

Modeling the Environmental Impact of Air Traffic Operations

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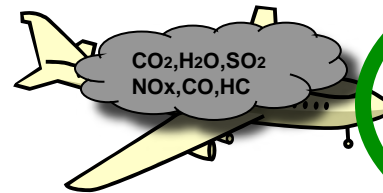
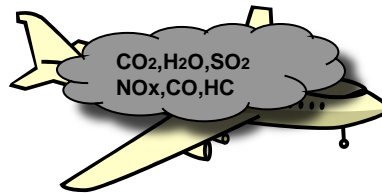
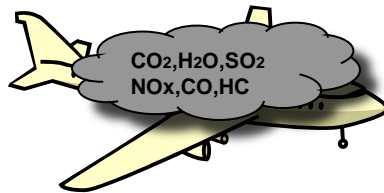
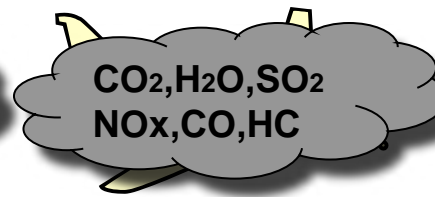
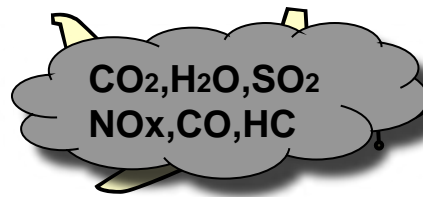
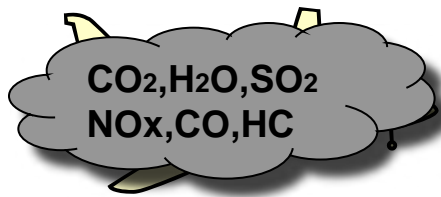
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Environmental Impact - Emissions

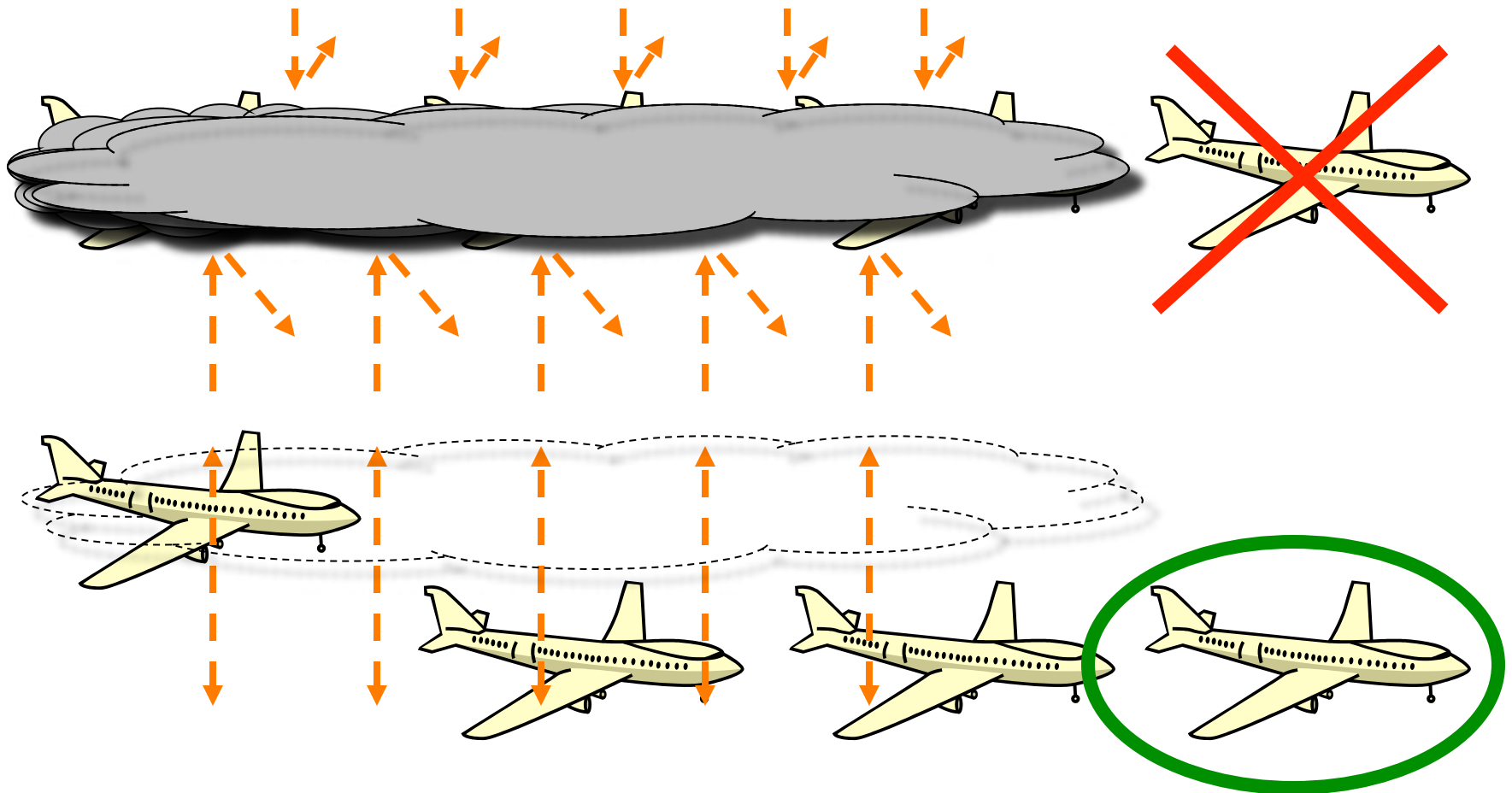
Aviation-induced environmental impacts include

