NATIONAL CENTER OF EXCELLENCE FOR
NEXTOR
AVIATION OPERATIONS RESEARCH

Improving System Performance Through Collaborative Decision Making (CDM)

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Highlights: CDM for Traffic Flow Management in the US

- Conceived in 1993 within FAA Airline Data Exchange (FADE) experiments.
- Initially efforts concentrated on Ground Delay Program Enhancement (GDP-E)
- Prototype Operations: January 1998 for GDP planning at SFO, EWR
- All US airports: September 1998
- Application in other areas, e.g. collaborative routing, is on-going
- Broad participation: FAA; air carriers; Metron; Volpe; Mitre, NEXTOR and other members of R&D community

CDM Concepts and Features

- **Philosophical components**:
  - improved information and common situational awareness
  - distributed control and decision making:
    - Decision made by most appropriate party
    - Economic tradeoffs made by airlines/users
  - strong and continuous interaction among airspace system managers and airspace system users
    - FAA—airlines
    - airline—airline; peer pressure
- **Technical accomplishments:**
  - new fair allocation principles
  - shared decision support tool (FSM)
  - shared communications network (CDMnet)
- **Reliance on data analysis and objective critique**

Ground Delay Program (GDP)

- Traffic Flow Management initiative instituted by Air Traffic Control System Command Center (ATCSCC) when arrival capacity for an airport is reduced usually due to poor weather.
- Flights destined for afflicted airport are given ground delays so that the arrival rate of flight matches arrival capacity.
- Planning problem: assignment of arrival time slots to flights.
- CDM resource allocation process:
  - **ration-by-schedule:** assigns slots to flights based on flight positions in OAG schedule
  - **cancellations and substitutions:** each airline reassigns flights to the slots it "owns"
  - **compression:** overall schedule is compressed in manner which provides benefit to each airline that has given up a free slot

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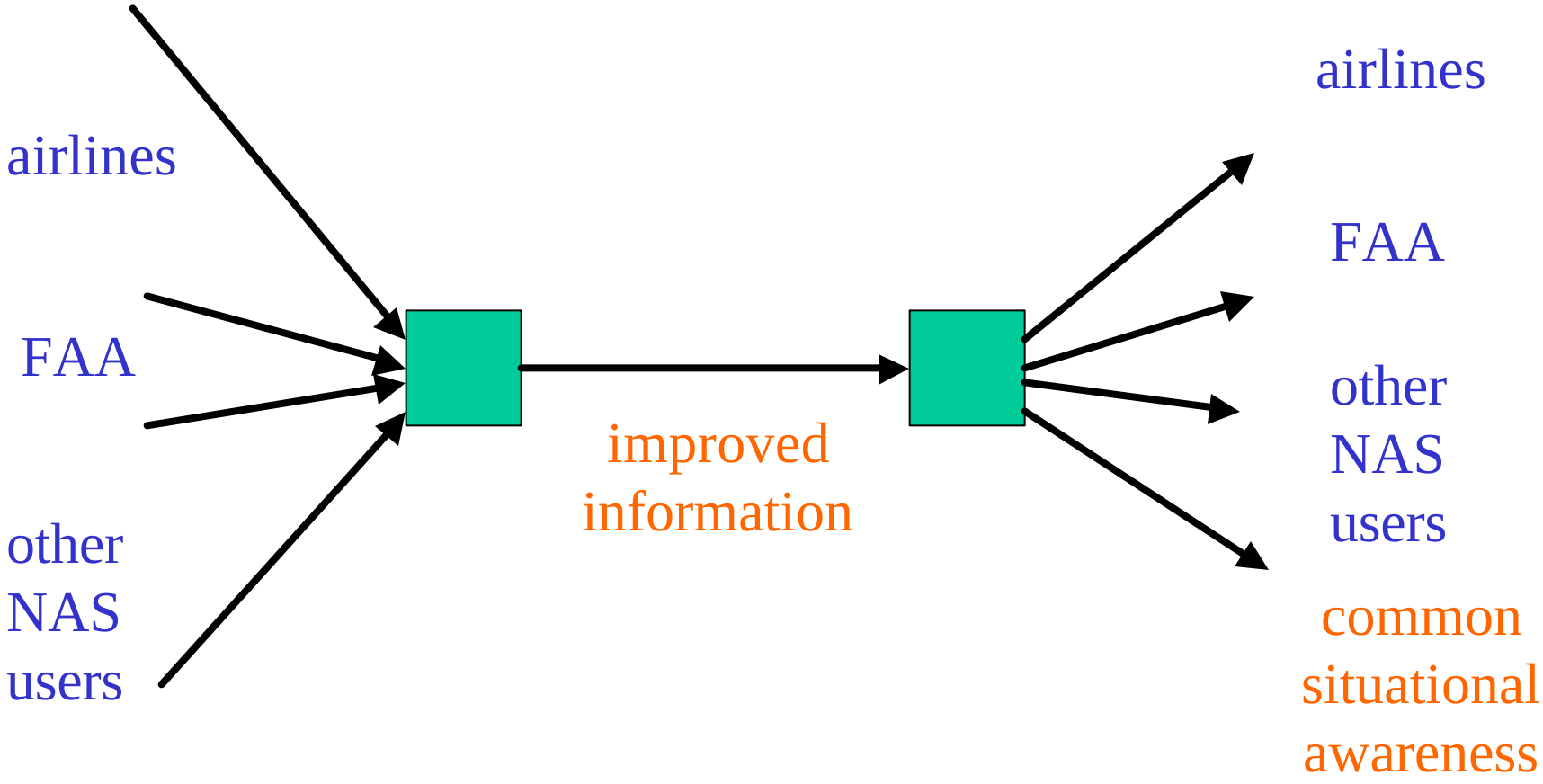
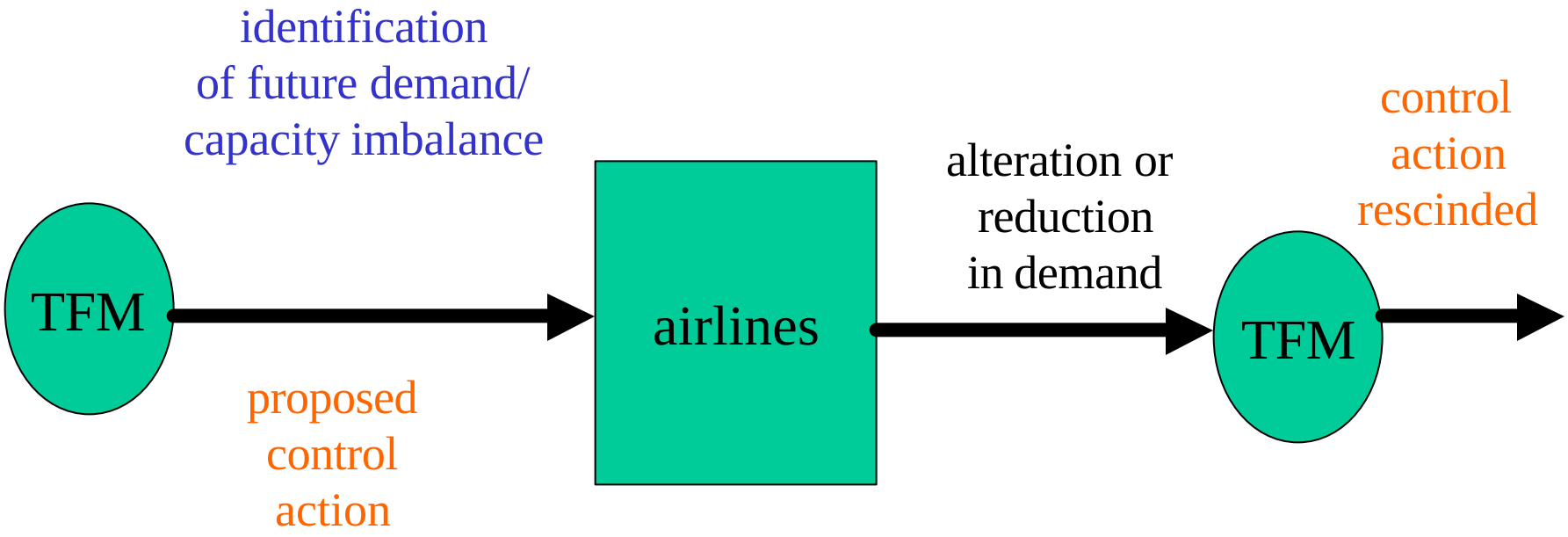
Models of CDM Impact on Resource Allocation and Decision Making

