

Co-operative Air Traffic Management

Airport Centered Planning

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- Balancing Demand and Capacity at different Levels
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 - CFMU – Centralized Flow Manager
 - AMAN - Arrival Manager
 - DMAN – Departure Manager
- CLOU – Cooperative Local Resource Planner
 - Constraints
 - Optimization Parameters
 - Metrics
- Summary

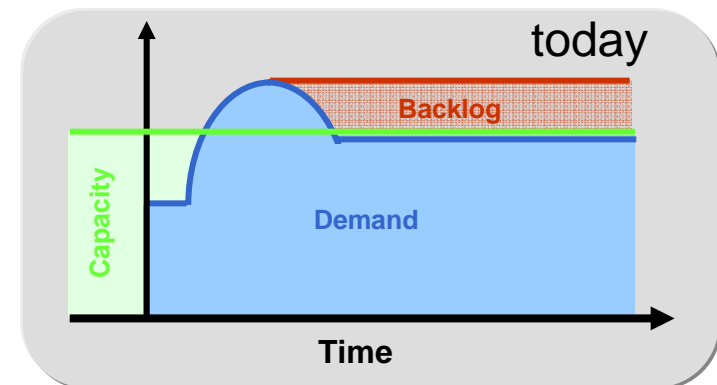
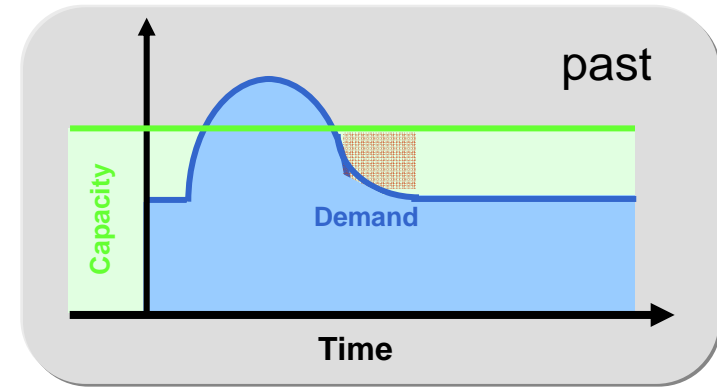
Problem – Limited Runway Capacity

- Hub-Airports are the pace-setting bottlenecks of the Central-European airspace

- Major Airports operate at capacity limits and are extremely susceptible to disturbances

Small disruptions can already cause severe effects

- Especially punctuality and connectivity recognized by passengers are concerned
- Efficiency of air and ground operations is degraded
- Human actors are exposed to high work load