- Direct emissions: CO_2 , Water vapor and other greenhouse gasses
- Indirect effects: NO_x affecting distributions of Ozone and Methane



Environmental Impact - Contrails

Aviation-induced environmental impacts also include effects associated with contrail formation



Contributions

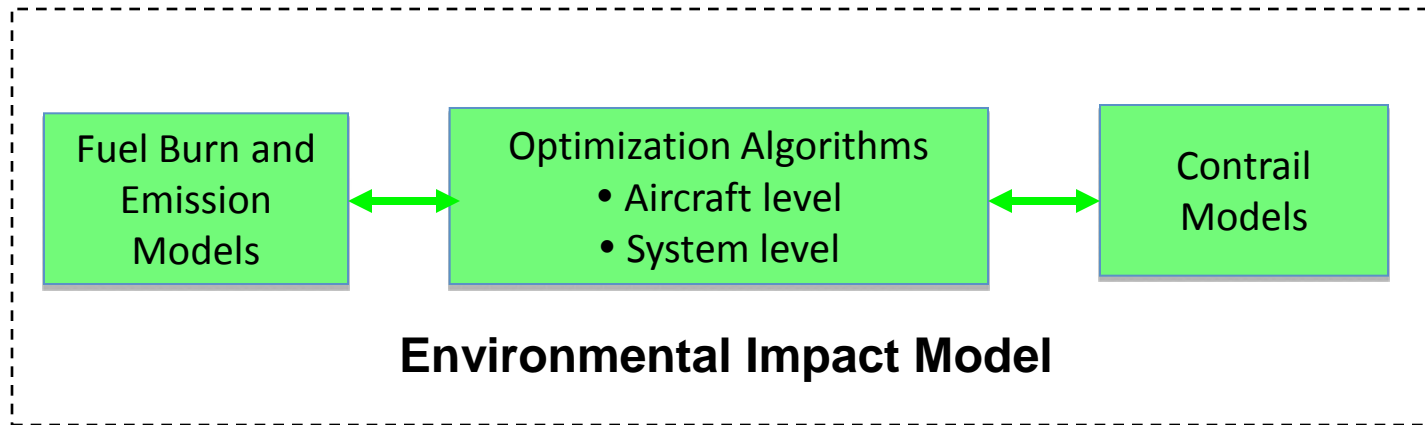
- Integrate environmental models to air traffic system models
- Enable trade-offs study among contrail formations and emissions
- Provide capability for evaluation of environmental policy based on scientific findings

Outline

- Environmental Impact Model
- Air Traffic System Model
- Integrated System
- Trade-off Study
- Conclusions

