MIT ICAT

MIT International Center for Air Transportation

Quiet Skies:
Mitigating the Impact of Aircraft Noise

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JUP Meeting

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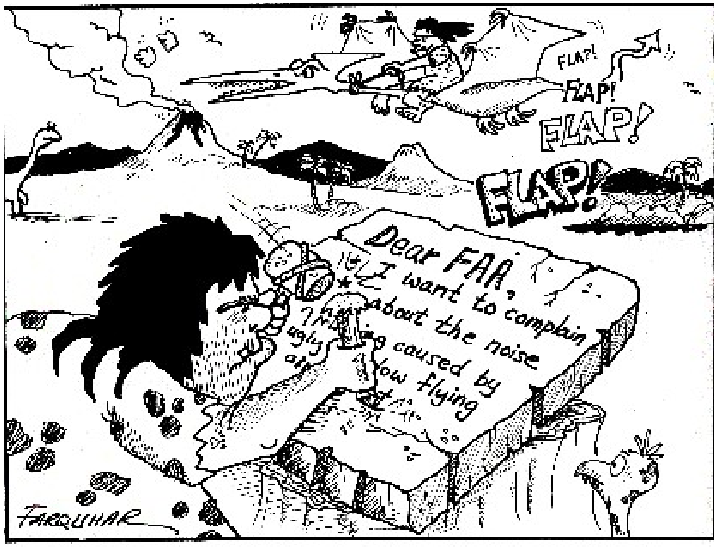
Impact of Aircraft Noise

- **Source of disturbance**



"THE FIRST RECORDED NOISE COMPLAINT WAS RECENTLY DISCOVERED IN A CAVE NEAR ST.LOUIS"

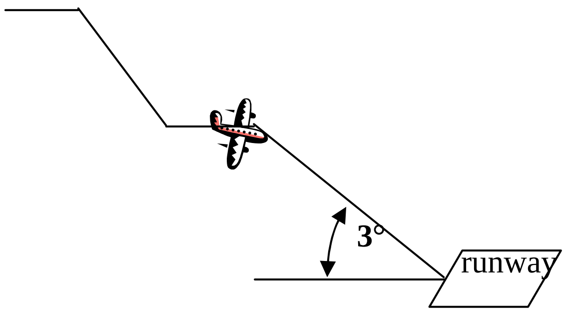
- **Impediment to airport expansion**
  - New runway at Logan: 25-year litigation battle
  - Five additional runways at US 30 busiest airport in past 10 years
- **Factor in air traffic congestion and delay**
  - Limiting the future growth of air transportation

Technological Opportunity

- **Advanced flight guidance technologies**
  - Global Positioning System (GPS)
  - Flight Management System (FMS)
- **Enable procedures that significantly reduce noise**
  - Thrust management strategies redistribute noise during departure and reduce noise during approach
  - Area Navigation (RNAV) enables flexible trajectories with noise mitigation as a consideration
  - Lateral navigation consistently directs aircraft away from populated areas