The Challenge – Balancing Demand and Capacity

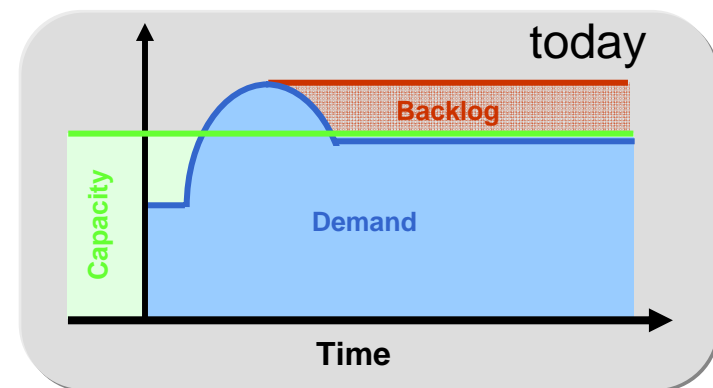
○ Challenge

- Avoid Overload Situations
- Provide tools for proactive control

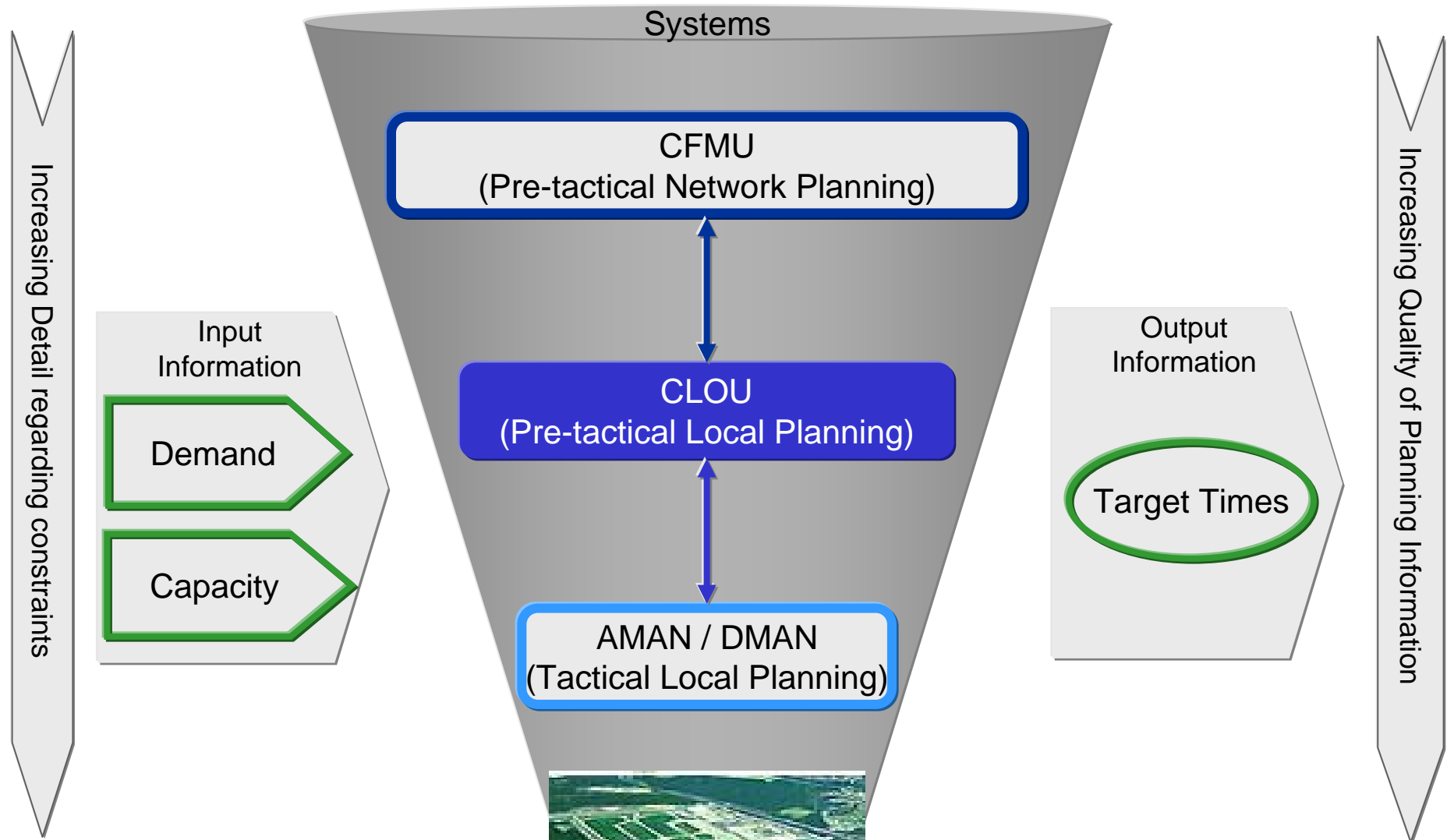


○ Proposed Solution

- Airport Centered Planning
- Balancing Demand and Capacity at Airports



Balancing Demand and Capacity – Different Levels



Balancing Demand and Capacity – ATM Objectives

Avoiding Overload of Sectors

Optimizing Runway Configuration

Minimizing Separations
Coordination between Controllers

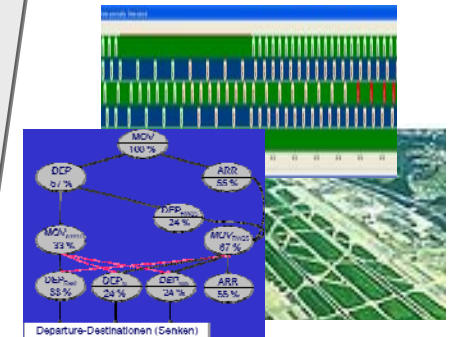
Systems

CFMU

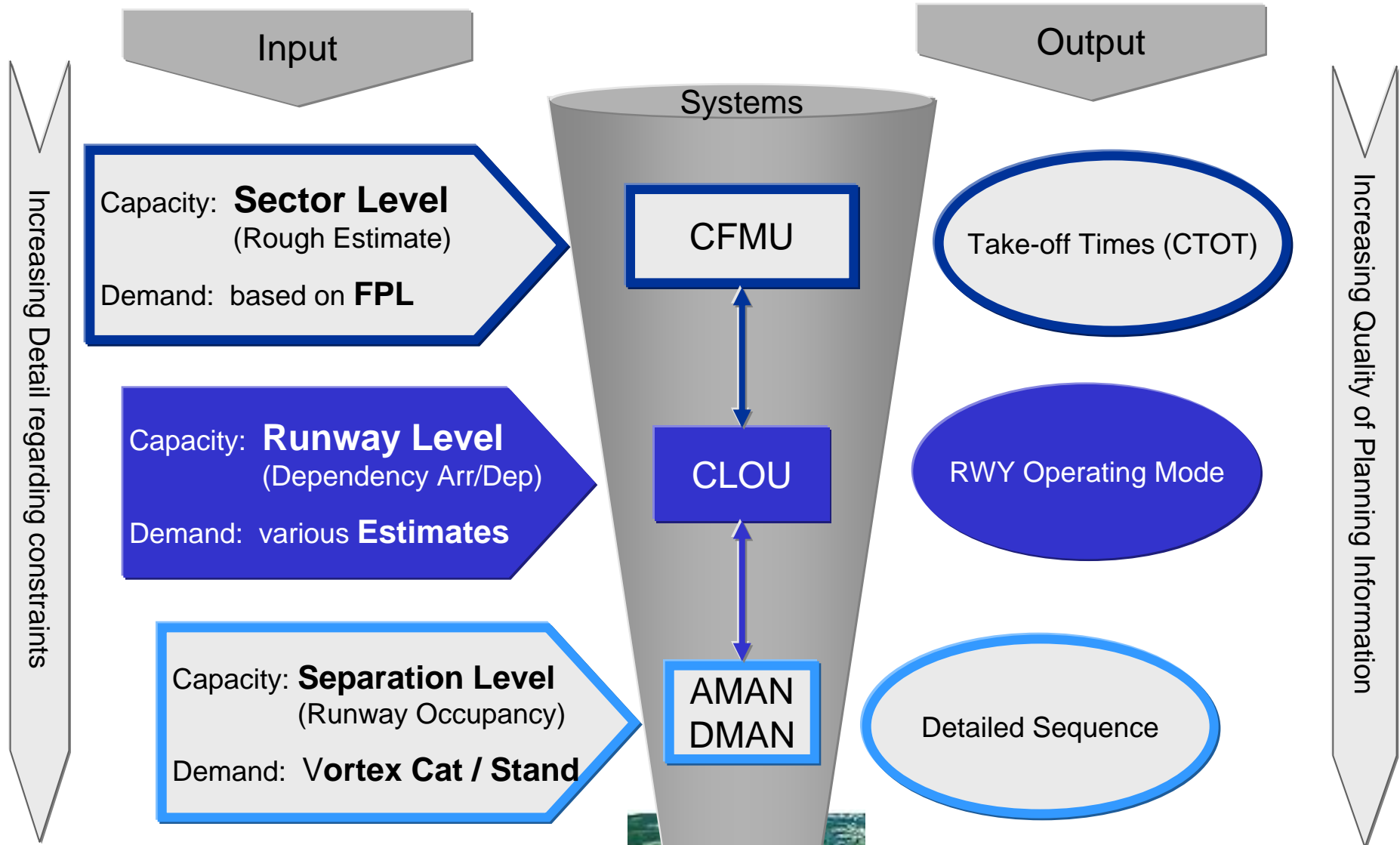
CLOU

AMAN
DMAN

Increasing Planning Horizon



Balancing Demand and Capacity – Different Planning Levels



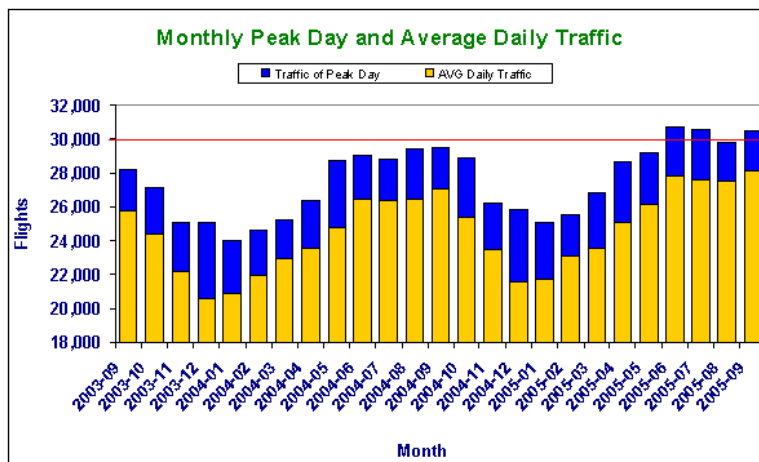
CFMU – Centralised Flow Management Unit

ATM-Objective
Avoiding Overload of Sectors

Airline Options

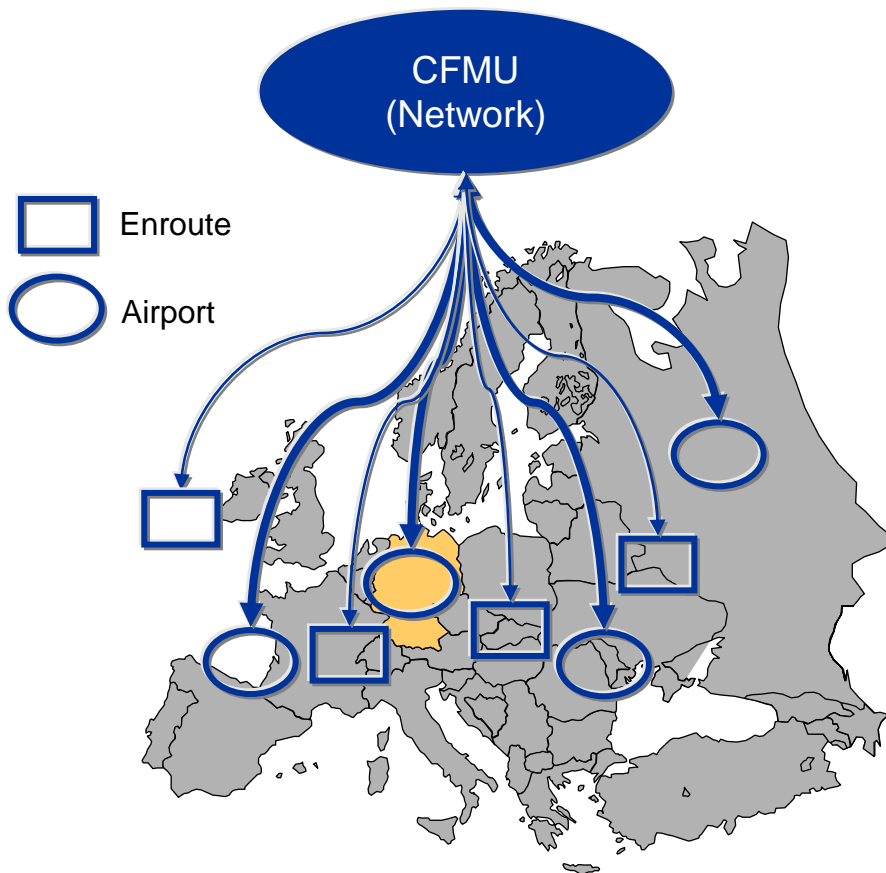
Rerouting is possible
(based on Info about regulated Sectors)

Swapping of CFMU-Slots



CFMU – Shortcomings

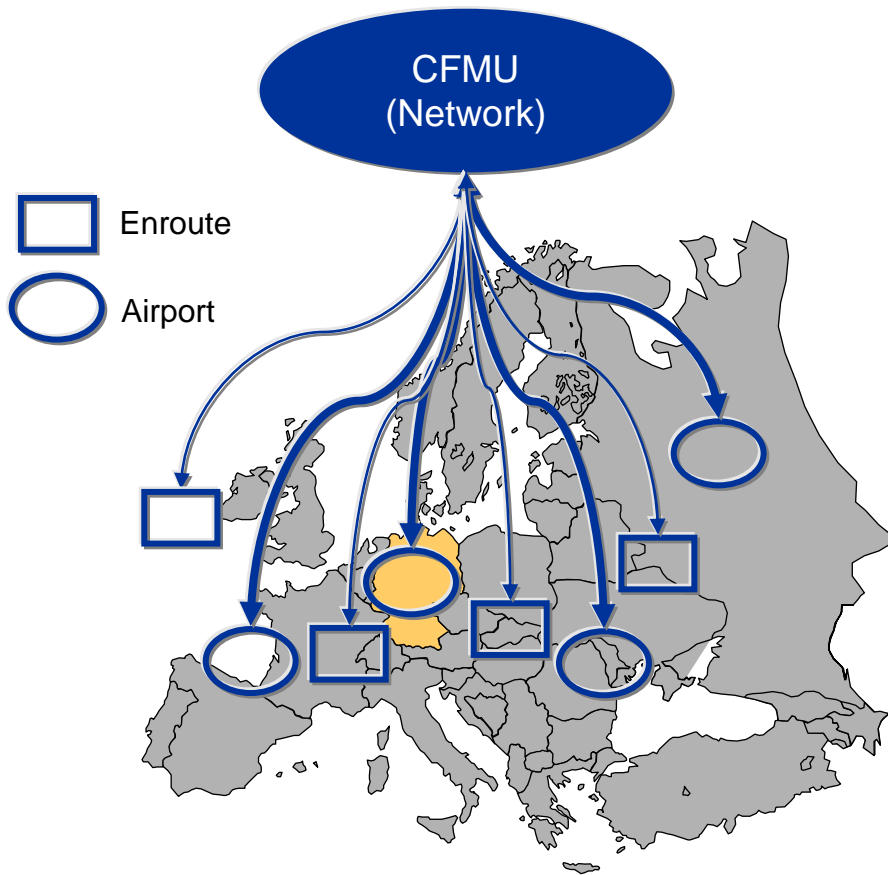
Today



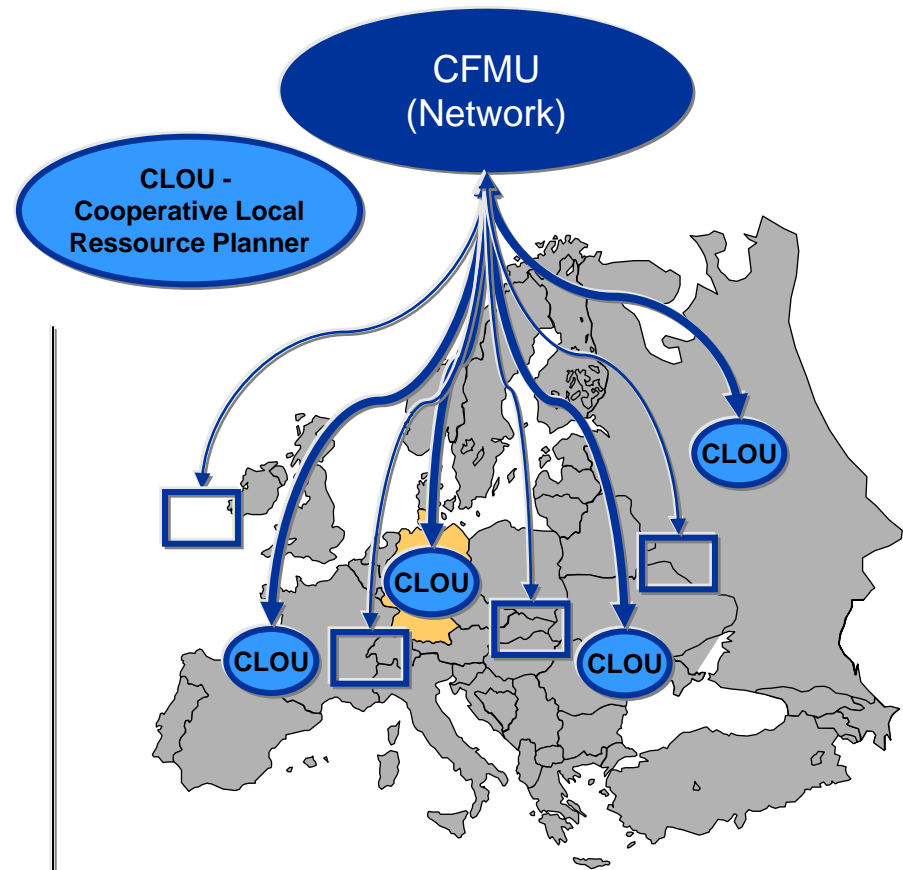
- CFMU was developed for enroute sector problems
- CFMU is now also used for regulating airports
 - Arrival Sector is regulated
Regulation is fairly coarse
 - Departure flights at disrupted airports are not regulated
(poor quality of departure off-block / Take off information)
- Airline has few possibility to prioritize flights

CFMU – Proposed Solution

Today



Future



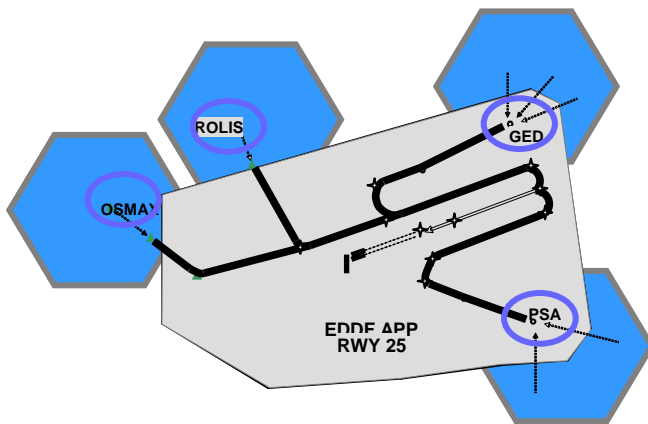
Network-Planning of CFMU has to be complemented by detailed local Airport-Planning (CLOU)

AMAN – Arrival Management (4D-Planer / DFS)

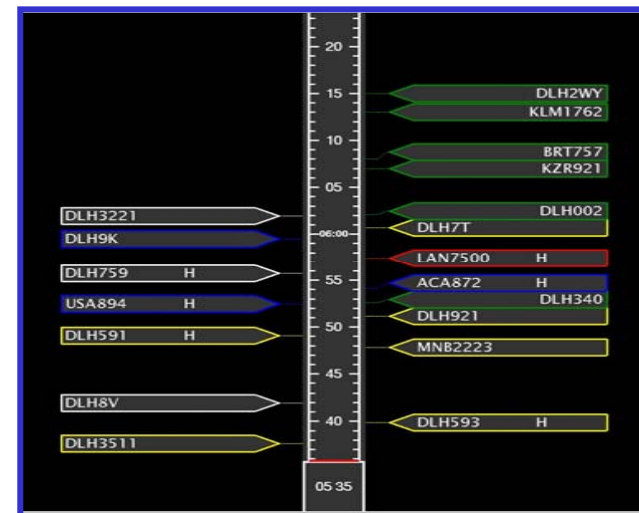
ATM-Objective
Maximizing Throughput

Airline Options

Highest Quality of Inbound-Information
(Estimated Landing Time)