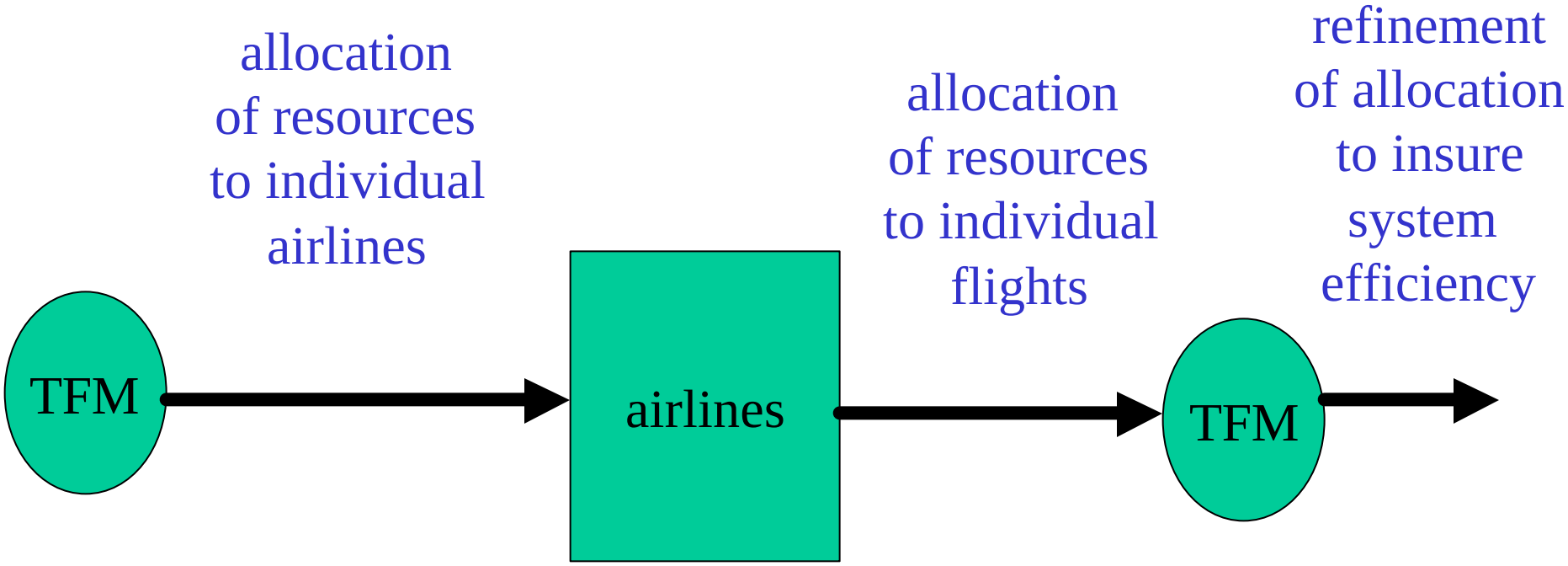
Improved Information and Common Situational Awareness



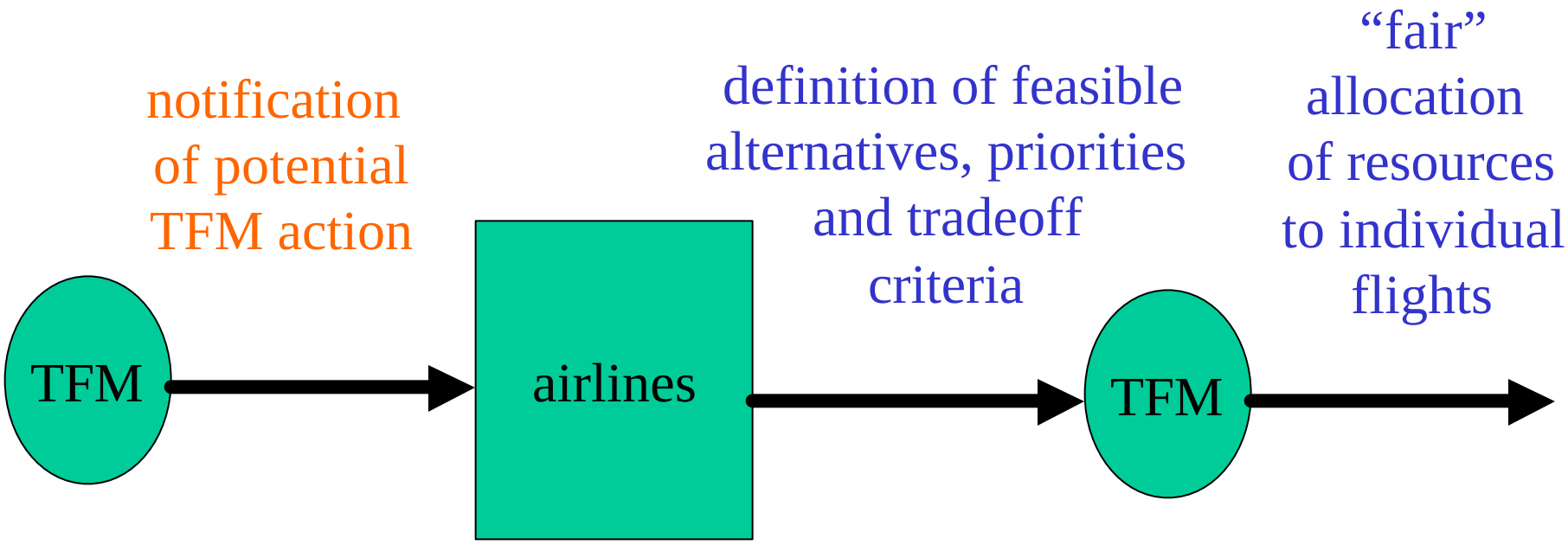
Users Solve Problem -- Control Action Unnecessary



