

Defining and Managing capacities

Brian Flynn, EUROCONTROL

Some Capacity Guidelines

- Capacity is what you know you can handle today
- Capacity = safe throughput capability of an individual or small team
- All individuals are different!
- Complexity and uncertainty are two important limiting factors
- Models are very valuable to compare different modelled scenarios (more than the model result with reality)

Complexity

- Traffic Mix
 - Cruise, climb, descent
 - Crossing tracks
 - Location of conflict points and types of conflicts
 - Aircraft types and performance
- Regularity of traffic pattern
 - Sudden and sustained peaks
- Regional airports, new schedules, new routes
- Standard control procedures, runway in use, SID, STAR
- Separation and coordination procedures
- Contingencies, technical problems

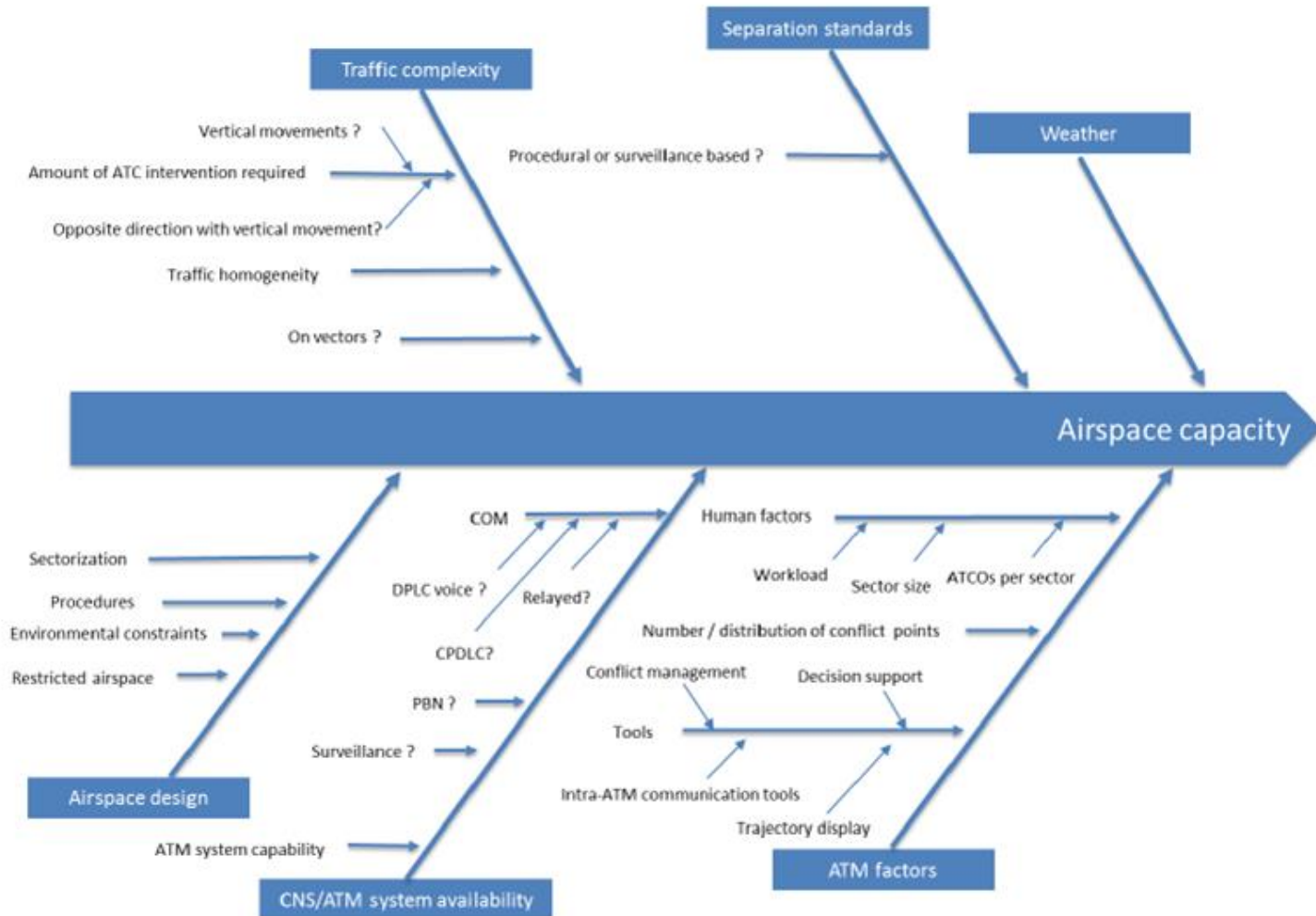
The Human Capacity

- Staff under training, recently qualified, experience, age
- Sustainable capacity (1 hour, 2 , 3)
- Fatigue (day, night, working conditions)
- The sector / tower team
- Language proficiency
- Your capacity and your neighbour's capacity
- Staff management relations