- Integration of Arrival Flows
- Optimal Feeding to Runways
- Communication between Controllers

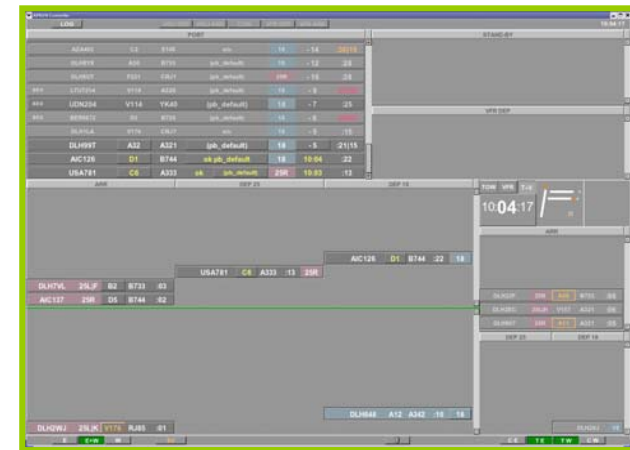
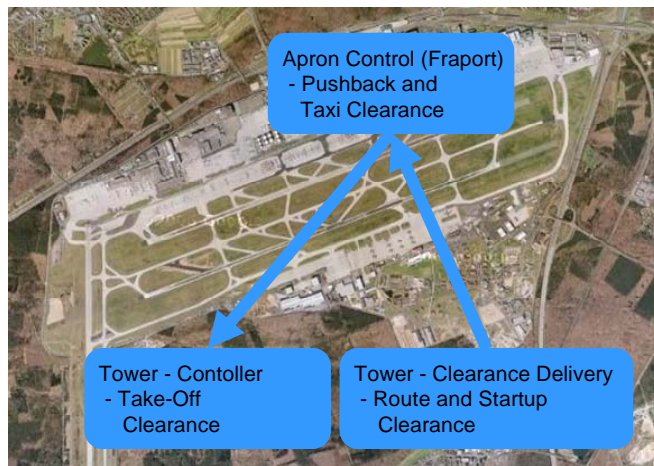


DMAN – Departure Management (darts / Delair)

ATM-Objective
Maximizing Throughput

Airline Option

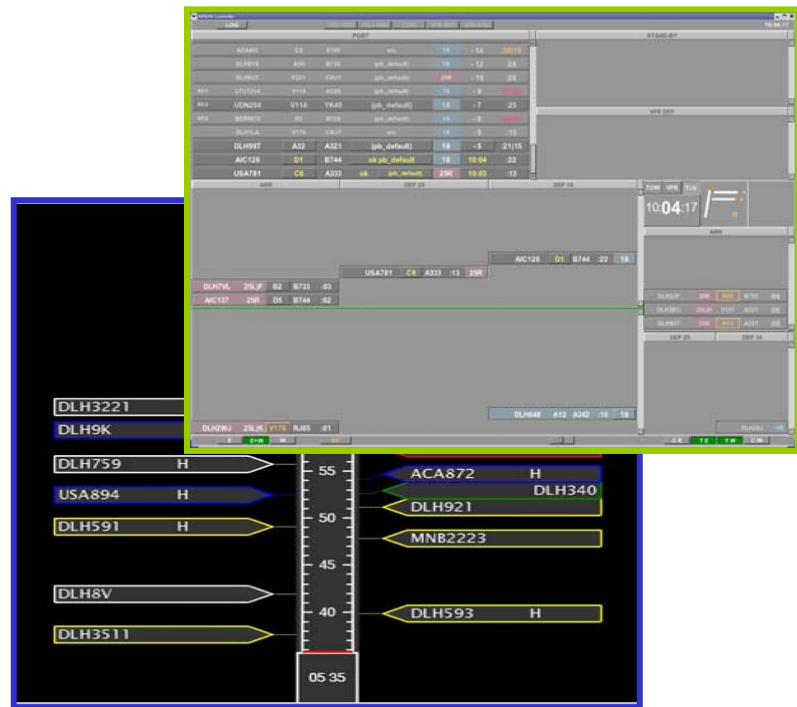
Highest Quality of Outbound-Information
(Estimated Off-Block Time)



- Optimal Feeding to Runways
- Communication between Controller

AMAN and DMAN – Shortcomings / Proposed Solution

- AMAN and DMAN do not support runway assignment (Load Balancing between runways)
- AMAN and DMAN do not consider the mutual dependency of In- and Outbound



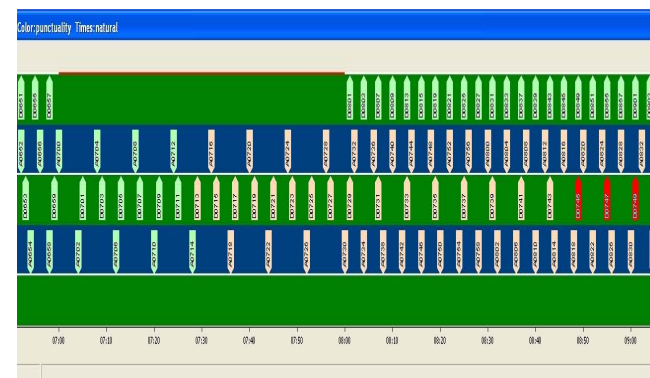
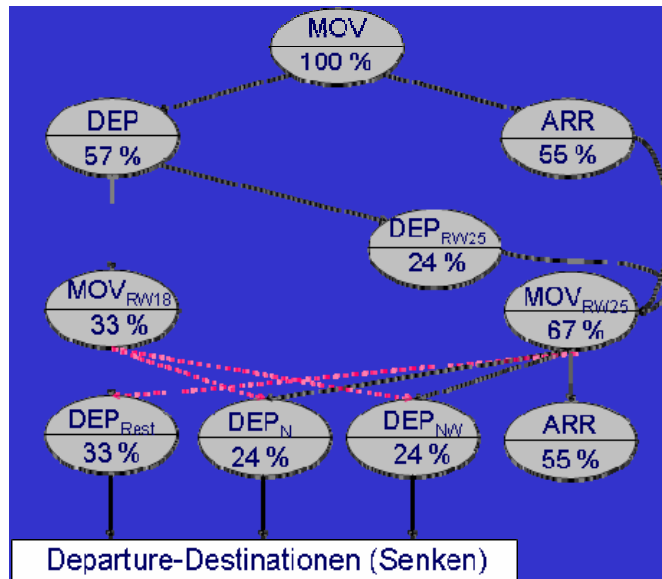
Planning and Controlling Flights
has to start earlier in order
to optimize runway usage

CLOU – Cooperative Local Resource Planner

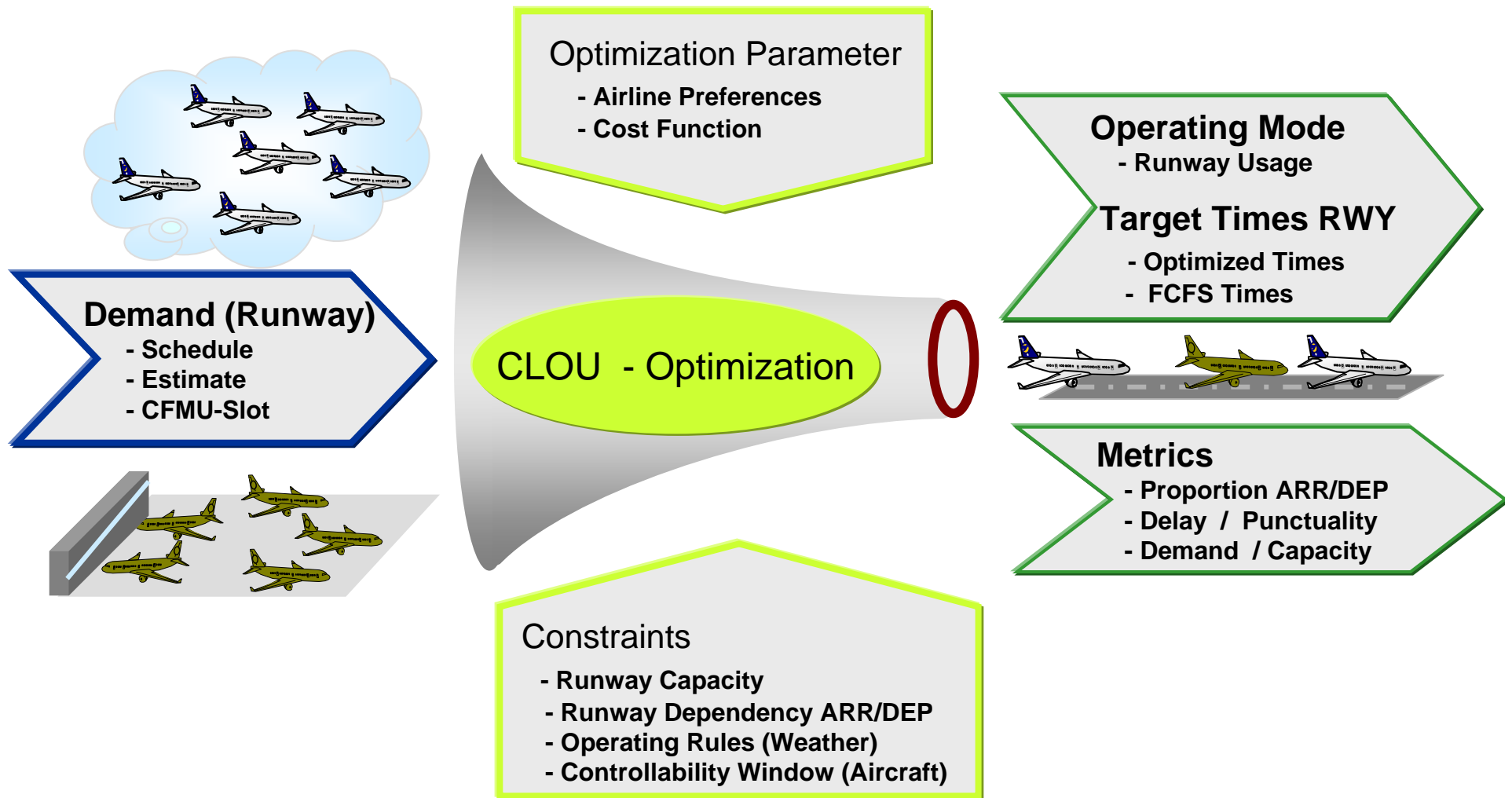
ATM-Objective
Optimize Runway Configuration