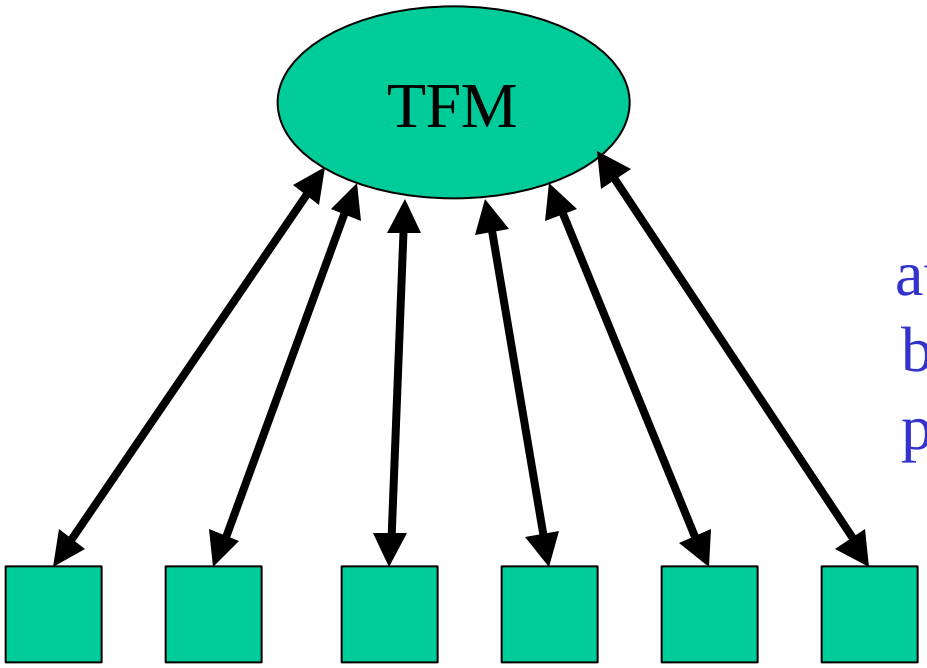
Two Level Resource Allocation



Fair Resource Allocation Consistent with Airline Priorities



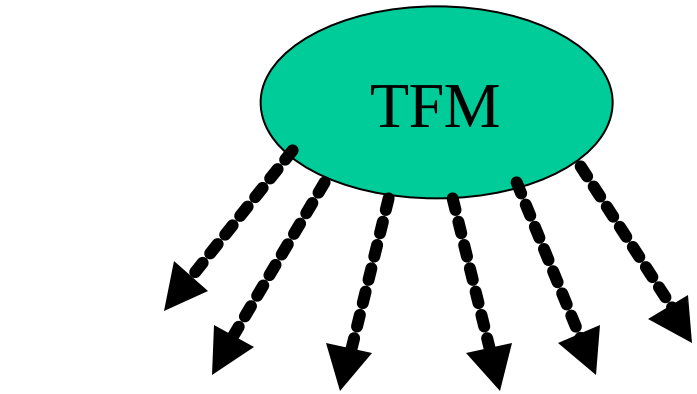
Auction/Bidding Process



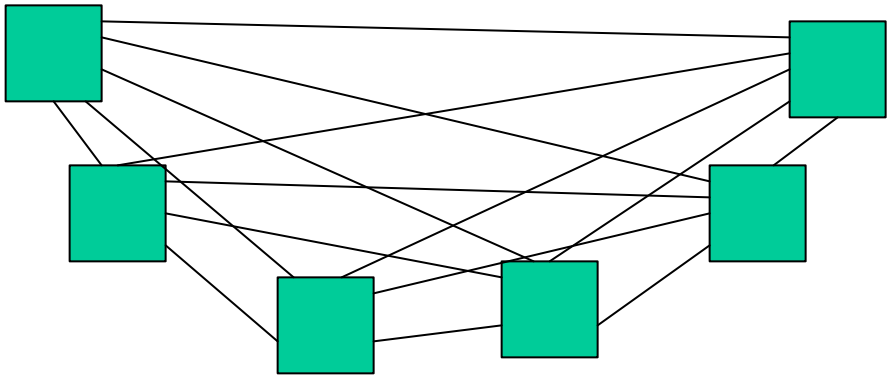
auction/
bidding
process

Airlines

Free Market/Trading Process



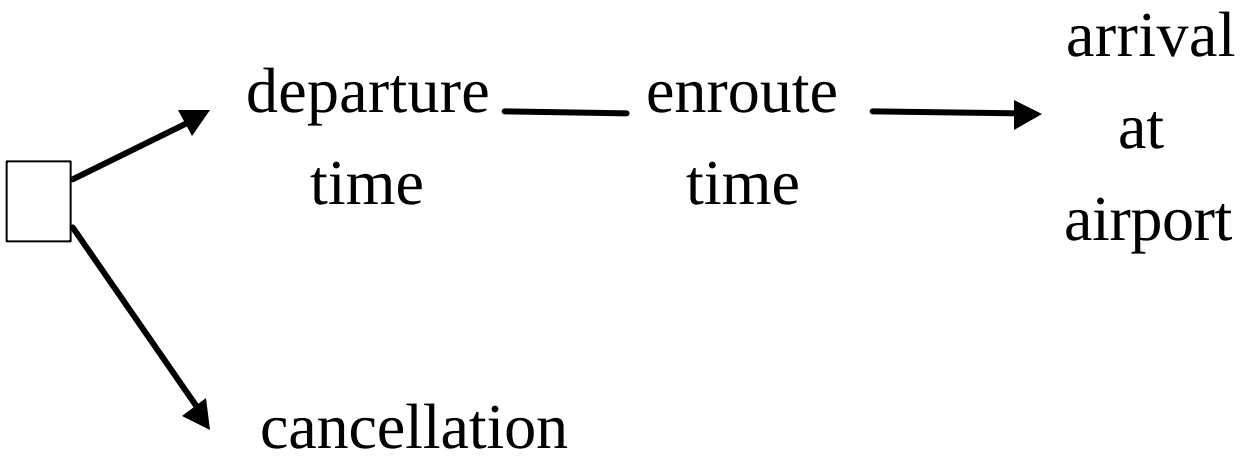
coordination