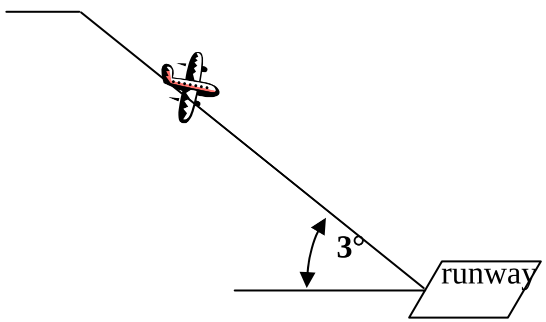
Noise Abatement Approach Procedures

Existing approach



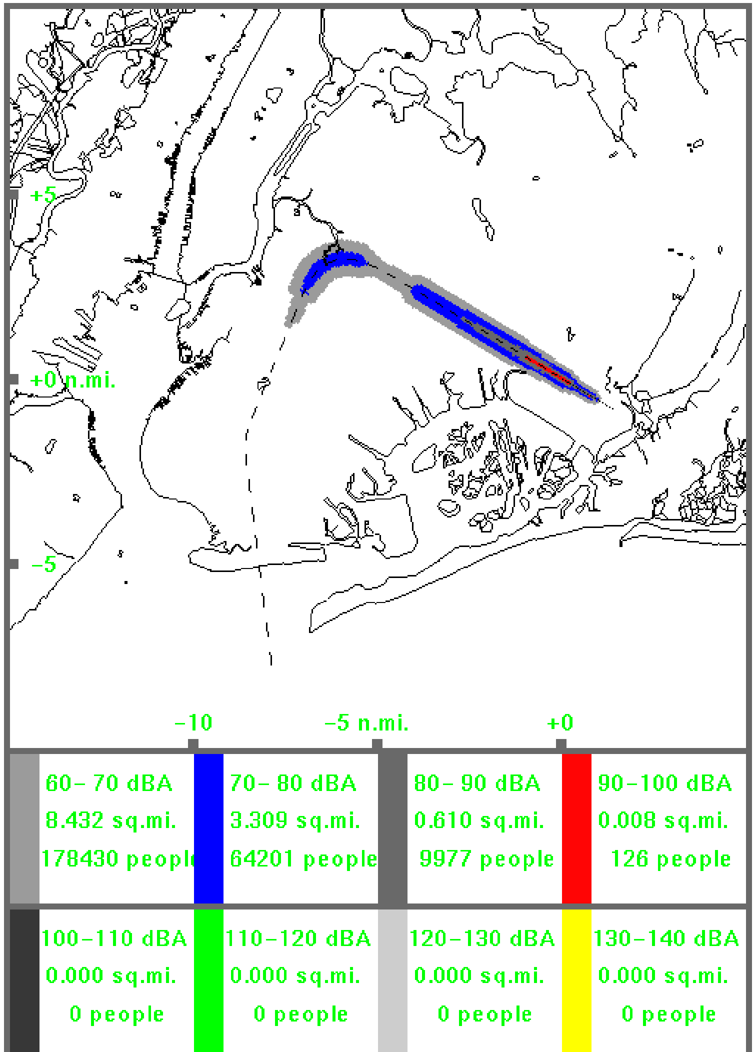
- Aircraft intercepting the 3° glide slope from below (technology constraint)
- Fly close to the ground and at high thrust
- Flaps/gear extension initiated early
- High noise impact