Predictability and Uncertainty

- Accurate prior knowledge of traffic
- Missing flight plans
- Inconsistent and incorrect flight plans
- Adherence to procedures (ATCO, pilot)
- Weather
- Military activity

Determining Enroute Capacity (Doc 9971)



Modelling Capacity

Workload assessment models

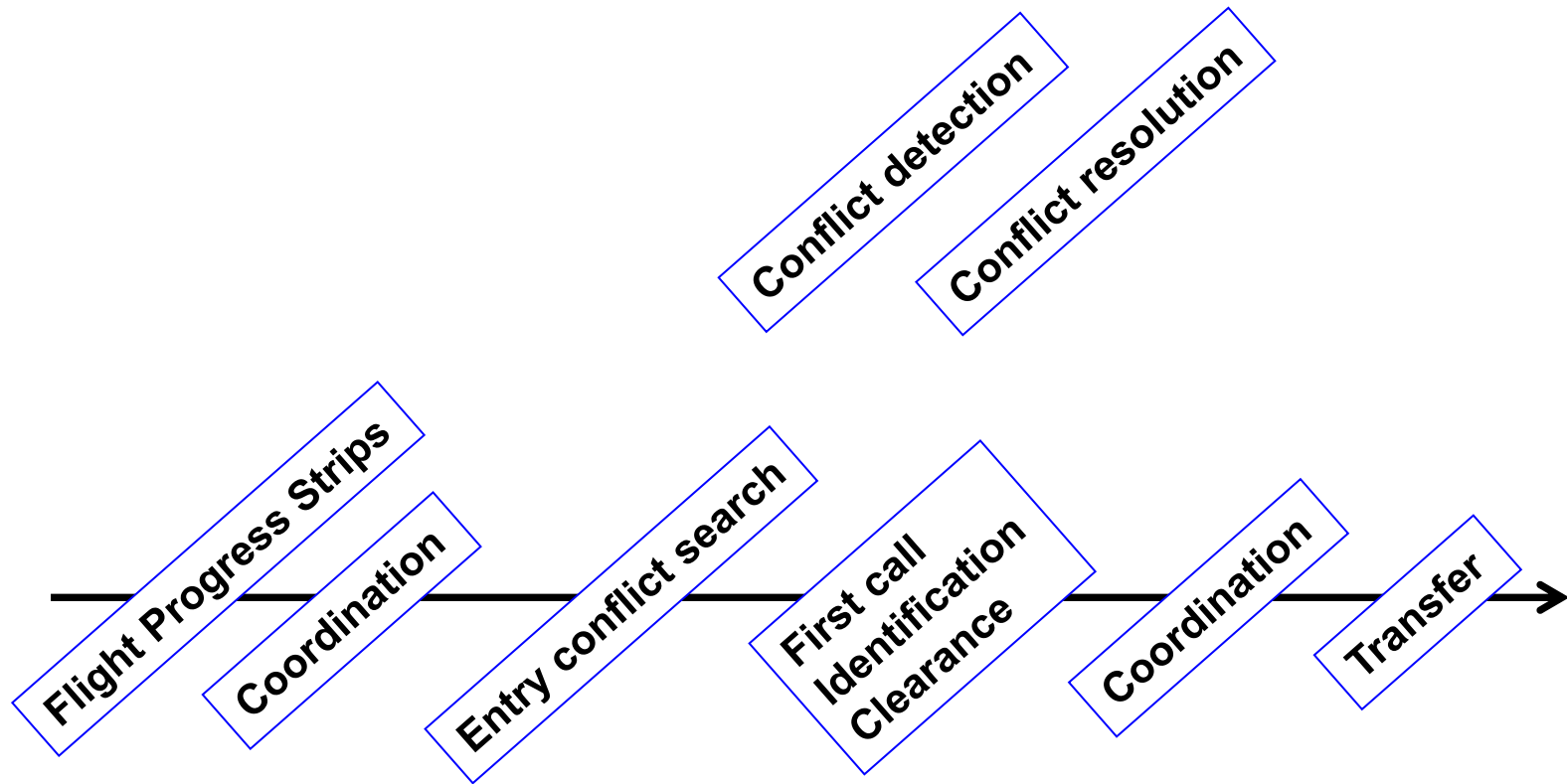
Critical event model:

- Sector entry
- Conflict Search
- Conflict Resolution
- Sector exit

Average task execution times and responsible defined

Many iterations of model required to obtain stable results.