Airlines

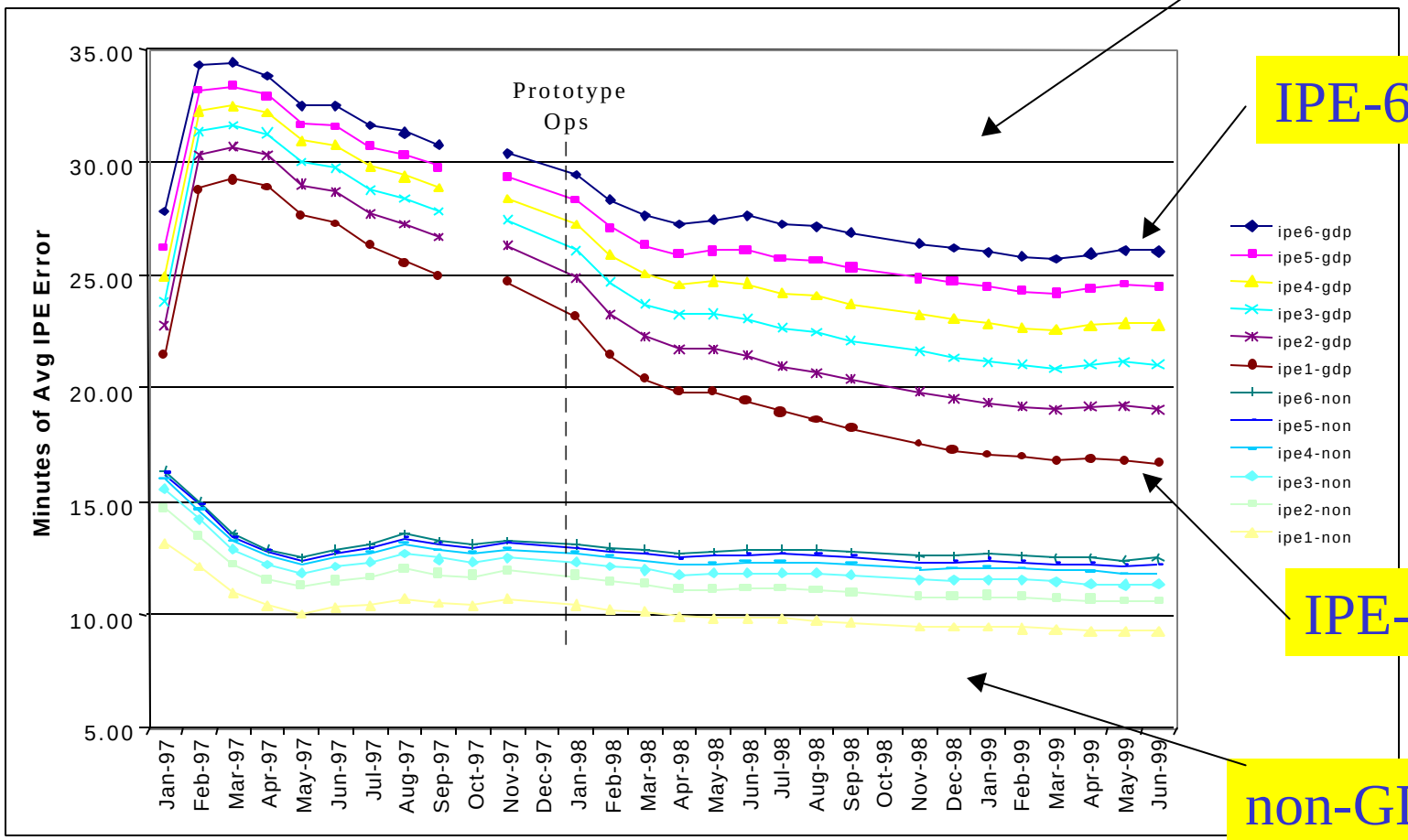
Improvements in Timeliness and Accuracy of Information

Accurate prediction of the arrival demand profile at an airport is essential to the calibration of a GDP.



- Cancellation notices
- Departure time predictions

Change in Accuracy of Departure Time Estimations: Integrated Predictor Error (IPE)



