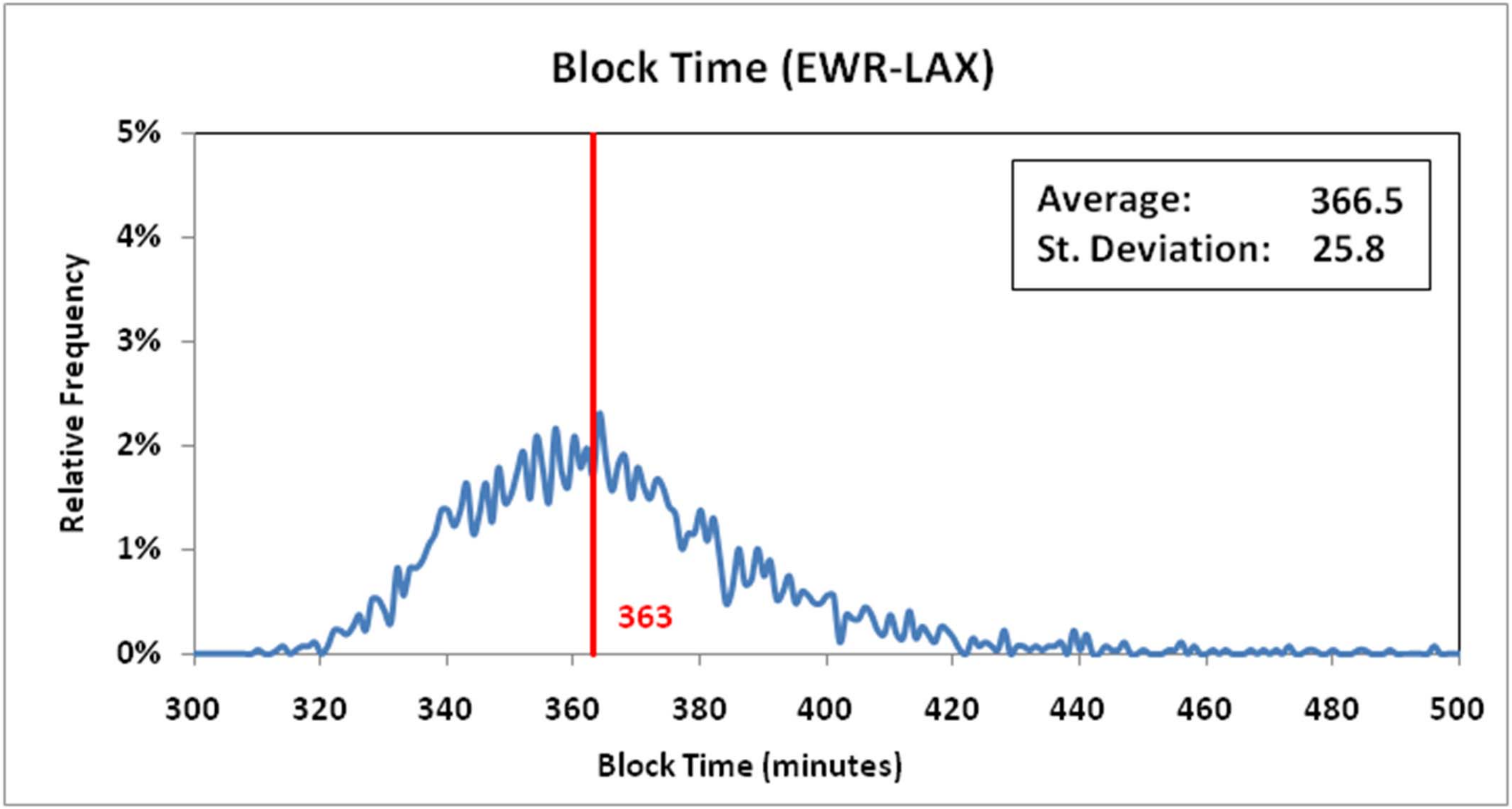
Example: Narrow Body Aircraft Maintenance Program

Type of Maintenance	Elapsed Time	Man-hours
Daily check (overnight)	1-4 hours	8
Weekly check (A)	8 hours	13
Monthly check (B)	12 hours	120
Annual base visit (C)	3 days	2,000-4,000
Four-year visit (D)	3-6 weeks	9,000-40,000

Scheduled Block Time

- **Block time = from door closed to door open**
  - Can also be from brake release to brake set
- **ACTUAL block time is variable, affected by**
  - Ground crews, pushback and taxi-out times at different airports
  - Different airport runway configurations on different days
  - Airport congestion, departure queues, ground holds
  - Weather and wind speeds while airborne; specific route flown
  - Arrival queues, descent patterns, taxi-in delays
- **SCHEDULED block time involves trade-offs**
  - Longer planned schedules increase “on-time” performance
  - But, increases operating costs, reduces utilization, gate issues
  - Should buffer be applied to block time or turn-around time?