Airline Options

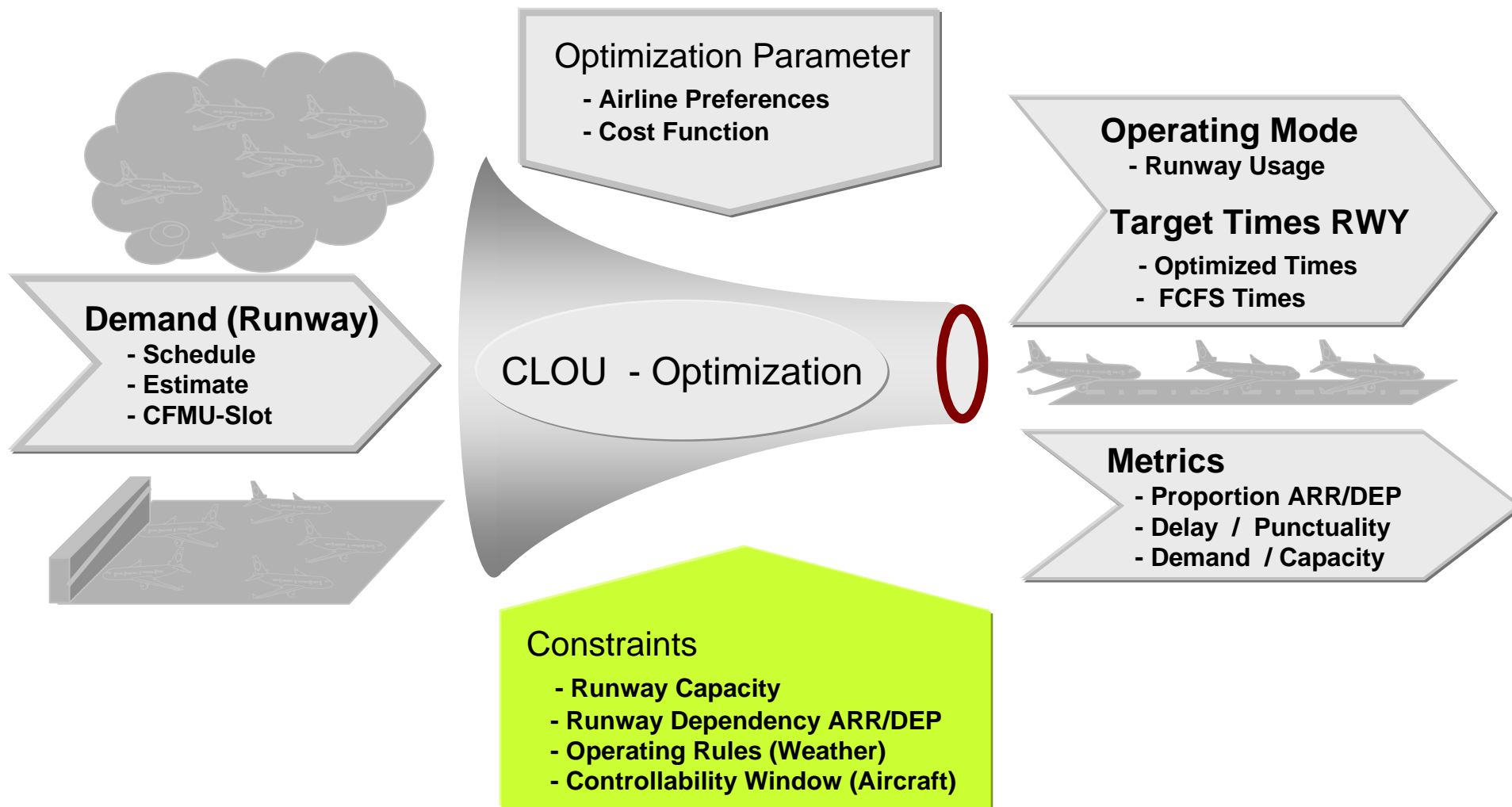
Airline Preferences are considered
(User Optimized Delay Management)



CLOU – Planning Elements



CLOU – Constraints

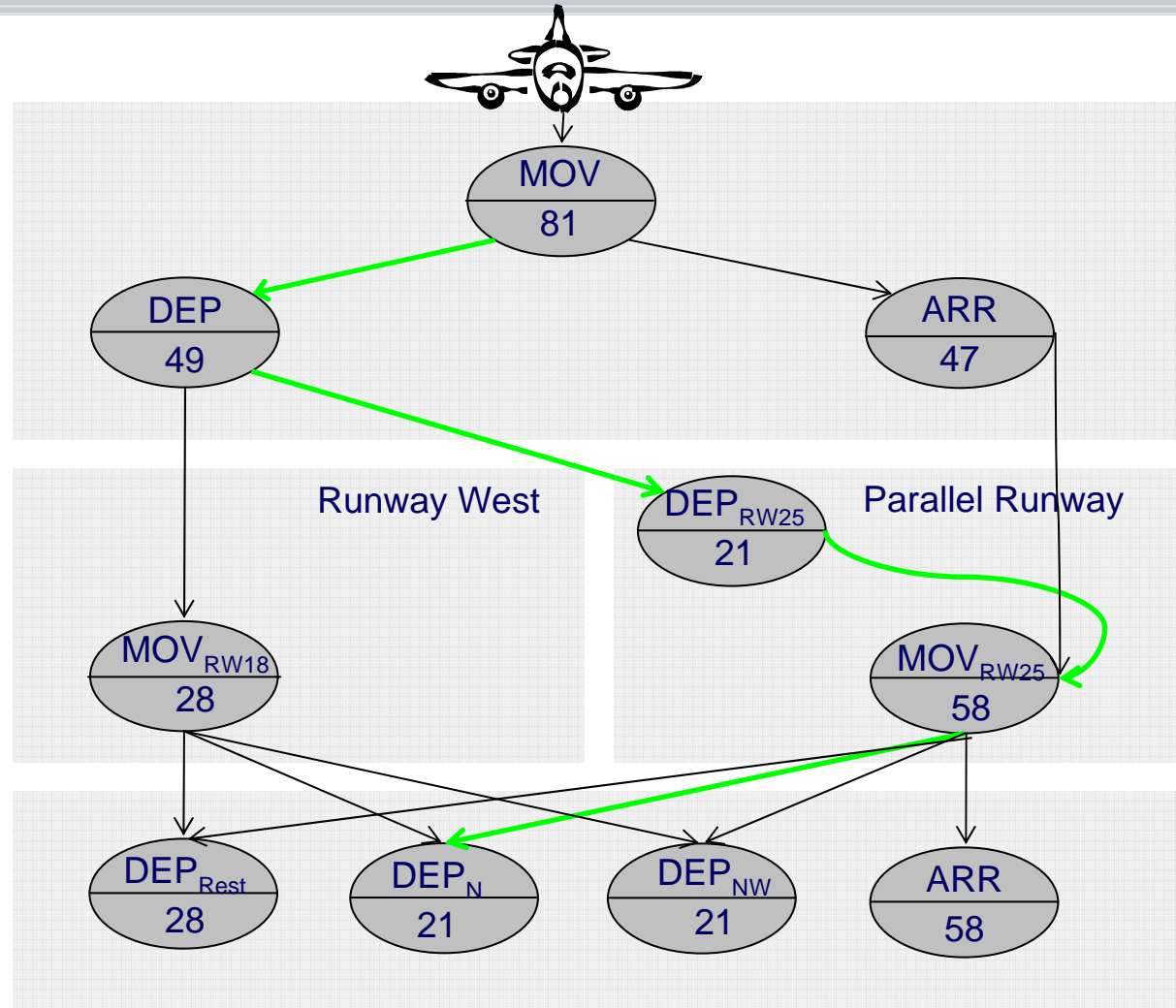


CLOU: Constraint Modeling - Capacity

Count of Flight Events
for Overall System

Count of Flight Events
for Single Runways

Count of Flight Events
for Departure Routes



Example: Departure leaving in northern direction (via TABUM)
Route in standard operating Mode (OM 6)

CLOU: Constraint Modeling - Controllability Window

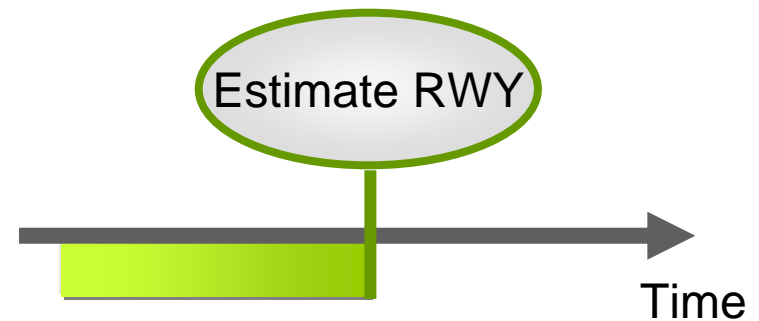
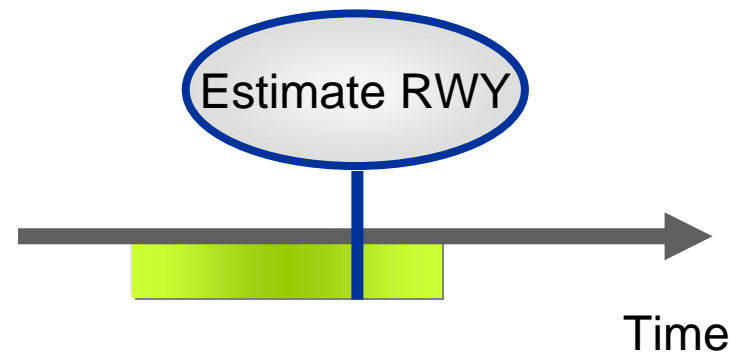
○ Controllability Window (Maximum Time to Loose / Time to Gain)

■ Arrivals

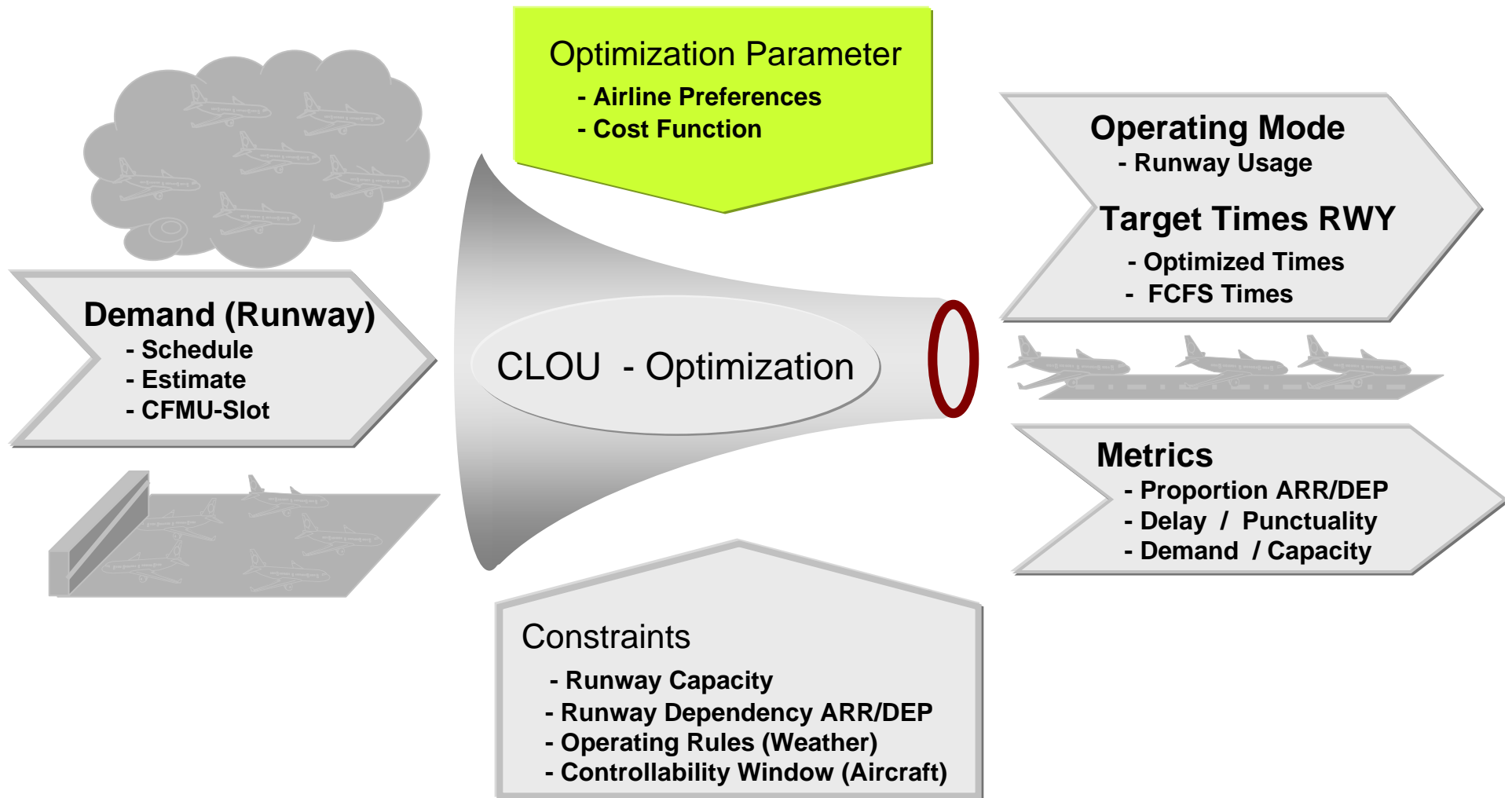
- Airborne Flights
 - Time To Loose / Time To Gain depending on remaining time till Touchdown
- Flights on Outstation
 - No Time to Gain
 - Time to Loose depending on remaining time till Take-off