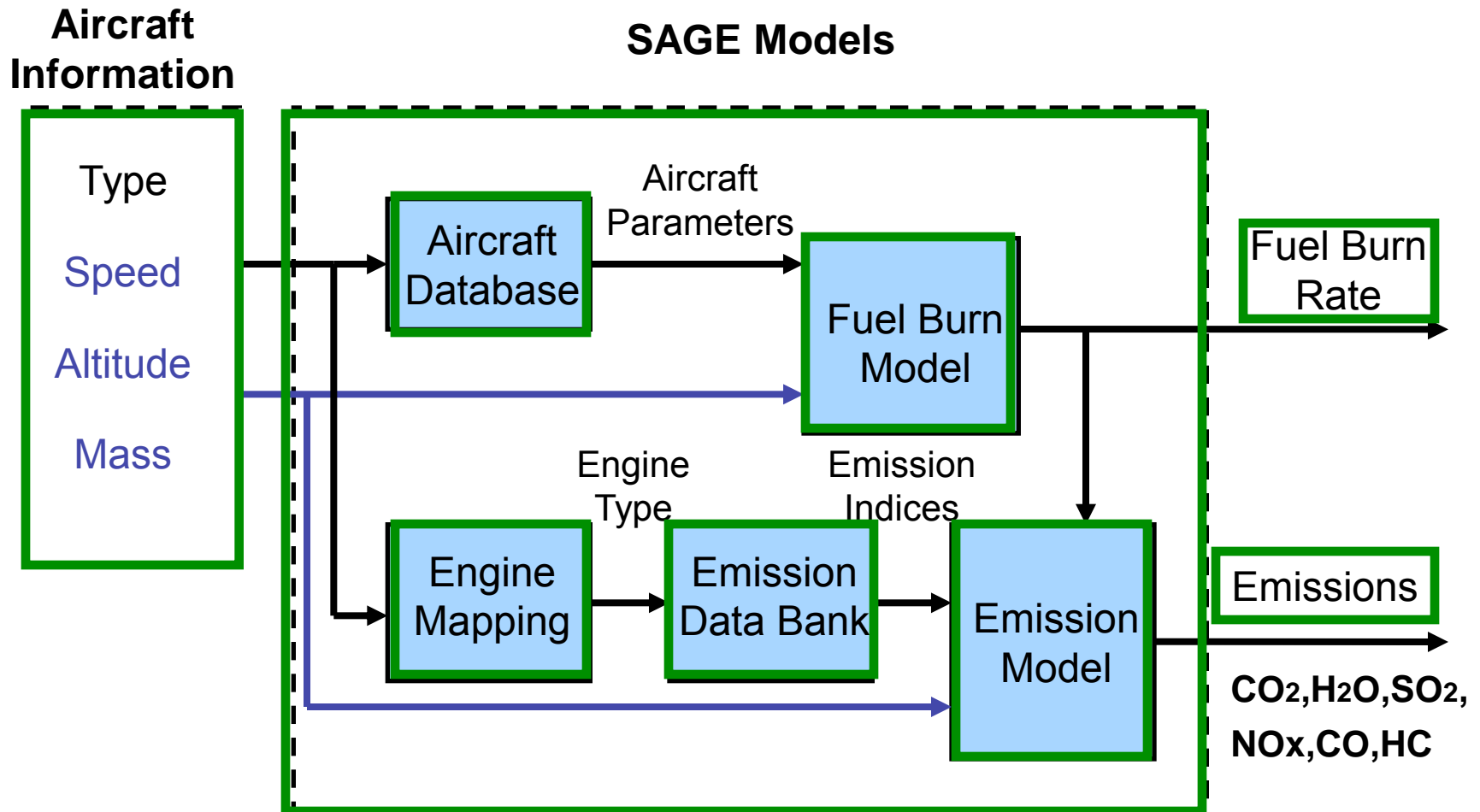


Environmental Impact Model



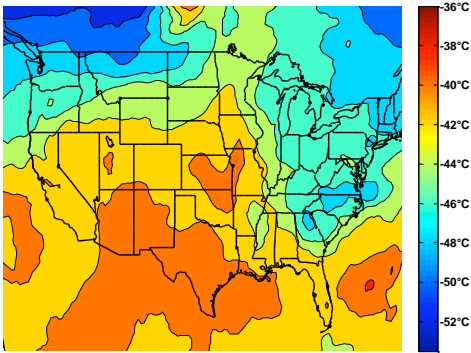
Fuel Burn and Emission Models

Use FAA's System for Accessing Aviation's Global Emissions (SAGE) Models

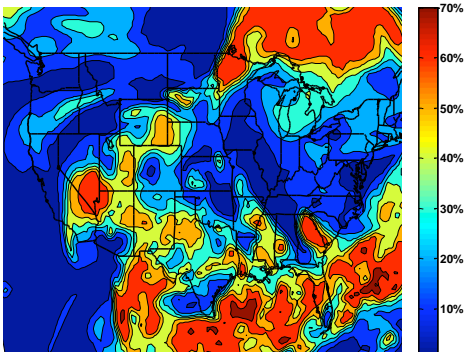


Contrail Models

Rapid Update Cycle