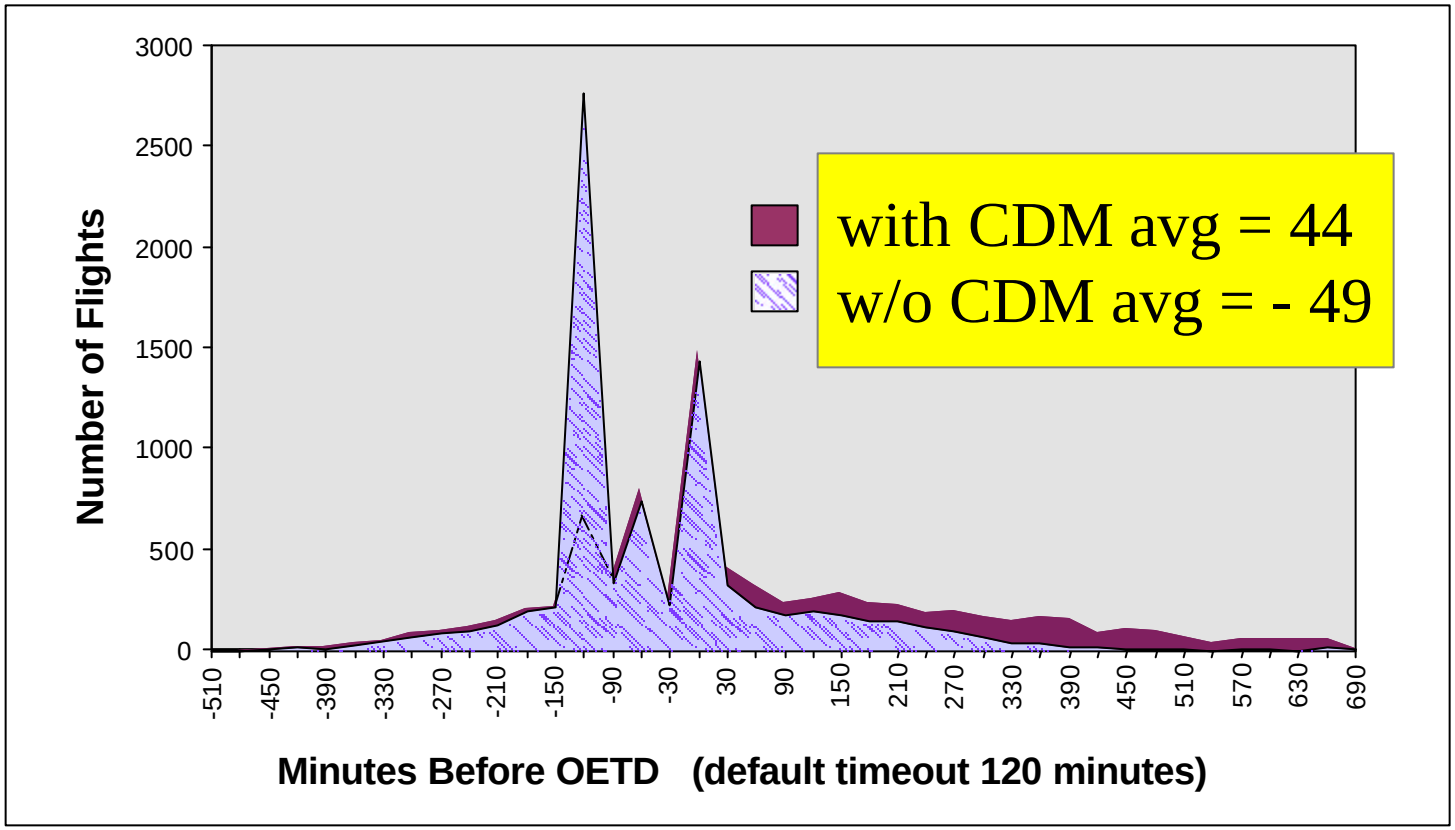
GDP days

IPE-6

IPE-1

non-GDP days

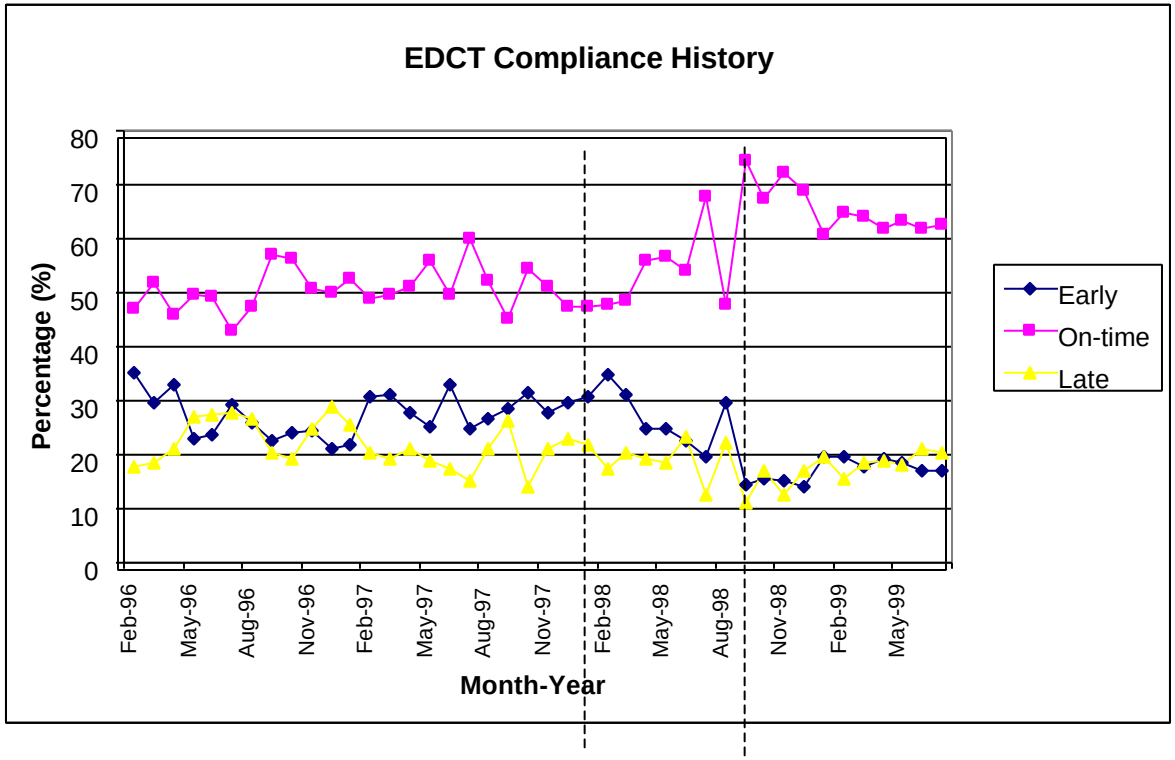
Shift in Distribution of Cancellation Notification Times