■ Departures

- Slotted Flights (CFMU)
 - CFMU-Slot window respected
- Others
 - No Time to Gain
 - Time to Loose depending on remaining time till Takeoff



CLOU – Optimization Parameter



Times related to one single Flight



Co-ordinated Perspective
(Airline Objective)

Single Flight Perspective
(Earliest Possible)



Schedule

Estimate



Cost Function – Punctuality



Co-ordinated Perspective
(Airline Objective)

Single Flight Perspective
(Earliest Possible)



Schedule

Estimate

Actual



Time

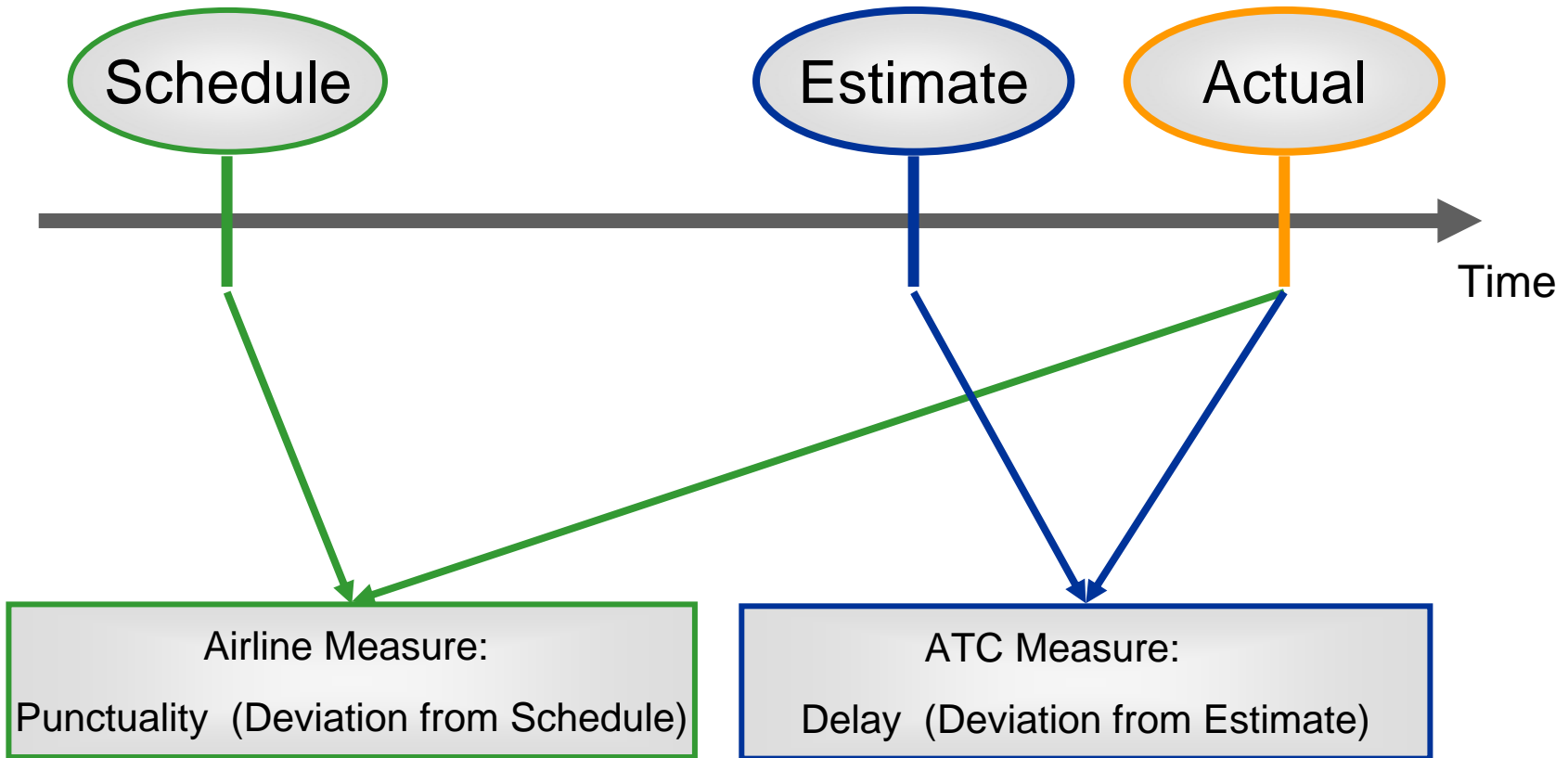
Airline Measure:
Punctuality (Deviation from Schedule)

Cost Function – Delay



Co-ordinated Perspective
(Airline Objective)

Single Flight Perspective
(Earliest Possible)



Cost Function – Target Time



Co-ordinated Perspective
(Airline Objective)

Single Flight Perspective
(Earliest Possible)



Schedule

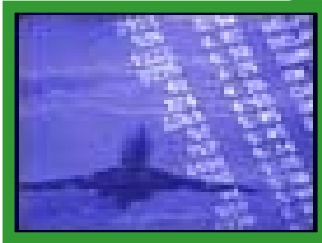
Estimate

Actual



Target

Target Times Consider
Delay and Punctuality



Co-ordinated Perspective
(Updated Target)

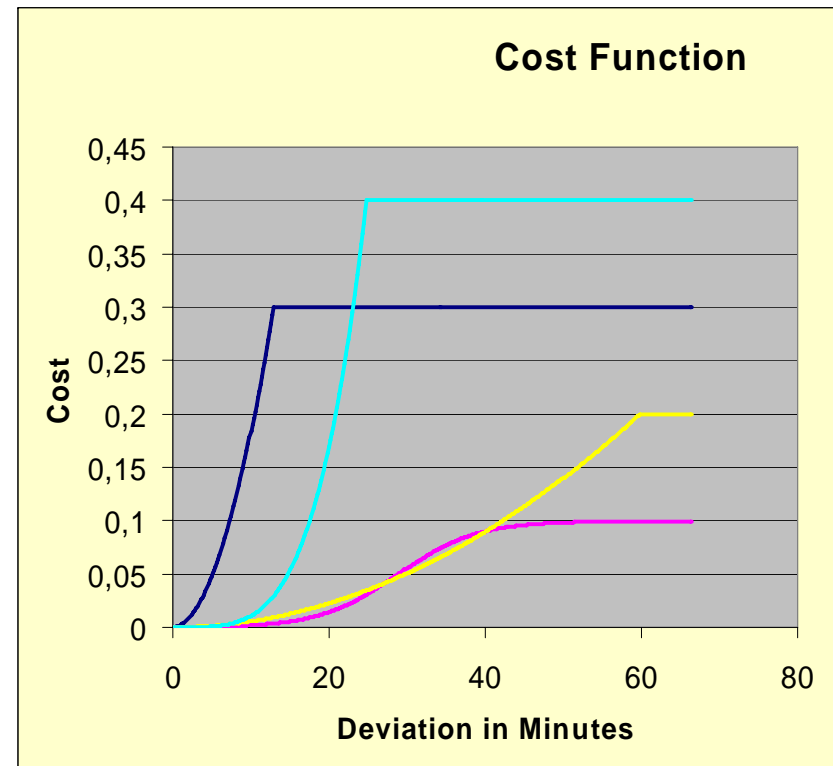
CLOU: Cost Function - Objectives

Minimizing Deviation from

- Schedule (Punctuality)
- Estimate (Delay)
- Controllability Window
- CFMU Slot

Balancing

- Airline Objectives
(Punctuality and Delay)
- Constraints
(Slot and Controllability Window)