Critical Event Model



Example Workload Threshold Analysis

The quantitative threshold values used and their corresponding qualitative interpretations are:

| Threshold | Interpretation | Recorded Working Time during 1 hour |
|---------------|-----------------|-------------------------------------|
| 70 % or above | Overload | 42 minutes + |
| 54 % - 69 % | Heavy Load | 32 - 41 minutes |
| 30 % - 53 % | Medium Load | 18 - 31 minutes |
| 18 % - 29% | Light Load | 11 - 17 minutes |
| 0 % - 17 % | Very Light Load | 0 - 10 minutes |

Example Model Output

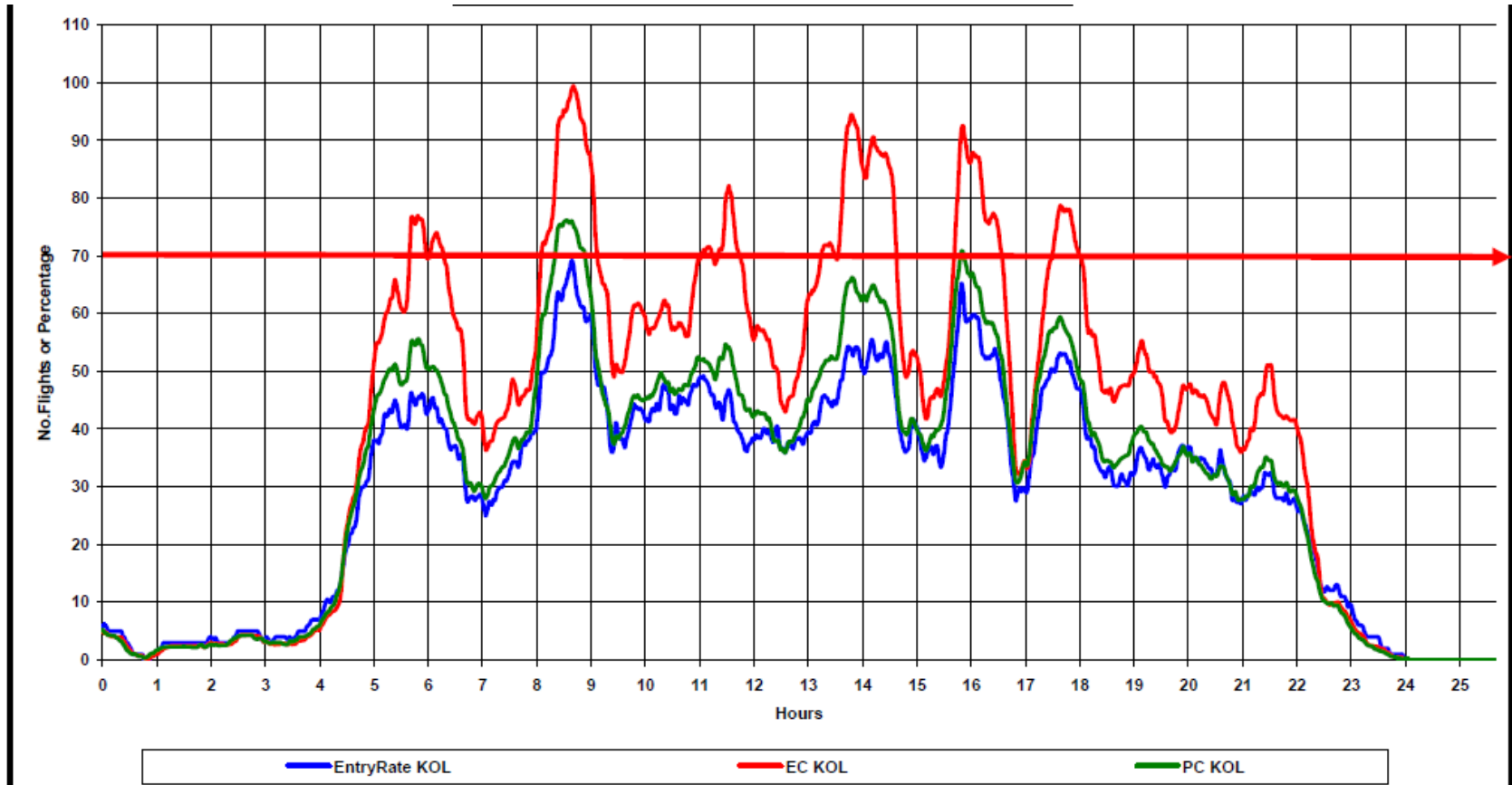


Figure 0-2 - Traffic Demand and Controller Workloads

Entry Count v Occupancy

Capacity for an airspace sector is normally defined as an entry count (maximum number of aircraft entering an airspace sector in a given period of time).

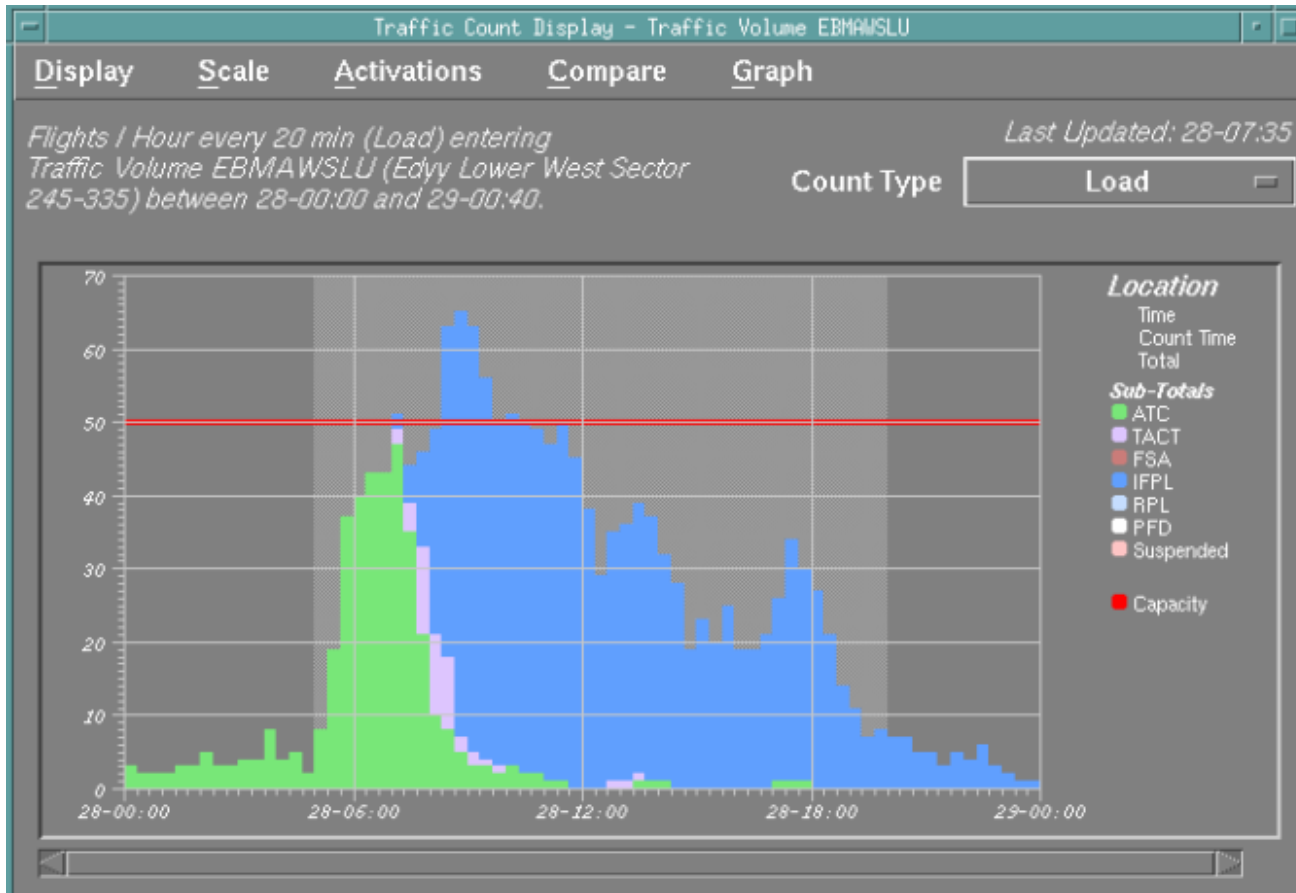
A complementary measure is occupancy count (maximum number of aircraft within an airspace sector in a given period of time).