(RUC) Data

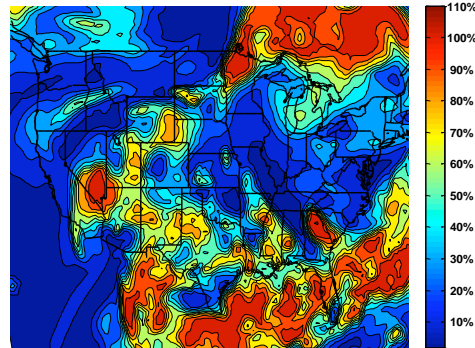


Relative Humidity with respect to water (RHw)

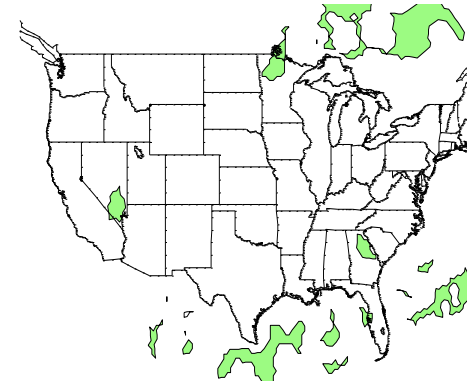


Temperature

$RH_w > \text{critical humidity}$
and
 $RH_i > 100\%$

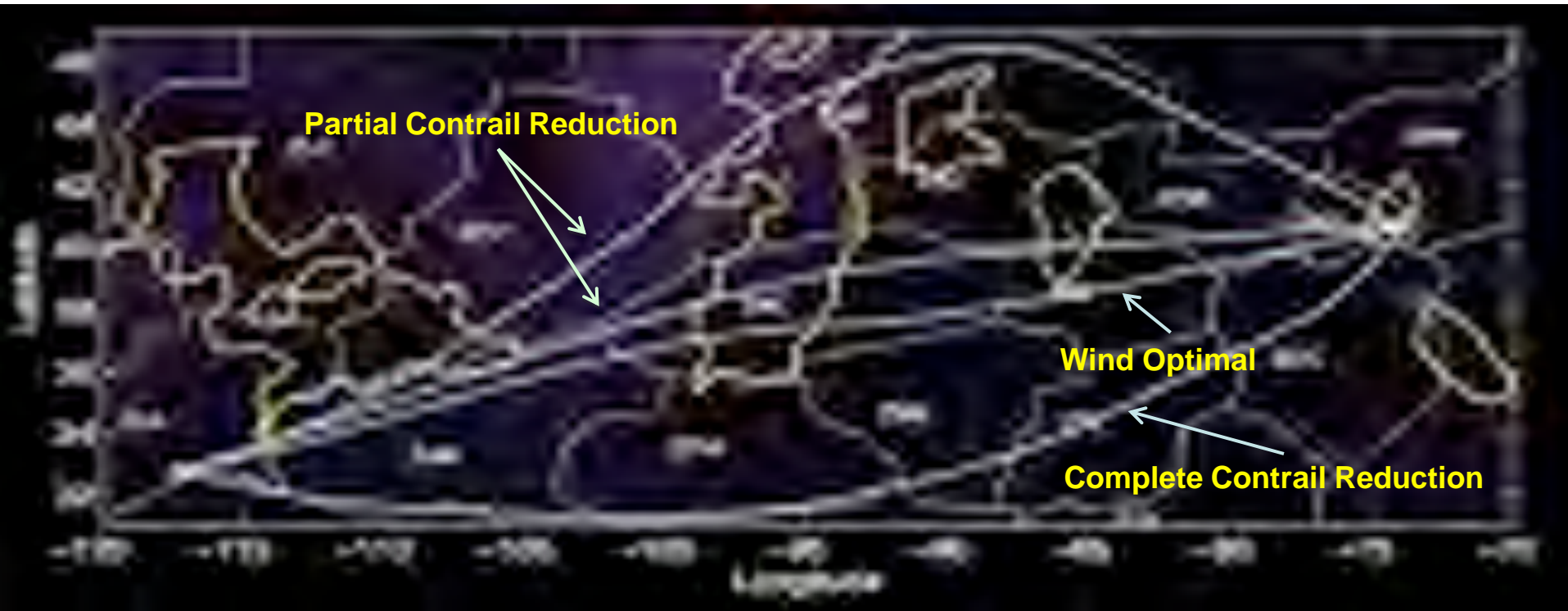


Relative Humidity with respect to ice (RHi)