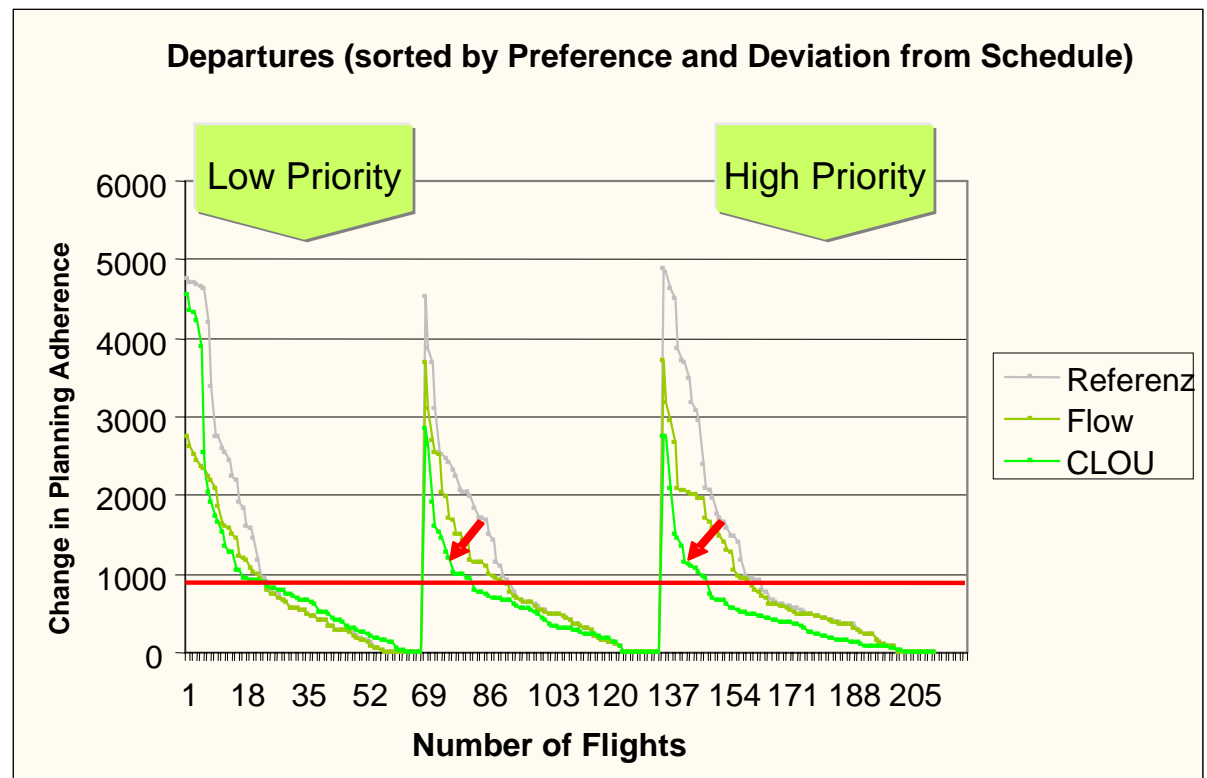


CLOU: Airline Preferences

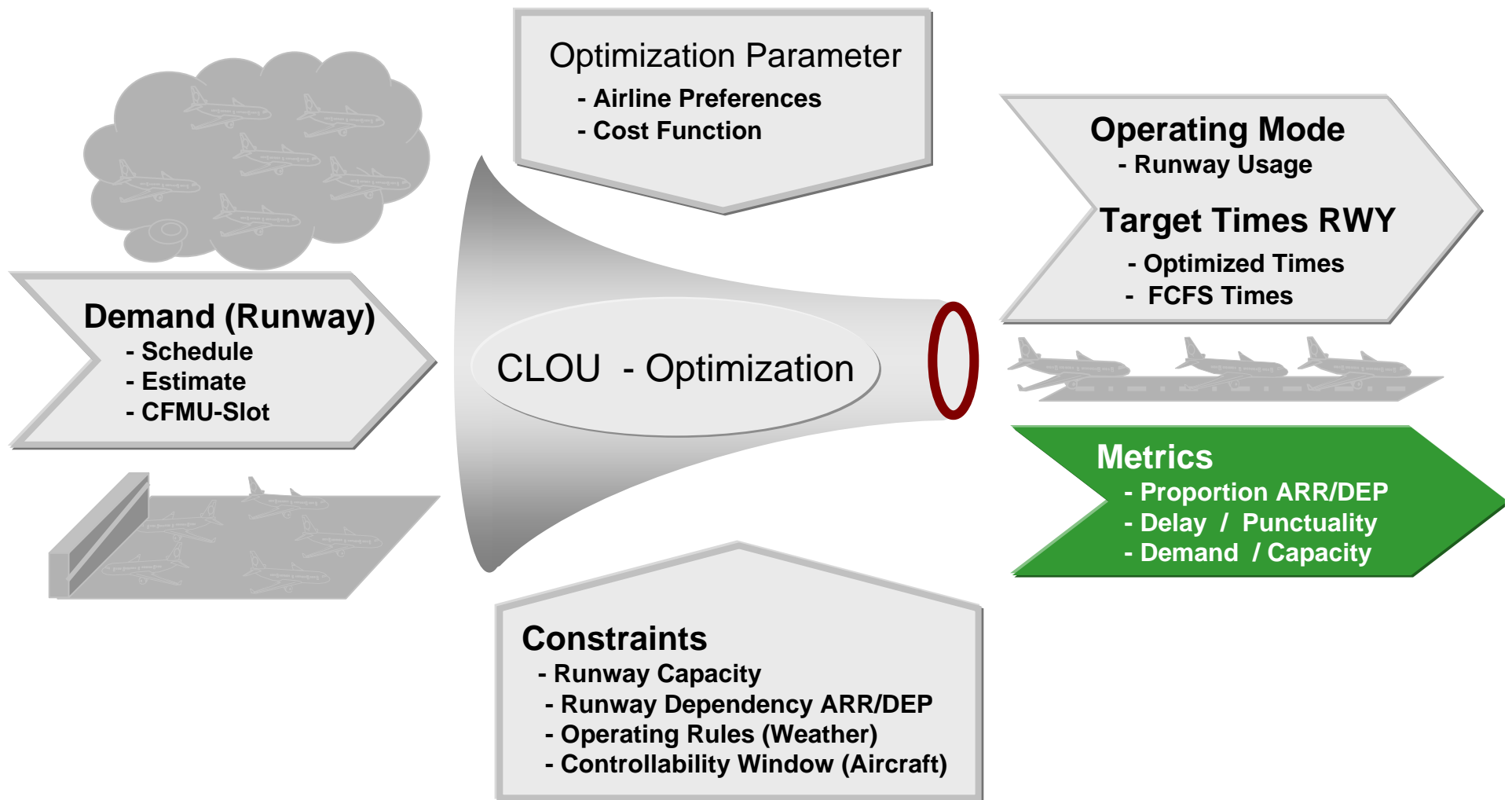
Airline Preferences

- High Priority
- Medium Priority
- Low Priority

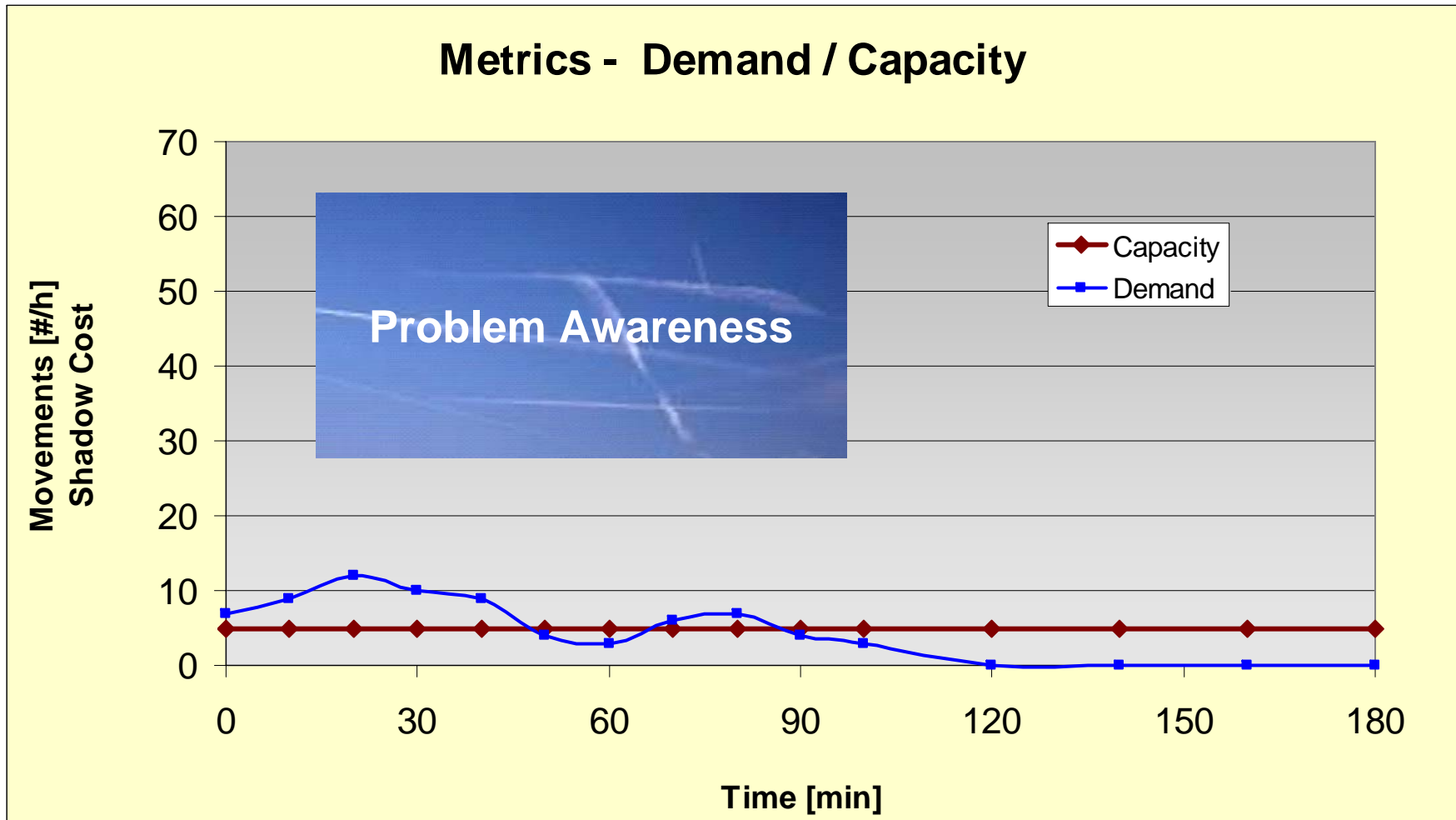
are considered as a factor in the cost function