Variability in Actual Block Times



Courtesy: G. Skaltsas

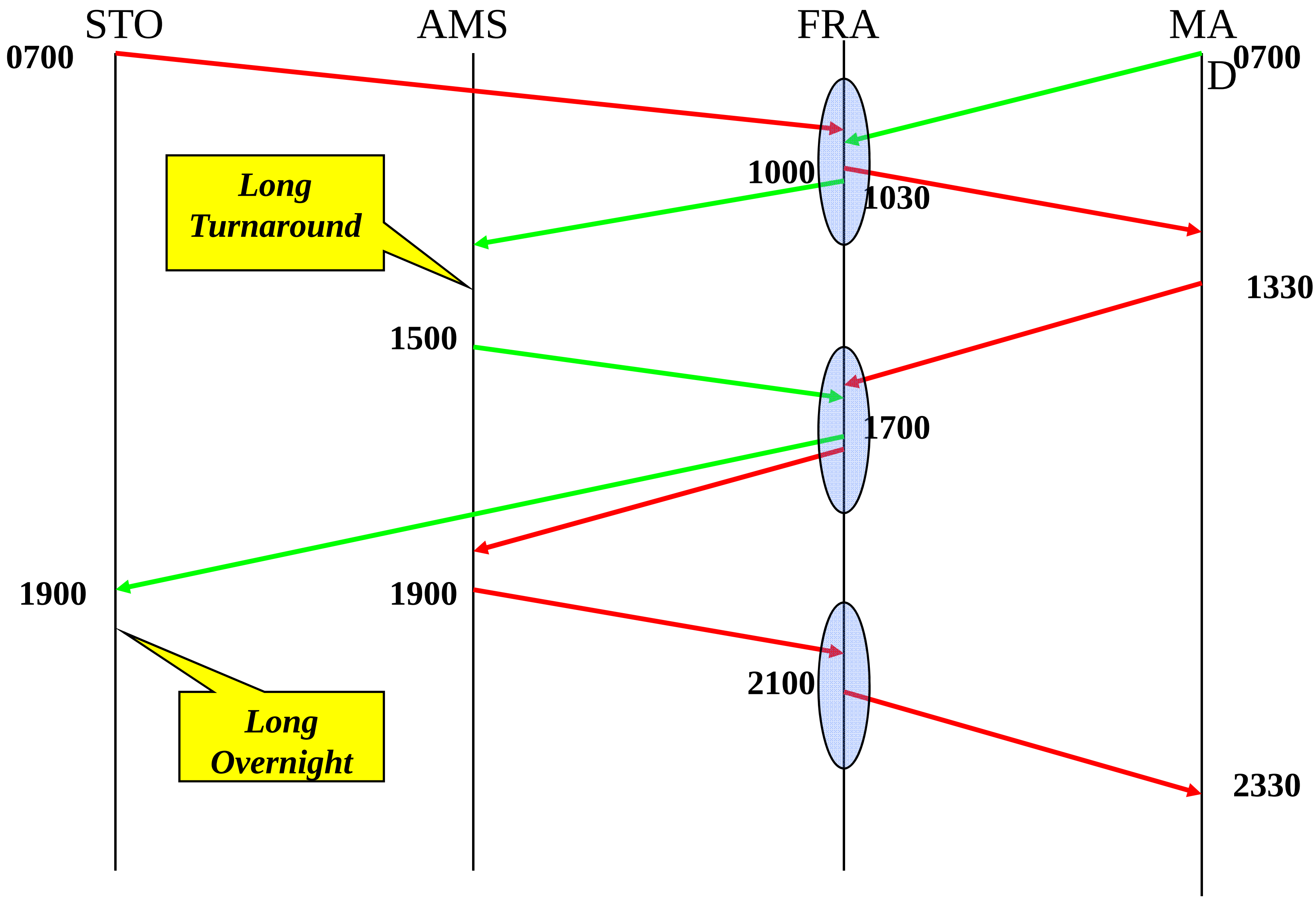
Additional Timetable Considerations

- **Increased planned block times can improve on-time arrival performance for airline, but has costs:**
  - Reduced utilization of aircraft and crew resources
  - Lower position on GDS display screens
  - Potential frustration for passengers with "early" arrivals

- **Each timetable shift has multiple impacts**
  - Previous and subsequent flights operated by same aircraft might also have to be shifted
  - Feasibility of crews, gates, maintenance, curfews, etc.
  - Potential demand (and revenue) impacts via Time of Day Demand and GDS displays