Occupancy count can be used to complement entry counts, and allow higher values for such entry counts, where accurate and frequent live surveillance data updates are included in the ATFM system and that these are available well in advance of flight entry into the given airspace sector and are constantly updated.

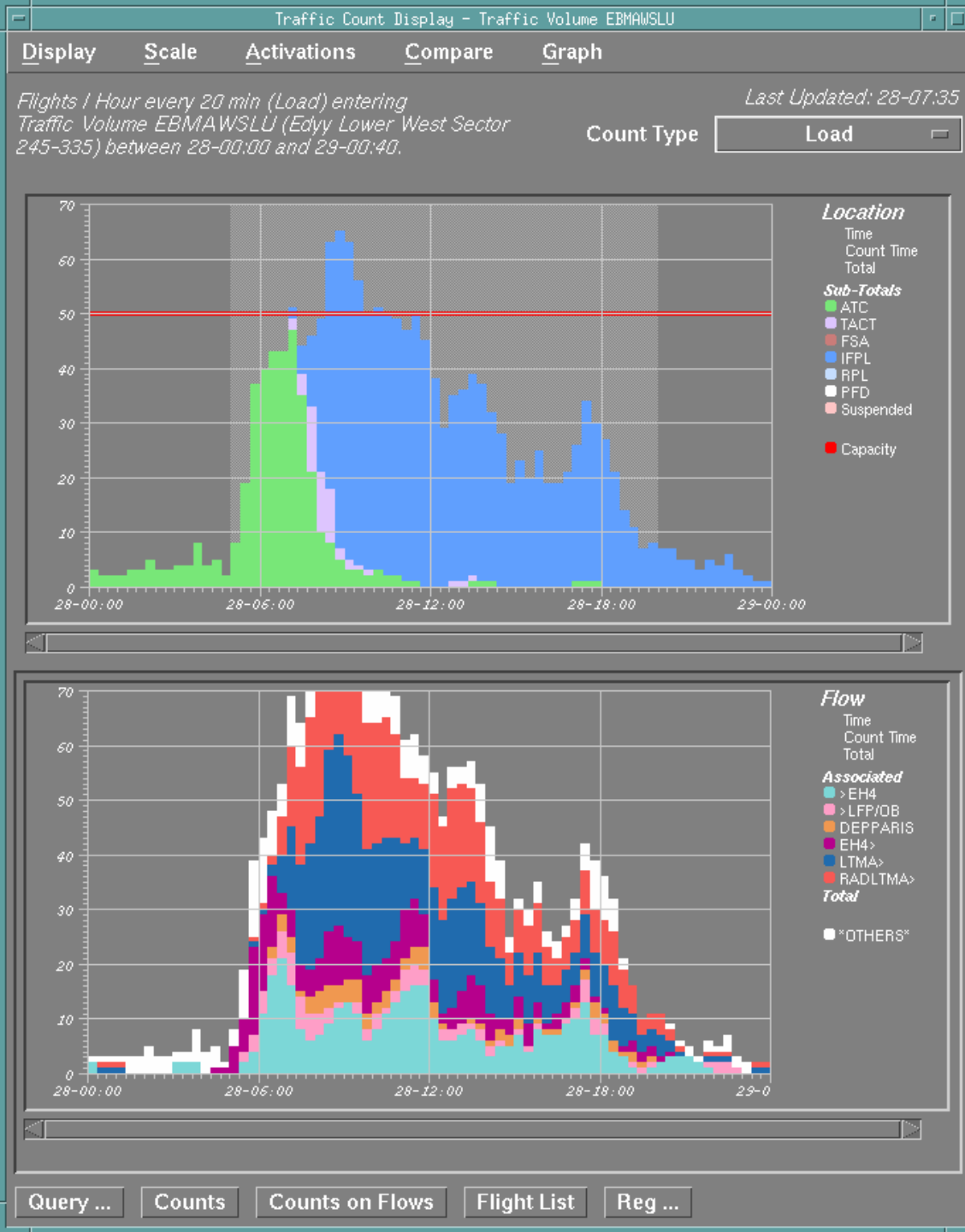
Operating at the limits

- Traffic Loads
- Occupancy counts

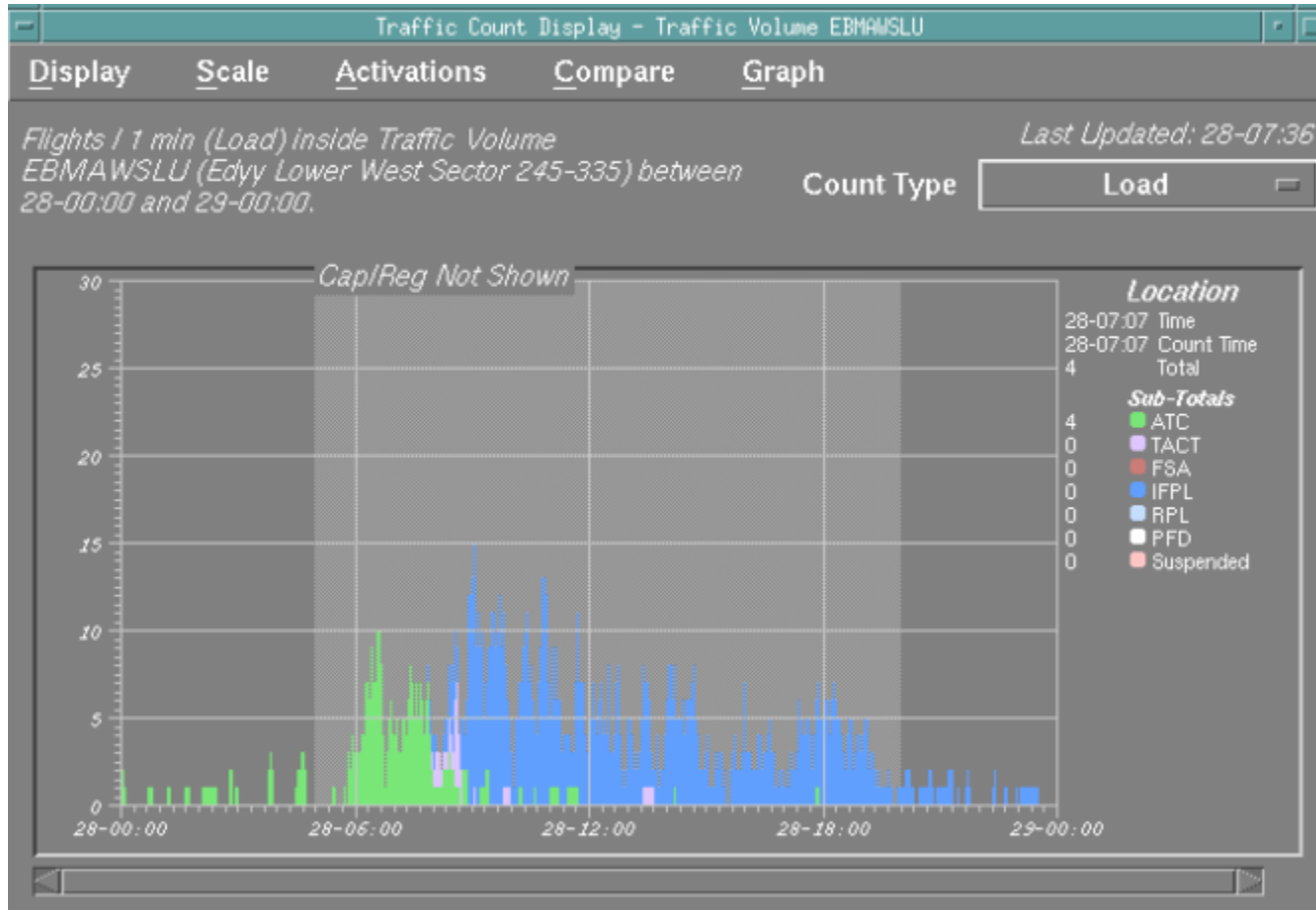