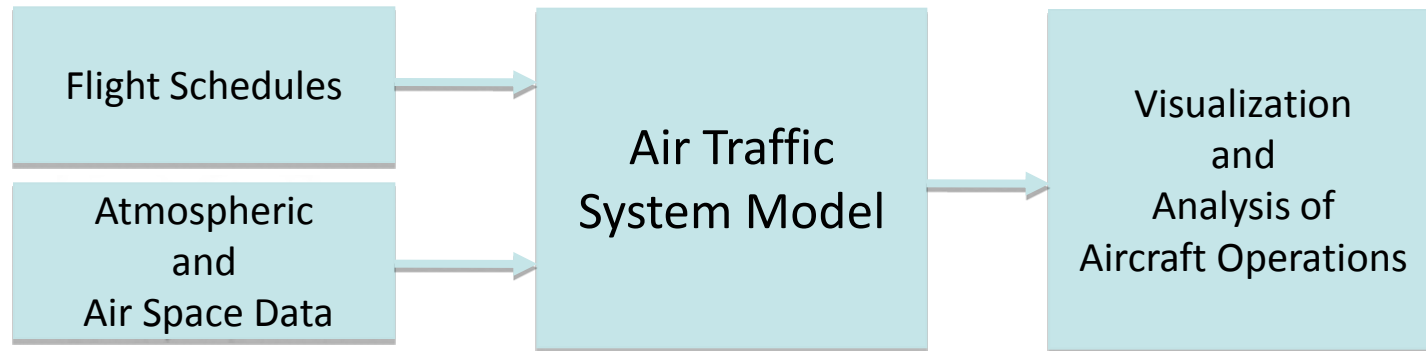
Contrail Favorable Regions

Optimization Algorithms

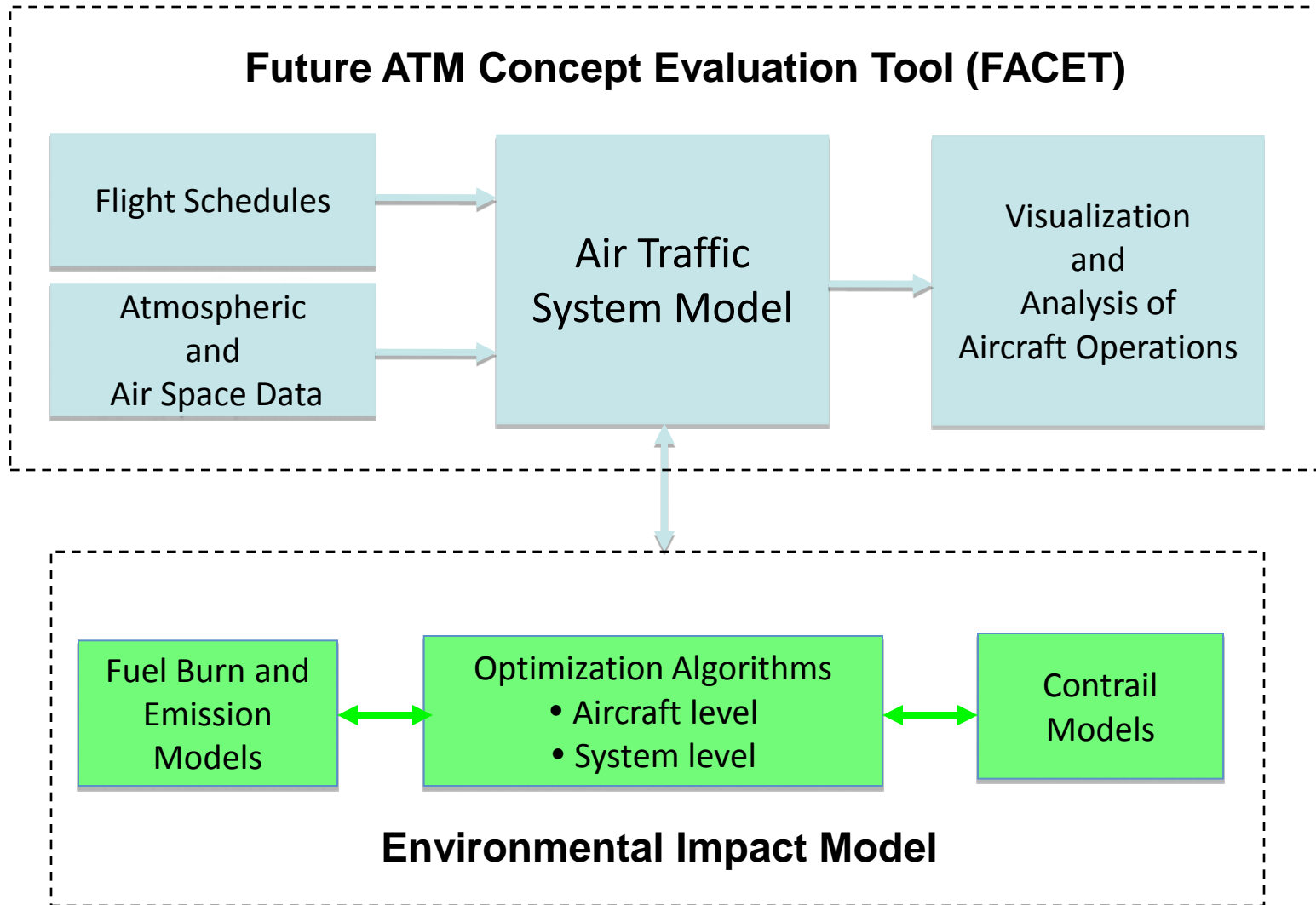