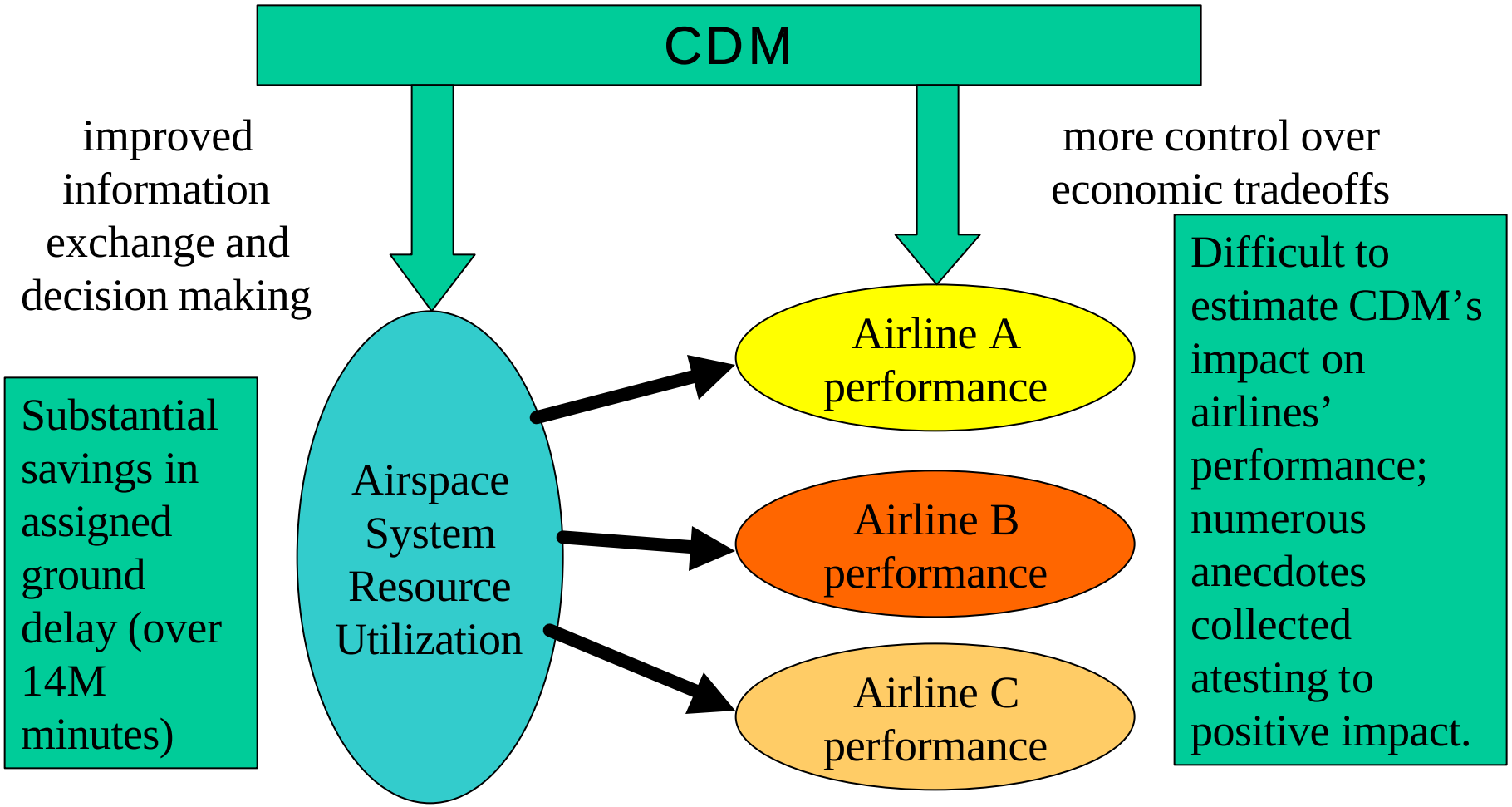
Notification time given in ***minutes before OETD***
(Original Estimated Time of Departure)
Airport = SFO

Positive Effect of "Group Dynamics"

EDCT compliance and overall information accuracy



Impact of CDM on System Performance



Overall Potential for CDM

Clearly CDM has had a positive impact -- to what extent can it be THE solution??

Current CDM is only a start:

- FAA and airline operational decision makers have to "learn" how to best take advantage of new technologies
- Operational problems, data quality issues, new system features, etc. are being addressed/debated at CDM meetings
- Major new systems and procedures are being designed

While CDM can only be viewed as a single component of the overall solution, it provides a context and philosophical approach appropriate for nearly all new systems and procedures.

Prospects for Future Performance Improvement: GDP-E

- Coordination of operational procedures with new decision support tool and information capabilities
- Keep the peer pressure on: improve quality of information
- More flexibility in use, planning and control of GDPs
- Integration of new weather products with decision support tools and operational procedures
- Arrival-Departure Capacity Coordination

Prospects for Future Performance Improvement: Collaborative Routing

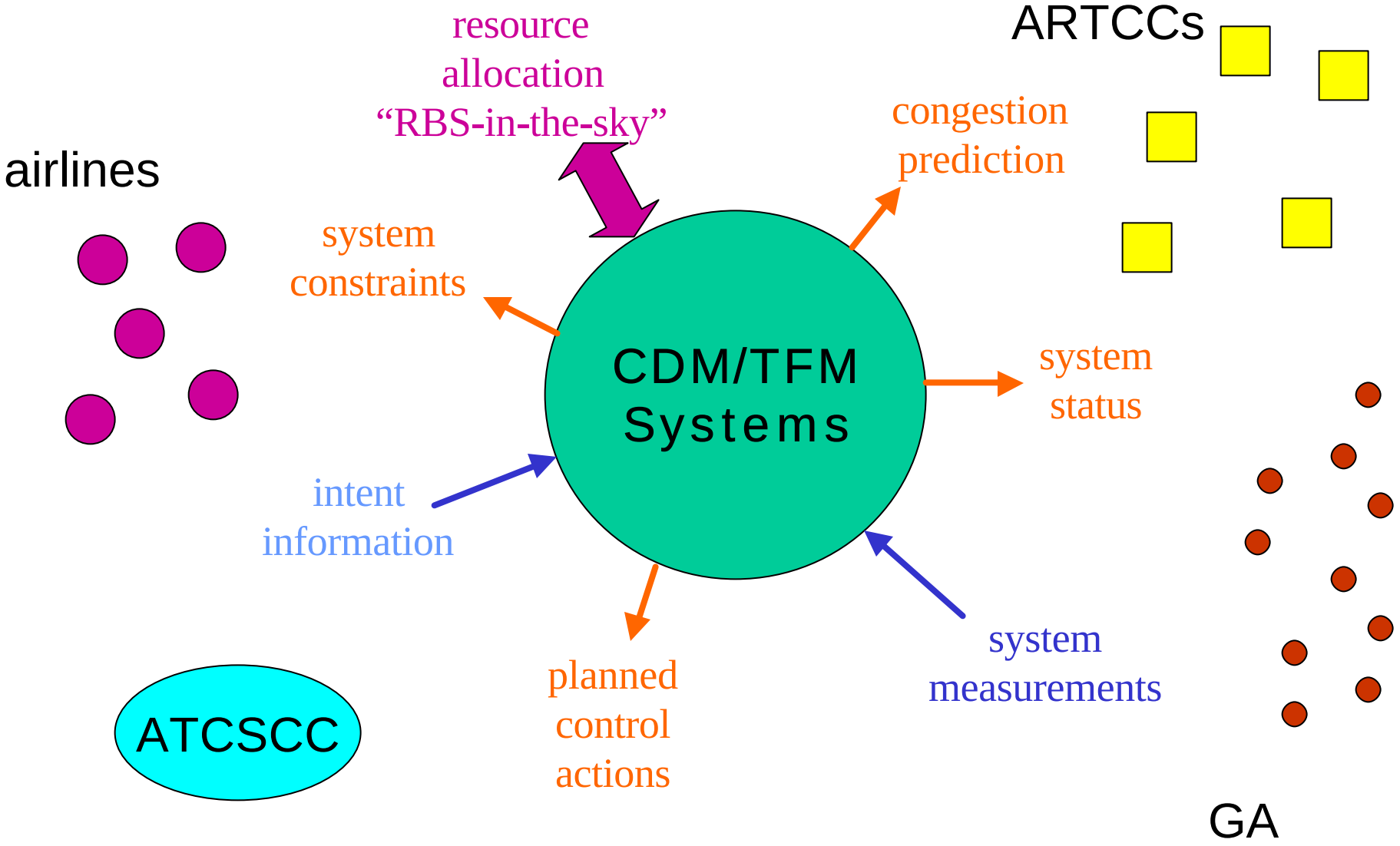
Challenges:

- Coordination of four entities: Air Traffic Control System Command Center (ATCSCC), Air Carriers, Air Route Traffic Control Centers (ARTCCs), General Aviation
- Need to take into account network-wide impact of local decisions
- Complex resource set/resource allocation mechanisms
- Need to tradeoff fair resource allocation and overall system utilization

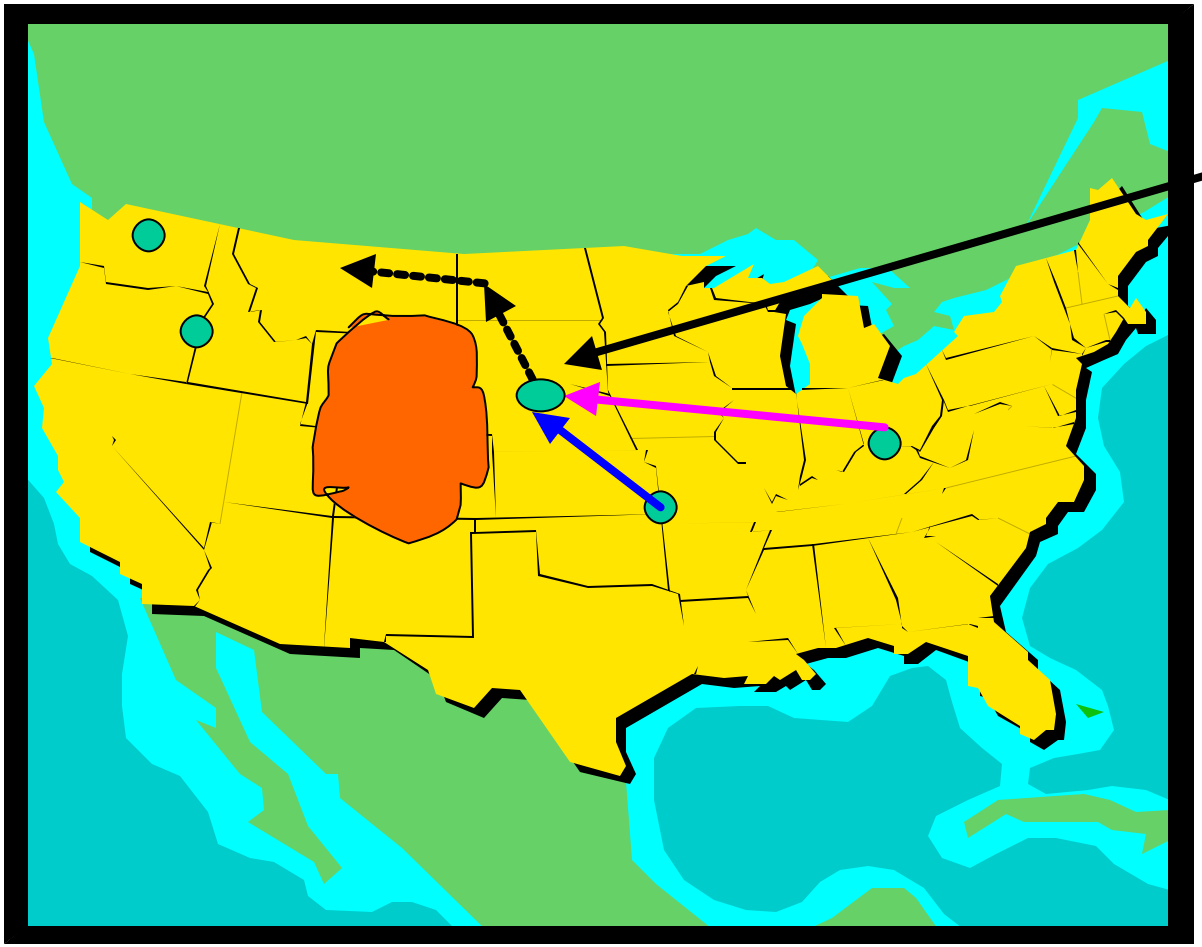
Collaborative Routing: Initial Steps

- National Playbook
- Strategic Planning Team
- CDR (Coded Departure Routes)
- LAADR (Low Altitude Arrival and Departure Routes)
- CCFP (Collaborative Convective Forecast Product)
- GDP in support of SWAP (Severe Weather Avoidance Program)
- CRCT and derived functionality, e.g. flow constrained areas
- Web based and CDM-Net based dissemination of NAS status information
- Sector Management Tool

Collaborative Routing: Vision



RBS in the Sky: allocation rule



Minimize the maximum delay: priority given to flight with largest accumulated delay