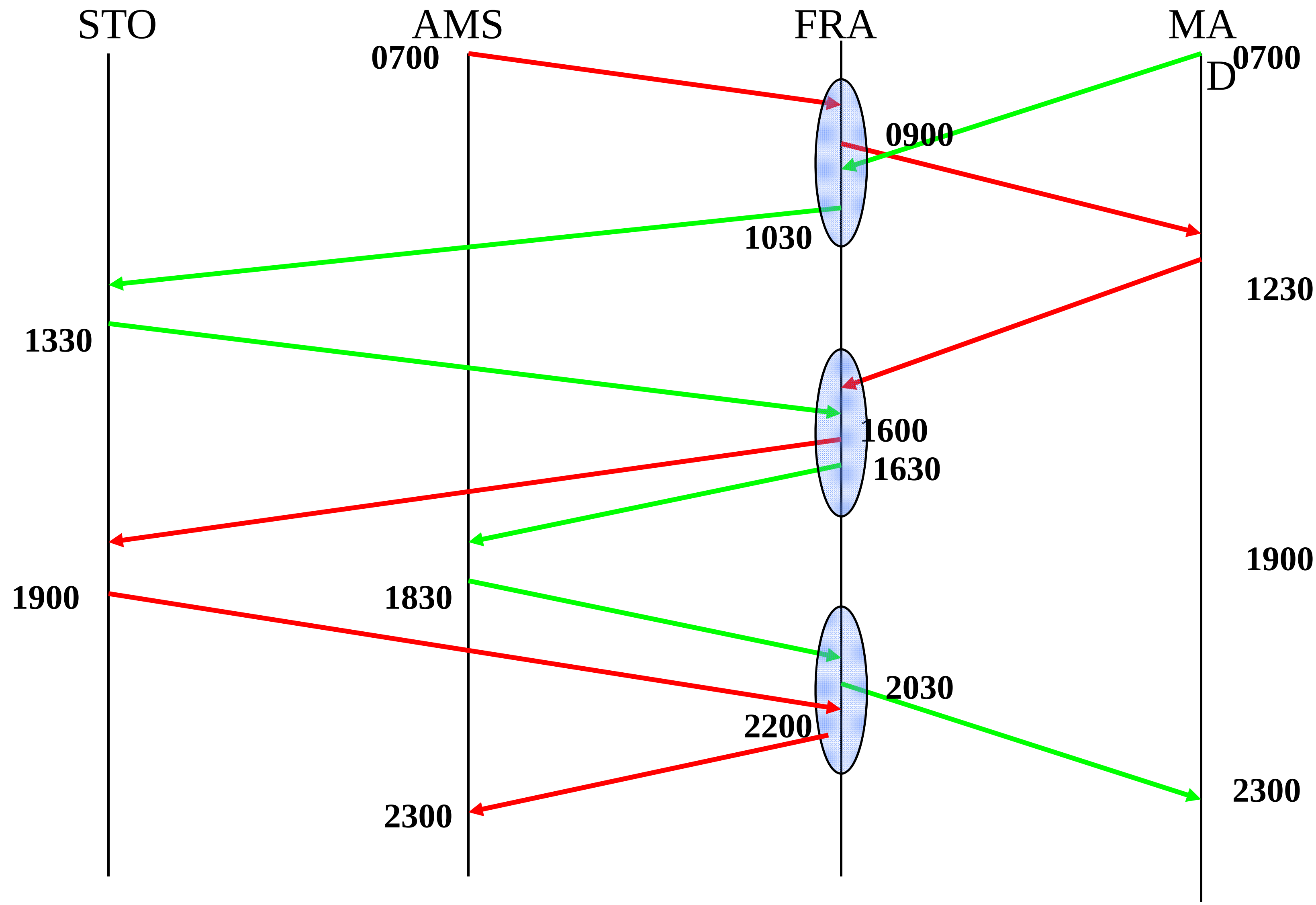
Example of a Schedule Map

2 aircraft; 10 flight legs; 9 block-hr/aircraft-day



Revised Schedule Map

2 aircraft; 12 flight legs; 11 block-hr/aircraft-day



OR Models in Airline Scheduling

- **Airline scheduling problems have received most operations research (OR) attention**
- **Use of schedule optimization models has led to impressive profit gains in:**
  - Aircraft rotations; fleet assignment
  - Crew rotations; maintenance scheduling
- **Current focus is on solving larger problems:**
  - Bigger aircraft fleets, more constraints, and more realistic representations of demand
  - Optimized solutions minimize planned costs, not actual costs under conditions of operational uncertainty and disruptions