Traffic loads



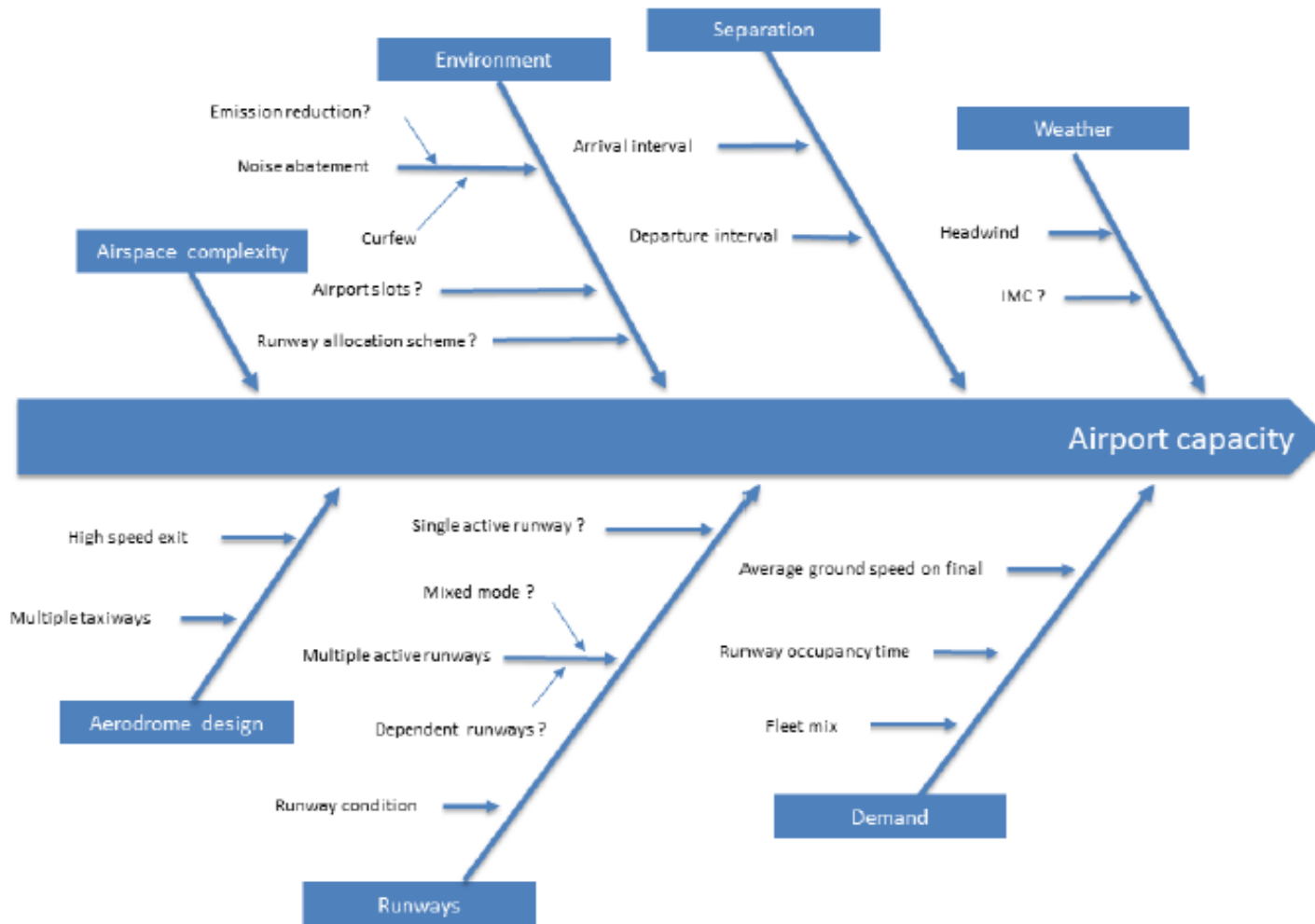
| Time | Tot | Cap |
|-----------------|-----------|-----------|
| 28-06:00 | 40 | 50 |
| 28-06:20 | 43 | 50 |
| 28-06:40 | 43 | 50 |
| 28-07:00 | 52 | 50 |
| 28-07:20 | 45 | 50 |
| 28-07:40 | 47 | 50 |
| 28-08:00 | 49 | 50 |
| 28-08:20 | 63 | 50 |
| 28-08:40 | 65 | 50 |
| 28-09:00 | 63 | 50 |
| 28-09:20 | 56 | 50 |
| 28-09:40 | 50 | 50 |
| 28-10:00 | 51 | 50 |
| 28-10:20 | 50 | 50 |
| 28-10:40 | 49 | 50 |
| 28-11:00 | 47 | 50 |
| 28-11:20 | 50 | 50 |
| 28-11:40 | 45 | 50 |



Occupancy counts



Determining Airport Capacity (Doc 9971)



Airport Capacity

Airport Acceptance Rate (AAR): Number of arrival aircraft that an airport, in conjunction with terminal airspace, ramp space, parking space, and terminal facilities can accept under specific conditions during any consecutive 60 minute period.