Air Traffic System Model

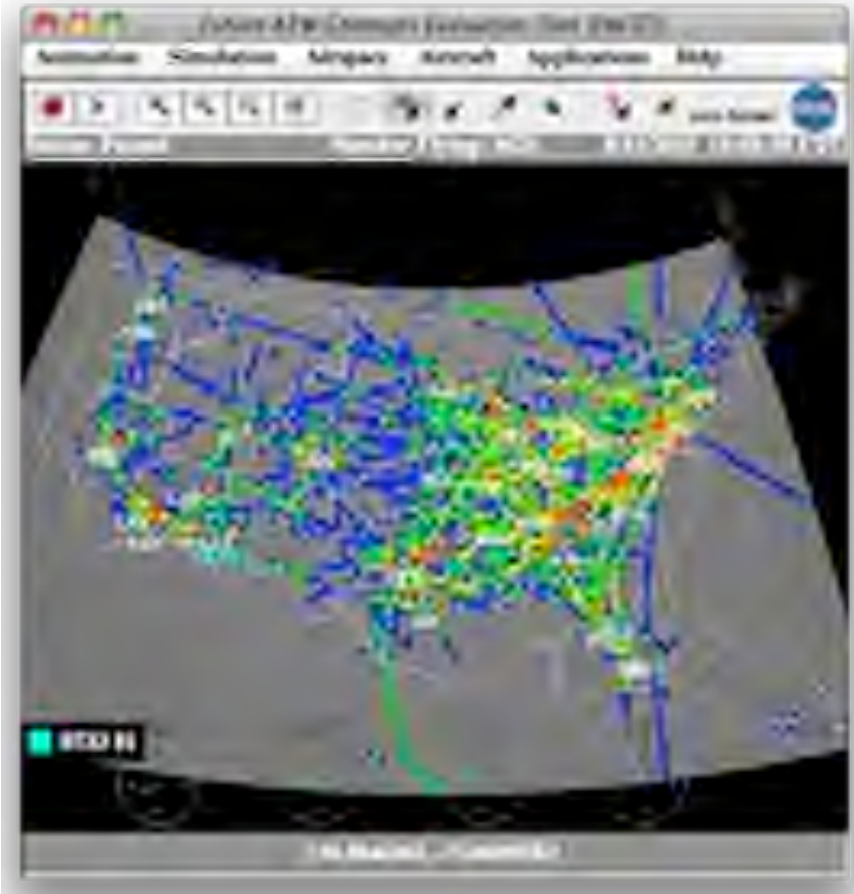
Future ATM Concept Evaluation Tool (FACET)