RBS in the SKY: priority transfer

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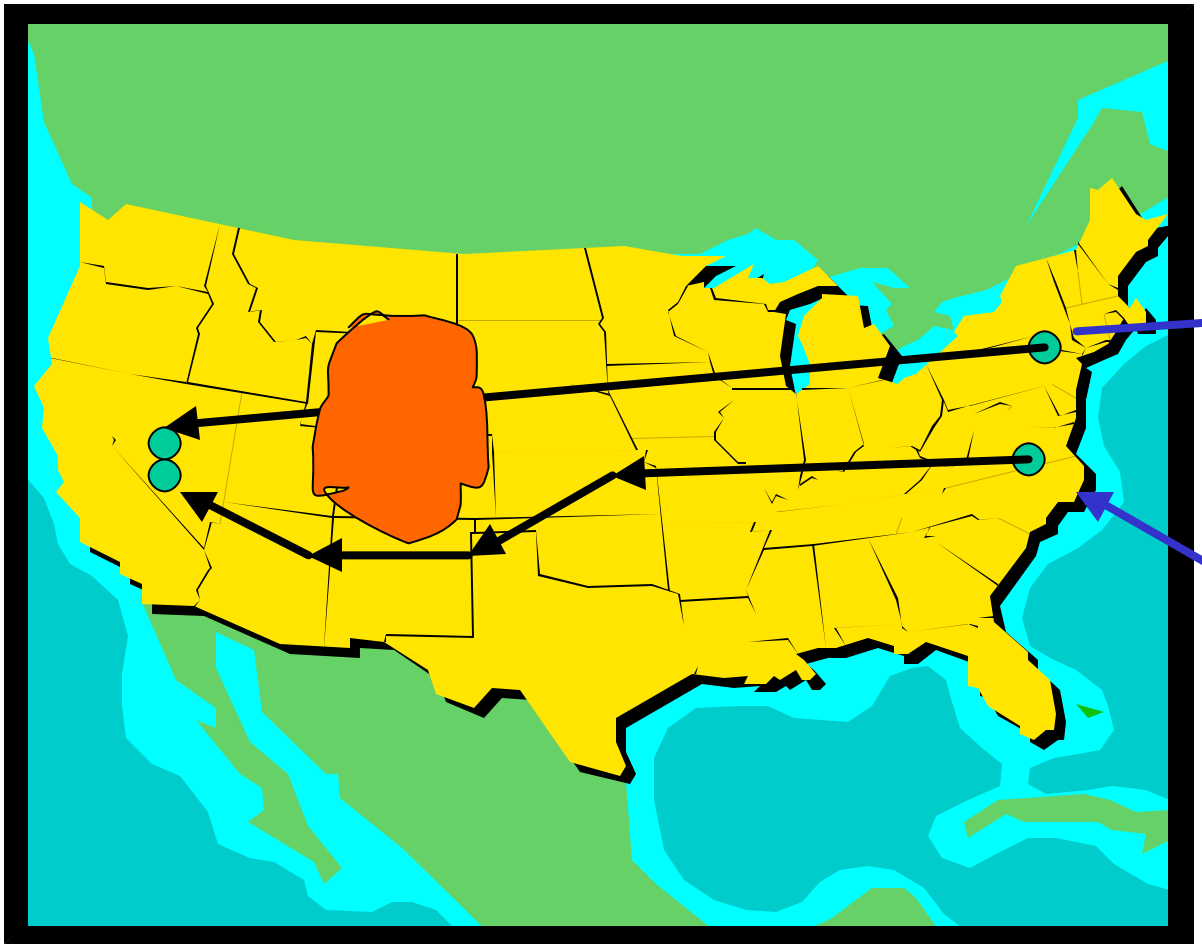
RBS (on-the-ground) effectively allocates slots to airlines who then have the freedom to assign any flight to a slot



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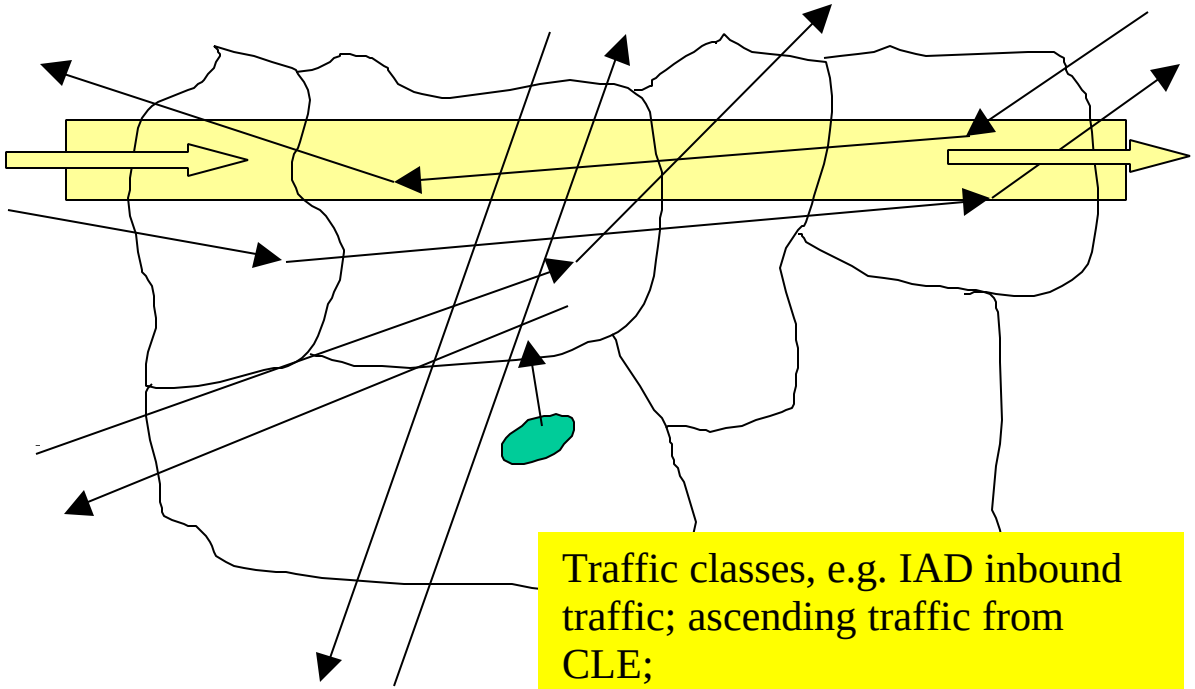
RBS in the Sky: balancing major flow categories



- Need to balance major flow categories
- Can be throughput/fairness tradeoff

Collaborative Routing:
characteristics of evolving solution

- Resource allocation criteria:
  - Minimize maximum delay
  - Transferability of priorities
  - Equity among traffic flow categories
  - Reward timely and accurate information provision
- Continuous control process
- Real-time distributed database
- Appropriate distribution of decision making responsibility among ATCSCC, ARTCCs, users (airlines: AOCs/flight deck; GA)
- Enhanced airline flight planning
- Post-departure control coordination