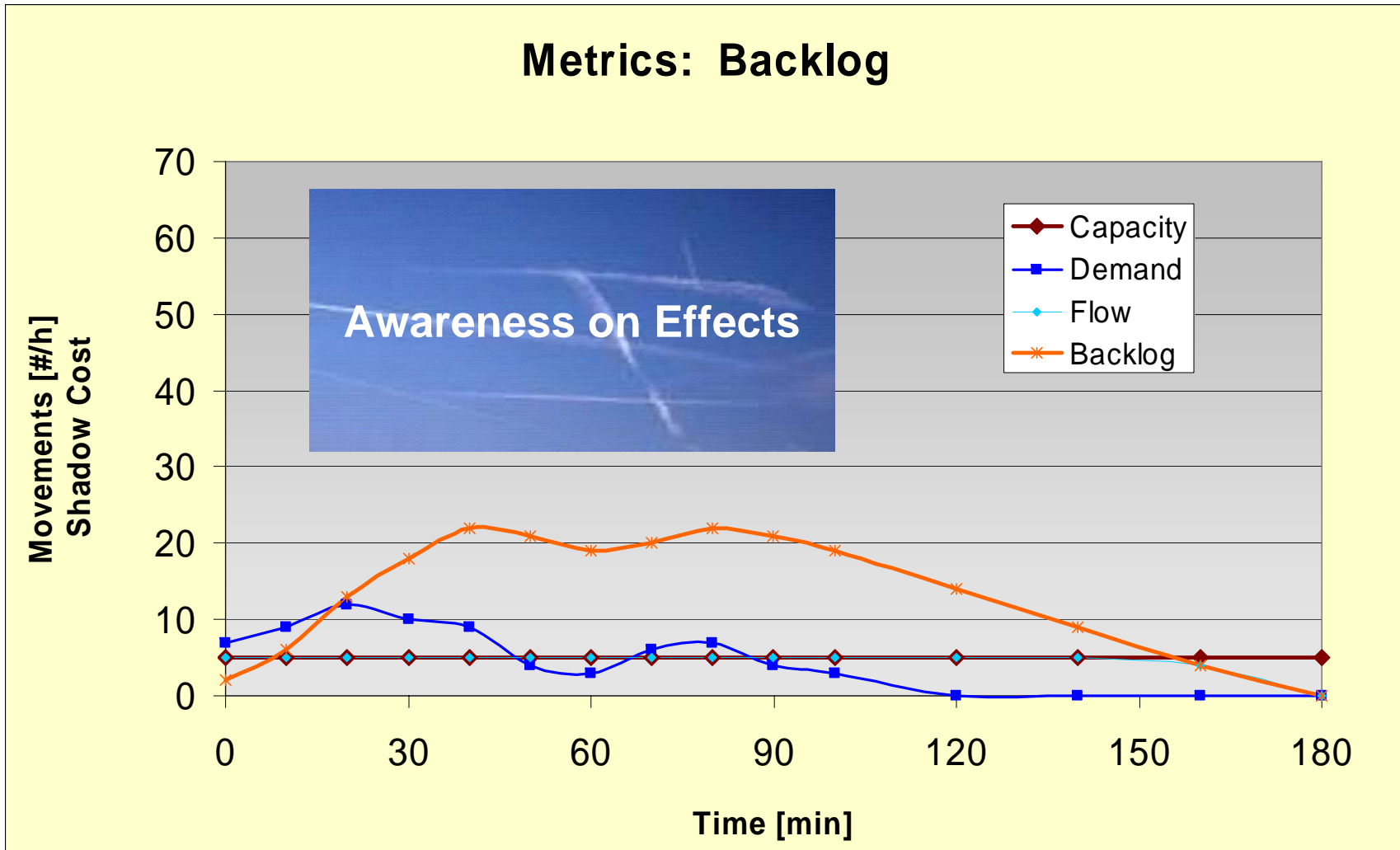
CLOU – Metrics



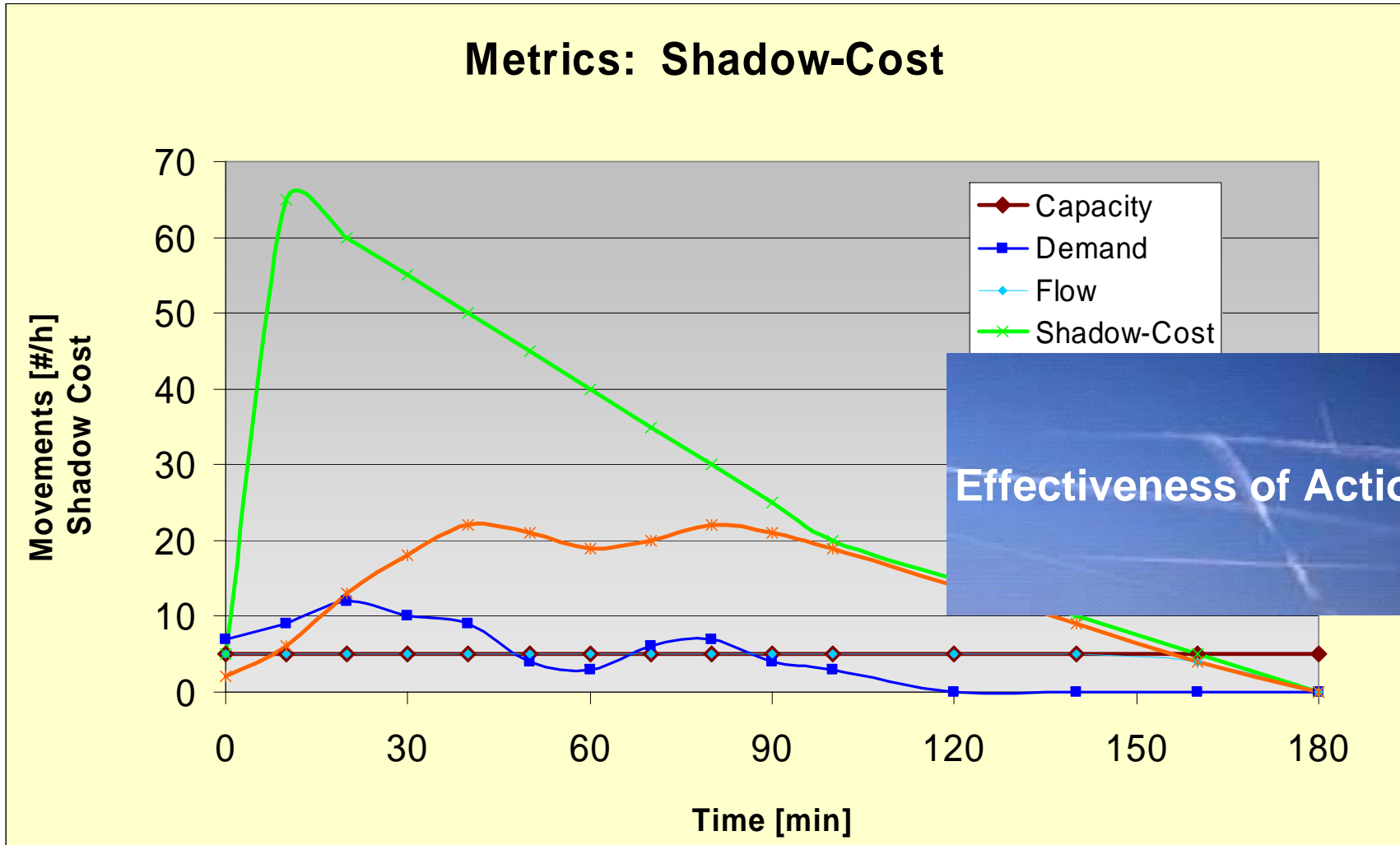
Metrics – Demand and Capacity



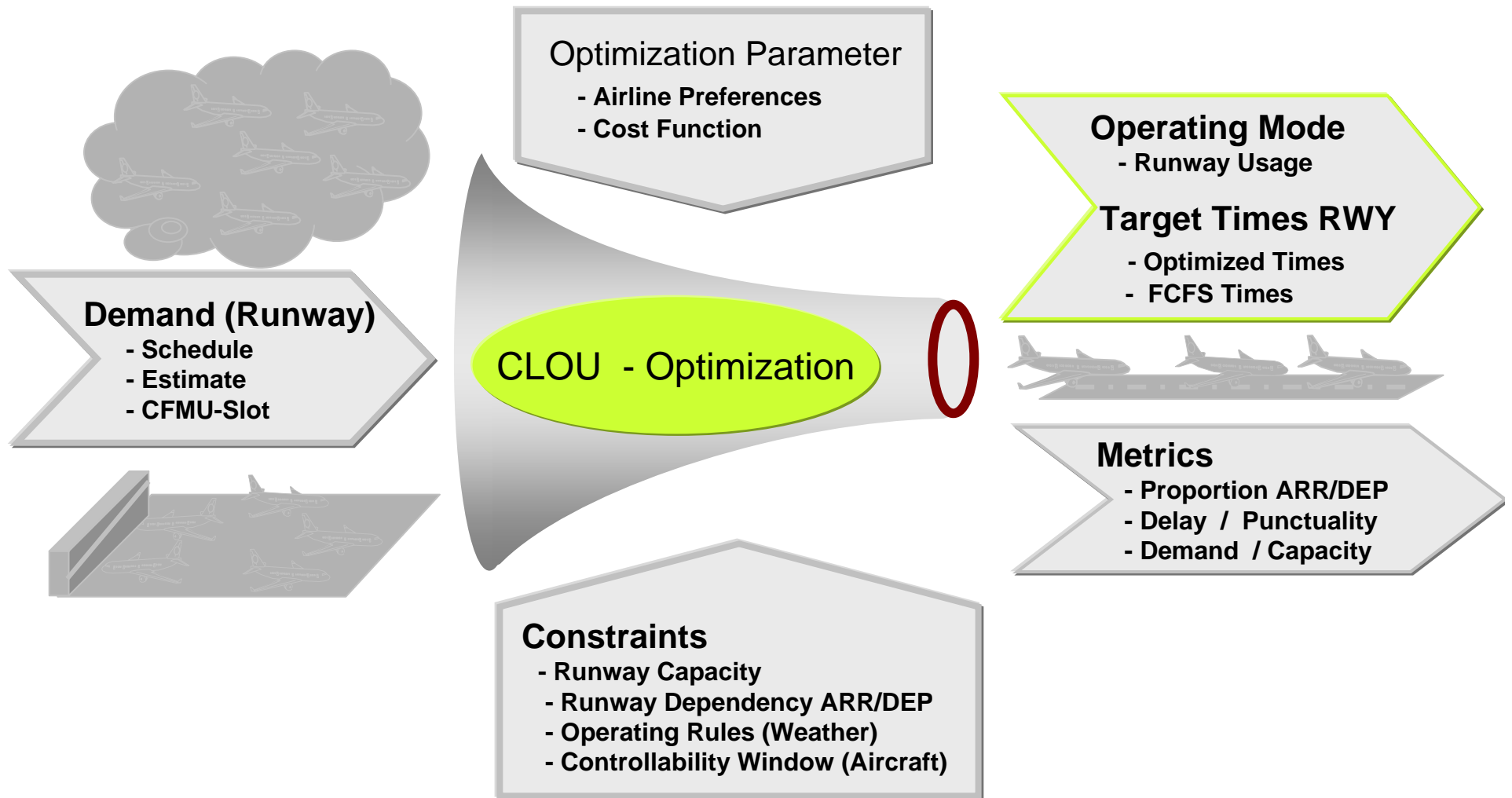
Metrics - Backlog



Metrics – Shadow Cost



CLOU – Optimisation Levels



CLOU – Optimization Levels

CLOU
Reference

Improving **Planning Quality** by
considering Aircraft and Airport constraints
Using today working methods
(First Come First Serve, Prioritization of Arrivals)

Short
Term

CLOU
Flow Optimized

Improving **Usage of Capacity** by
anticipatory usage of runway operating mode while
applying First Come First Serve

Medium
Term

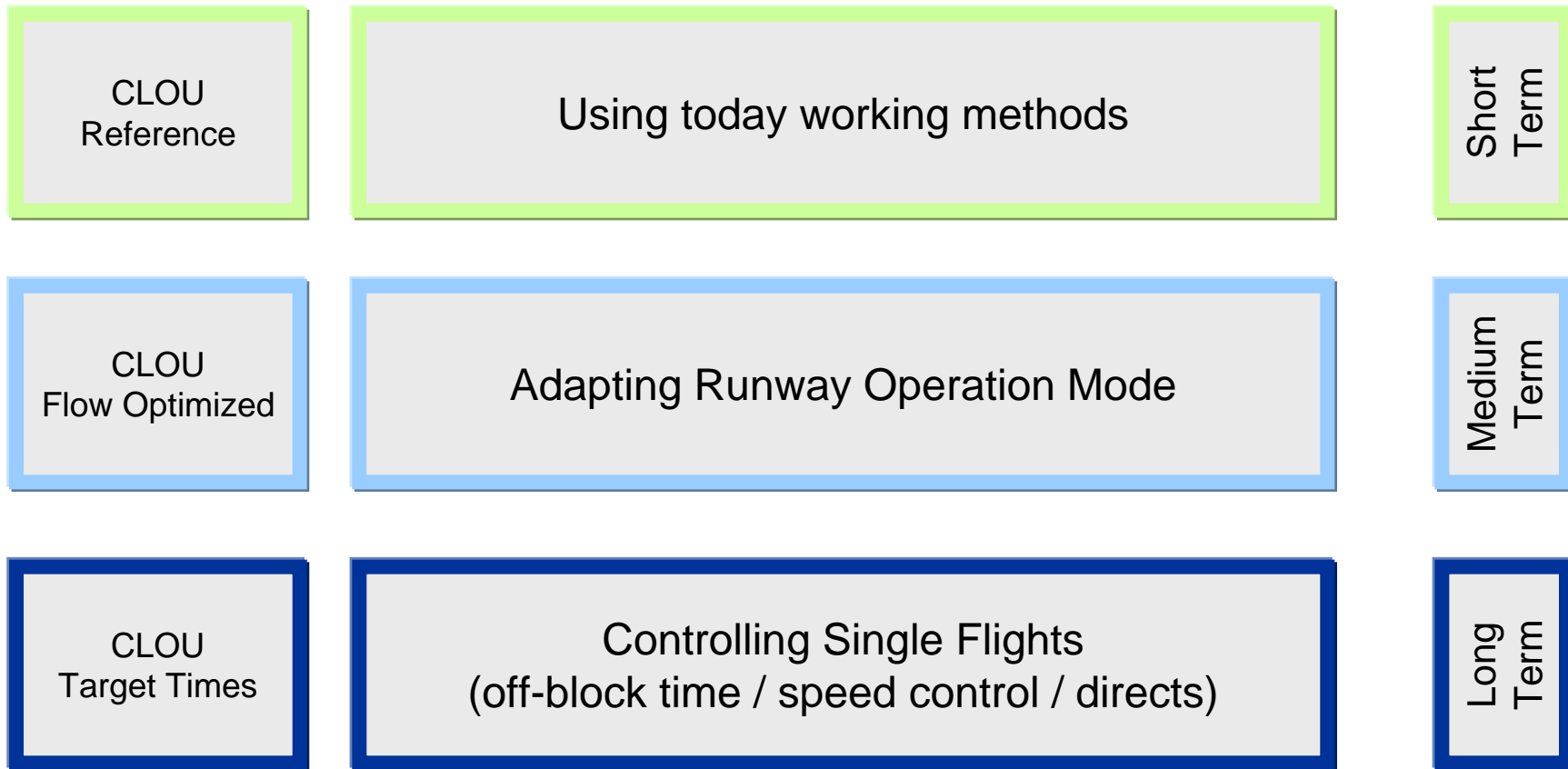
CLOU
Target Times

Improving **Punctuality** and **Flexibility** by
anticipatory usage of runway operating mode and
controlling aircraft according to Target Times

Long
Term

All improvements are realized in bottleneck situations
(Demand is bigger than available Capacity)