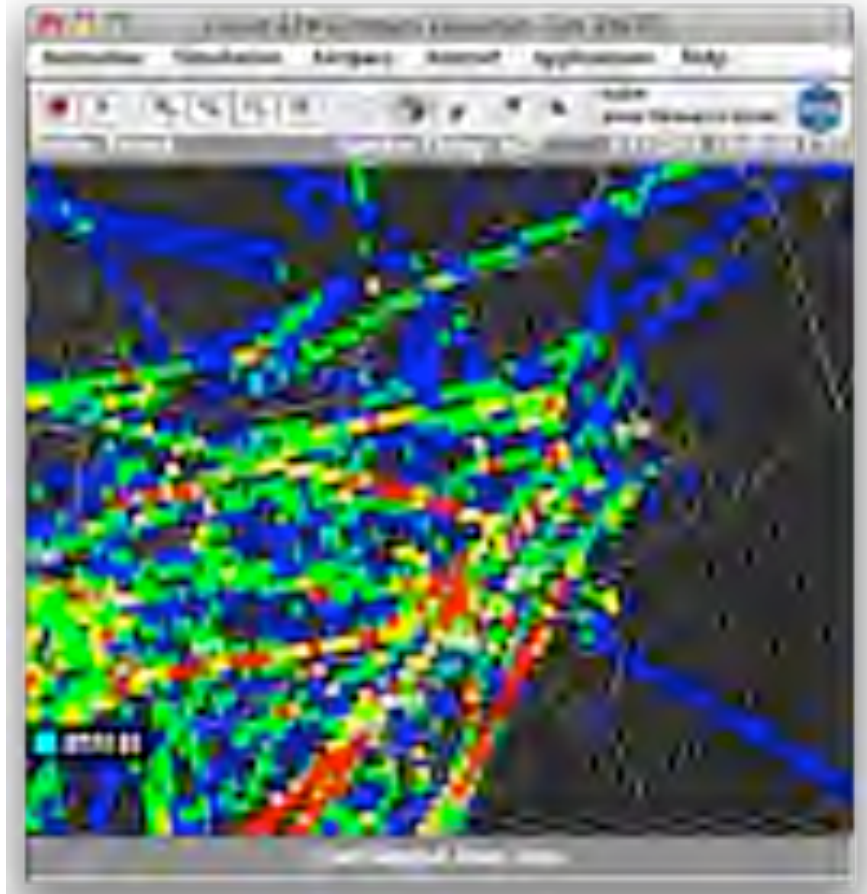
Integrated System



Integrated System Display - Emissions



Entire US



Zoom-In around New York Area

Integrated System Display – Contrails



Trade-off Study – Contrails and Emissions

- Reduce contrail formation by changing aircraft pre-departure cruising altitudes
 1. find aircraft at the same cruising altitude
 2. compute total contrails formed and emissions at different cruising altitudes
 3. select altitude with least contrails
- Contrail reductions result in extra emissions

Contrail Reduction Strategy

Contrails

Emissions

FL420

FL400

FL380

FL360

FL340

FL320

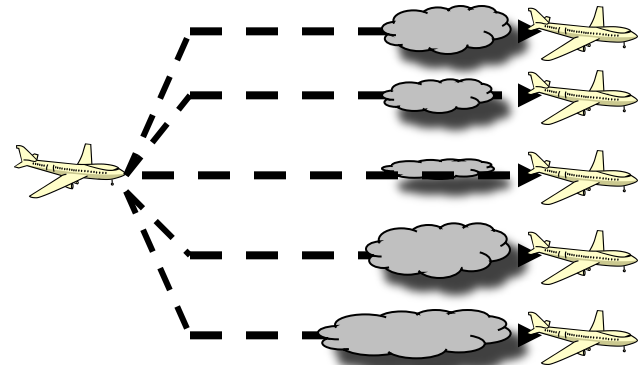
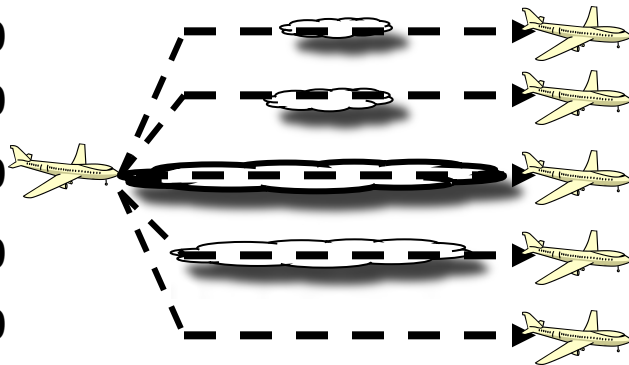
FL300