Varies greatly with each runway configuration and weather

Theoretical single runway capacity = Ground Speed / separation required at threshold

- Intersecting arrival and departure runways
- Lateral distance between arrival runways
- Dual use runways – runways that share arrivals and departures
- Land and Hold Short operations
- Availability of high speed taxiways
- Airspace limitations and constraints
- Procedural limitations (noise abatement, missed approach procedures)
- Taxiway layouts
- Meteorological conditions

Speed based arrival capacity calculation

| Ground speed | Miles separation | Time separation | Capacity |
|--------------|------------------|-----------------|----------|
| 150 | 5 | 2 | 30 |
| | 4 | 1,6 | 37,5 |
| | 3 | 1,2 | 50 |

| Ground speed | Miles separation | Time separation | Capacity |
|--------------|------------------|-----------------|----------|
| 120 | 5 | 2,5 | 24 |
| | 4 | 2 | 30 |
| | 3 | 1,5 | 40 |

Time based capacity calculation

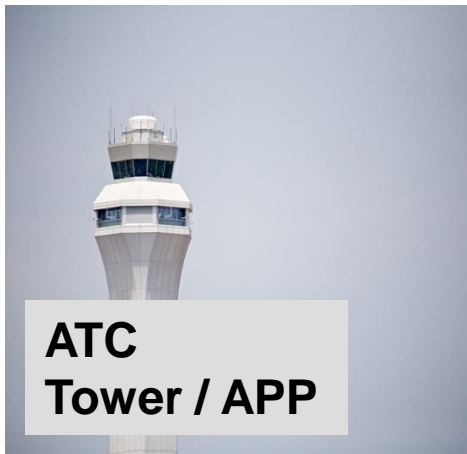
| Time clearance to land | Time to land | Time to clear | Total time | Capacity |
|------------------------|--------------|---------------|------------|----------|
| 2 | 1 | 1 | 4 | 15 |
| 1 | 1 | 1 | 3 | 20 |
| 1 | 1 | 0,5 | 2,5 | 24 |
| 1 | 1 | 0 | 2 | 30 |
| 0,5 | 1 | 0 | 1,5 | 40 |

| Time clearance to line up and TO | Time to take off | Time to clear | Total time | Capacity |
|----------------------------------|------------------|---------------|------------|----------|
| 2 | 1,5 | 0 | 3,5 | 17 |
| 1 | 2 | 0 | 2,5 | 24 |
| 1 | 1 | 0 | 2 | 30 |
| 0,5 | 1 | 0 | 1,5 | 40 |
| 0,5 | 0,5 | 0 | 1 | 60 |

Single Runway Mixed Mode Operations

| Flight | Arr/Dep | Time Required | Time Required |
|--------------------------|---------|---------------|---------------|
| FLT 1 | A | 4 | 1,2 |
| FLT 2 | D | 2 | 1 |
| FLT 3 | A | 3 | 1,2 |
| FLT 4 | A | 2 | 1,2 |
| FLT 5 | A | 2,5 | 1,2 |
| FLT 6 | A | 1,5 | 1,2 |
| FLT 7 | D | 1 | 1 |
| FLT 8 | A | 1,5 | 1,2 |
| FLT 9 | D | 2,5 | 1 |
| FLT 10 | D | 2 | 1 |
| FLT 11 | A | 2 | 1,2 |
| FLT 12 | A | 2 | 1,2 |
| FLT 13 | A | 1,5 | 1,2 |
| FLT 14 | D | 1,5 | 1 |
| FLT 15 | D | 1 | 1 |
| Total time | | 30 | 16,8 |
| Number of flights | | 15 | 15 |
| Hourly capacity | | 30 | 54 |

Airport Capacity



Capacity - Conclusions

- Capacity = safe throughput capability of an individual or small team
- All individuals are different!
- Participation of Controllers is essential in discussing and modelling capacity
- Complexity and uncertainty are very important limiting factors
- Models can provide valuable assistance in establishing, validating current and future capacity baselines.
- Capacity is dynamic – it changes!

Thank you