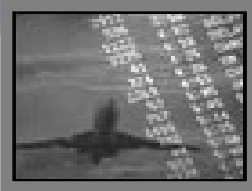
CLOU – Optimization Levels



CLOU – Target Times

Co-ordinated
Updated Target

Target

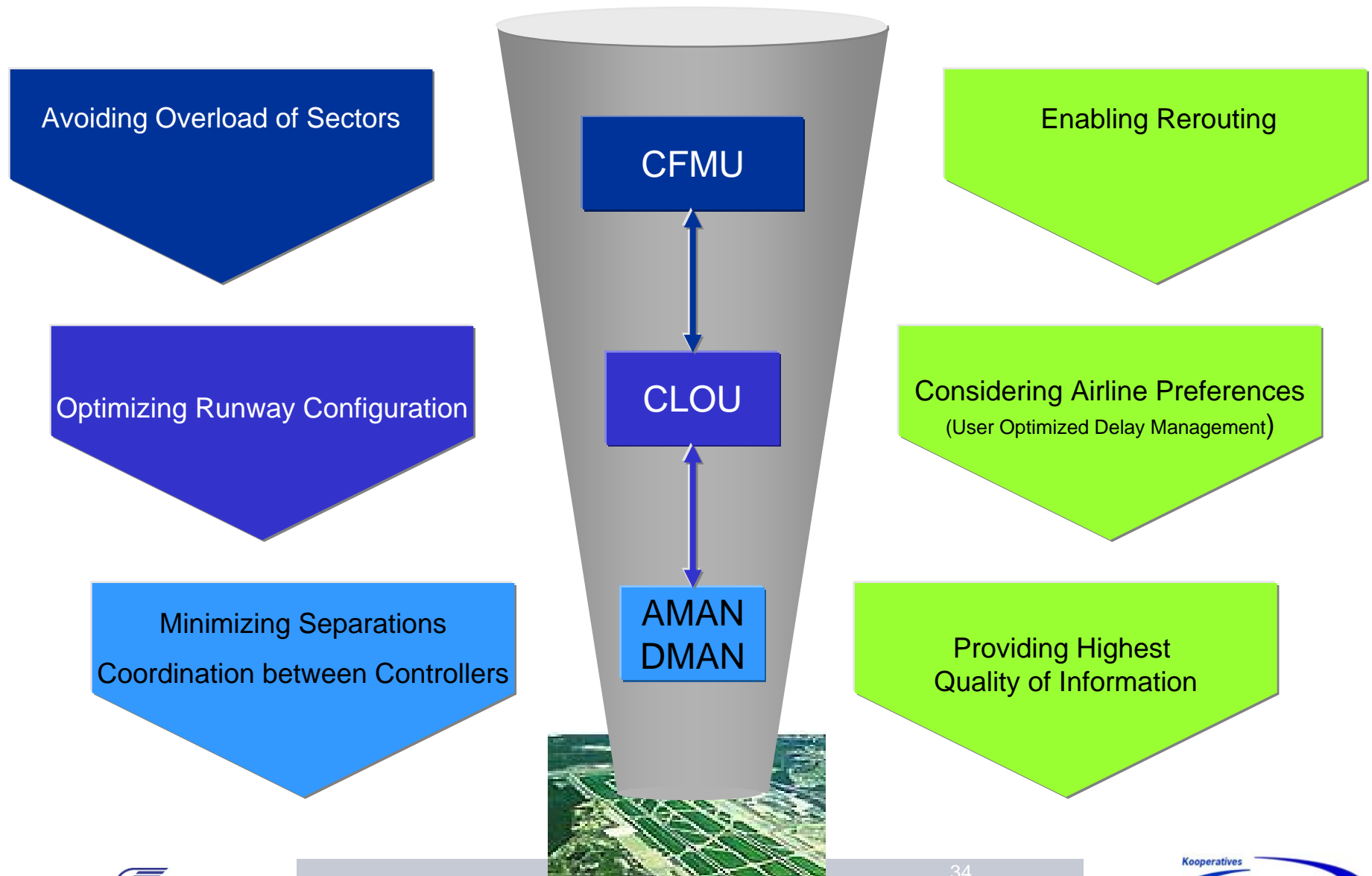


To work
accordingly

Target Times have to be

- up to date
- commonly agreed on
(by cost function)
- commonly implemented
(by controllers and pilots)

Summary - Balancing Demand and Capacity



Summary

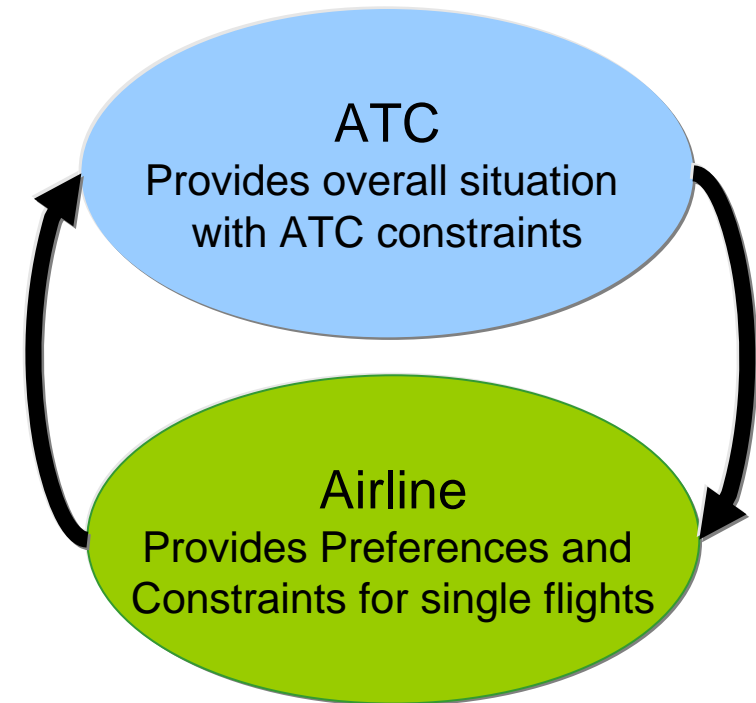
○ Summary

■ Balancing Demand and Capacity

- is an ATC task with high potential for Airlines
- has to be done on different Levels
- has to consider Airline, Airport and ATC objectives

○ Status CLOU Development

- Prototype is realized for Frankfurt airport and tested with generic data
- Benefit-Evaluation with live data is planned for second half of 2007
- Partners:



○ Backup

Discussion

○ Discussion points

- Are Airlines aware of Developments in ATM regarding AMAN/DMAN?
Are Airlines using the information already available?
 - AMAN (4D-Planer from DFS)
 - DMAN (darts from delair)
- Are Airlines providing best available information to ATM?
 - (If not so, what are the reasons)
- What decisions want Airlines take in severe traffic disruptions on an Airport?
 - How can flexibility be improved while maintaining high predictability?

K-ATM - Kooperatives Air Traffic Management

■ Framework: 3rd National Aeronautical Research Programm

■ Sponsoring: Ministry of Economics and Technology

■ Duration: 09/2003 till 12/2007

■ Partner:

➤ Projekt Co-ordination:

➤ Service Provider:

➤ Industry:

➤ Research:

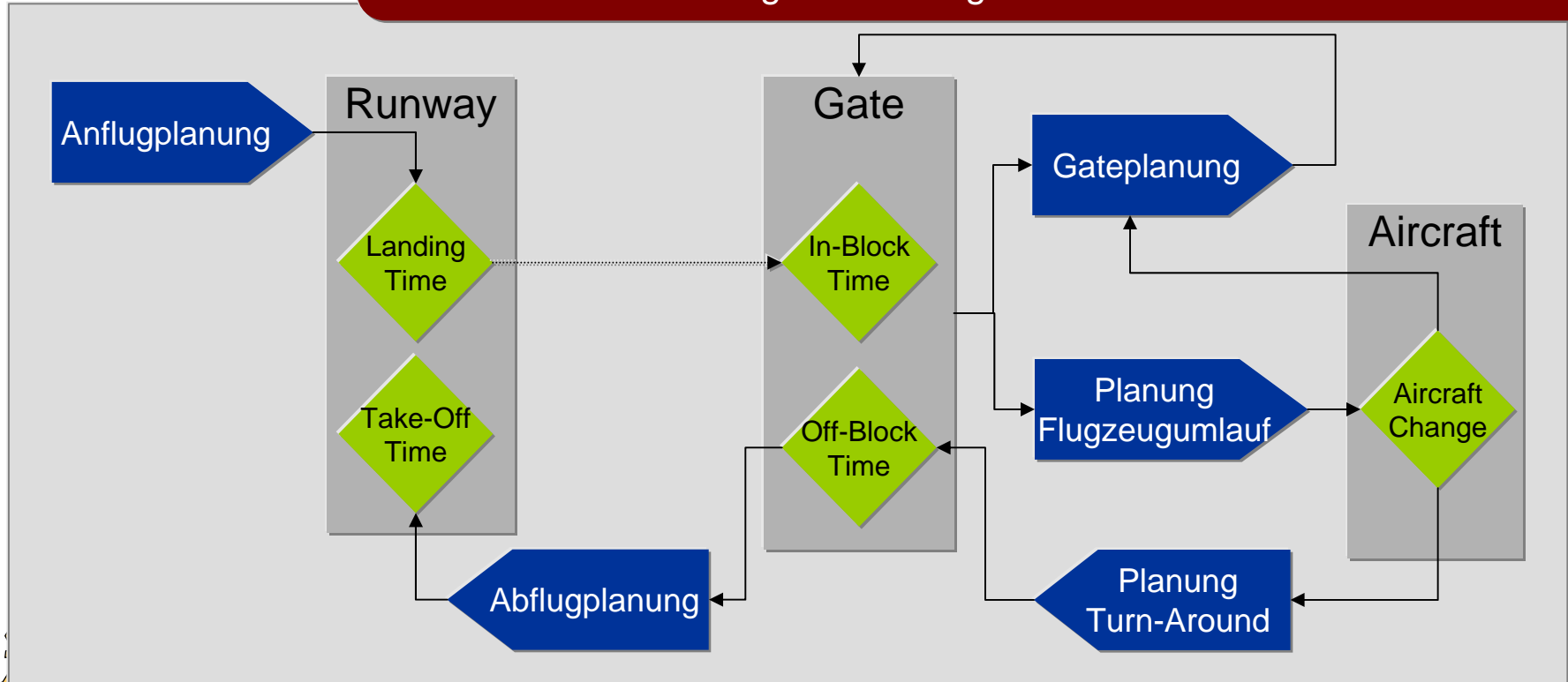


Co-operative AMAN/DMAN

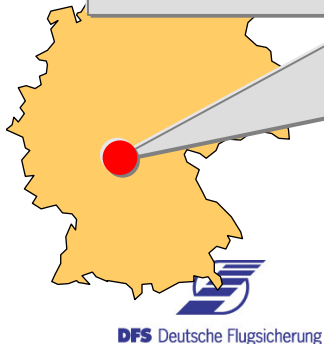
- **Objective of co-operative AMAN / DMAN**
 - Increased throughput at the existing runway system
 - Increased capacity
 - Improved punctuality
- **Solution**
 - Improved use of the existing runway capacity
 - by co-ordination of arrivals and departures by an early adaptation of inbound and outbound priorities
 - by minimizing gaps in the sequence
- **Objective of trials**
 - Proof of concept in real time simulations with controllers
 - Verification of the project objectives (commercial viability)

Extreme Verknüpfung der Prozesse am Flughafen

Prozesse der Partner am Flughafen sind extrem miteinander verknüpft. Die Wechselwirkung findet statt zwischen den Prozessen und über die von In- und Outbound gemeinsam genutzten Ressourcen.



Optimierung der einzelnen Ressourcen ist weitgehend ausgeschöpft. Weitere Optimierung muss durch Gesamtbetrachtung erfolgen.



CLOU - Metrics

- Today:
 - (Rough) Problem Identification
 - Gap between Demand /Capacity (Based on airport values)

- Detailed Problem Identification
 - Gap between Demand / Capacity (Based on Runway values)
 - Considering Dependency between Arrivals and Departures

- Identification of Effects resulting of Disruptions
 - Delay
 - Punctuality

- Controlling Traffic
 - Applying optimized Runway operating mode
 - Aircraft according to Target Times