FL280

FL260

FL240

FL220

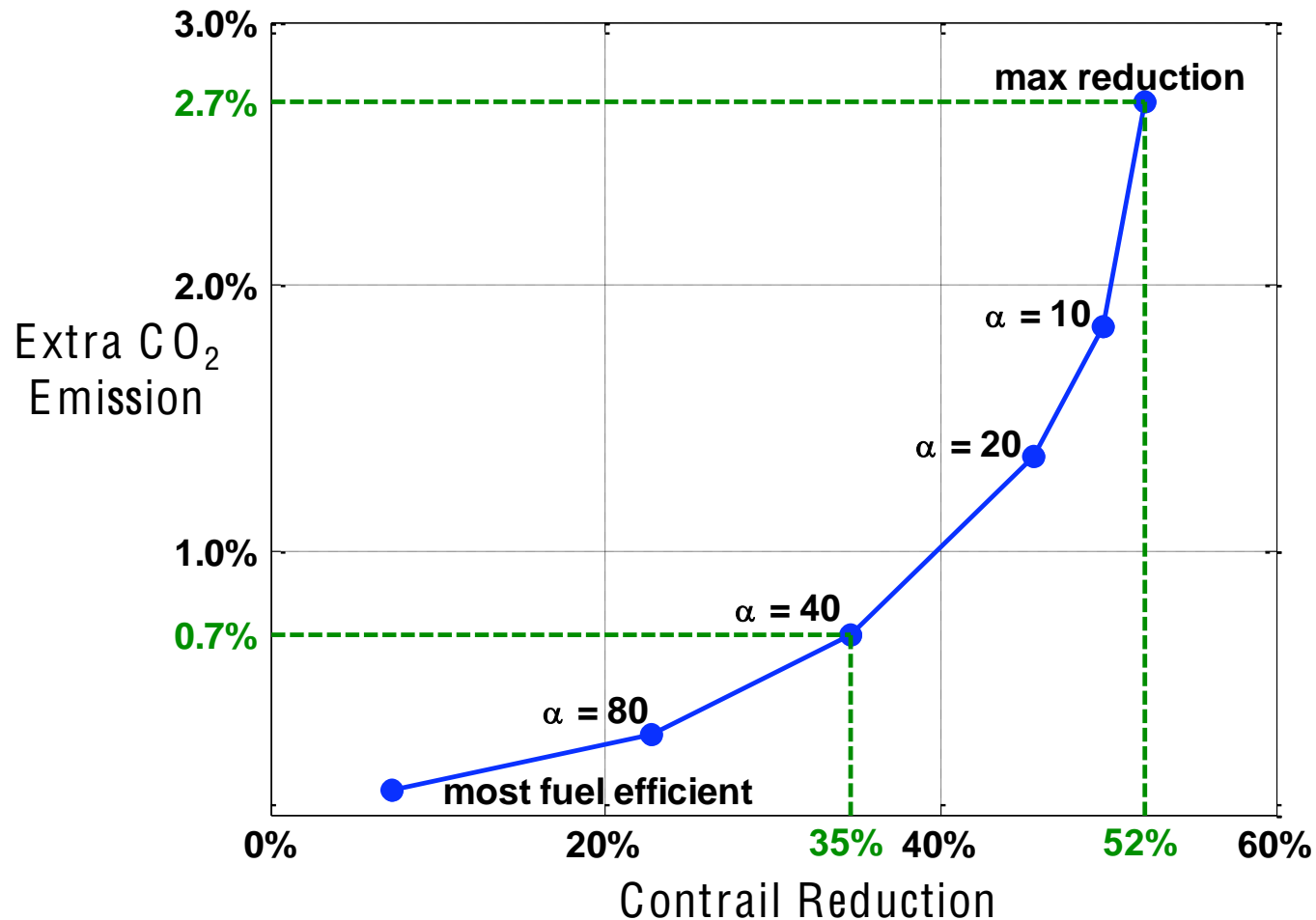


$$\text{Threshold} = \frac{\text{contrail reduction (nmi)}}{\text{extra CO}_2 \text{ emission (1000kg)}}$$

Result of the Trade-offs Study

08/01/2007

$$\alpha = \frac{\text{contrail reduction (nmi)}}{\text{extra CO}_2 \text{ emission (1000kg)}}$$



Conclusions

- Integrate environmental models to air traffic system models
- Enable trade-offs study among contrail formations and emissions
- Provide capability for decision maker to evaluate environmental policy based on scientific findings