3 ° decelerating approach

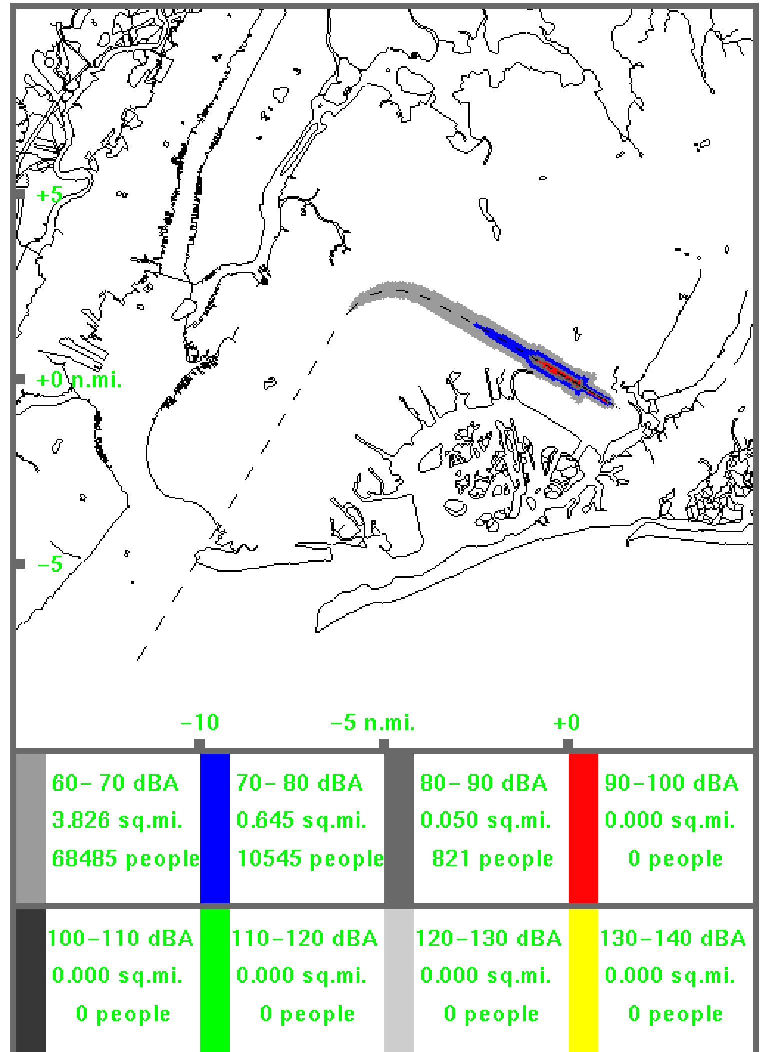


- Intercept 3° glide slope at high altitude (GPS guided)
- Fly higher above ground and at idle thrust
- Flaps/gear extension delayed
- Minimal noise impact Global Positioning System (GPS)

Noise benefit of 3° Decelerating Approach (JFK 13L)

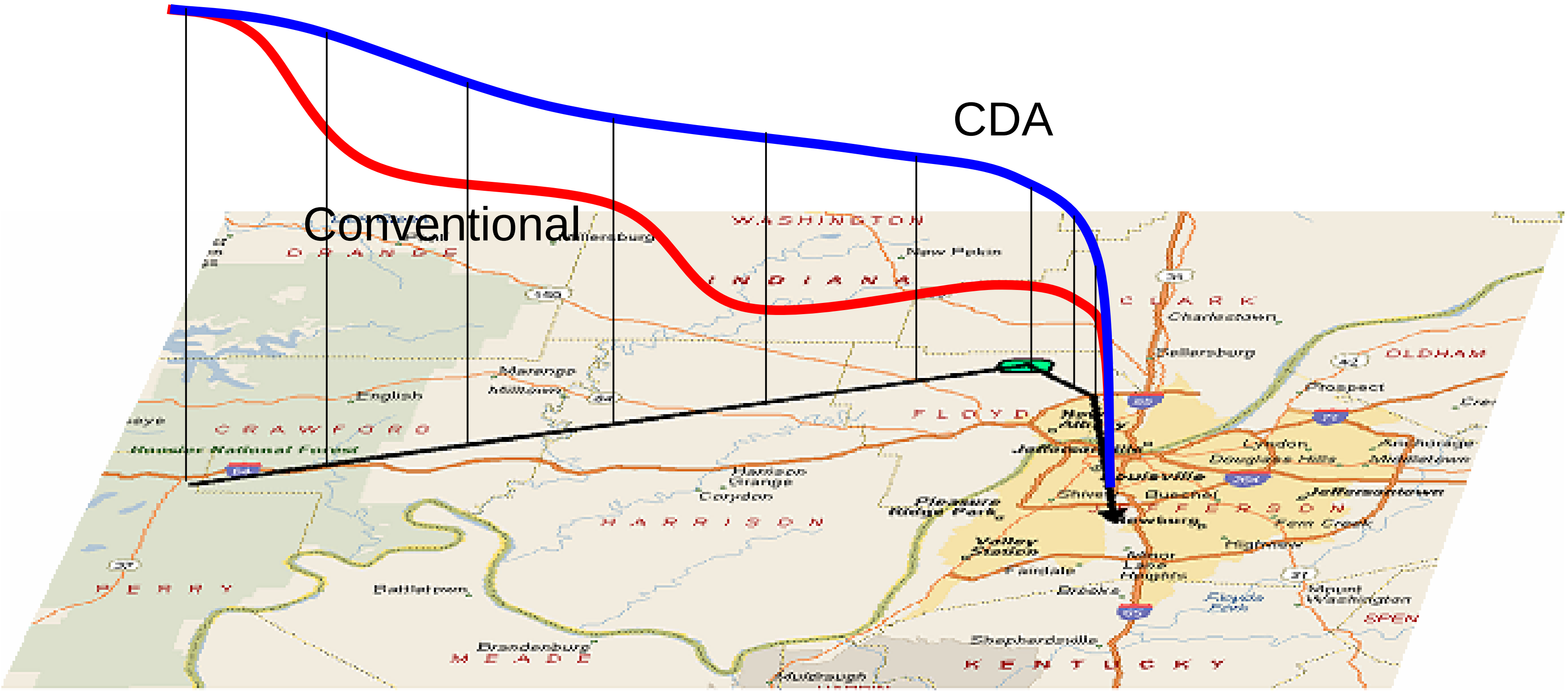


Existing Approach

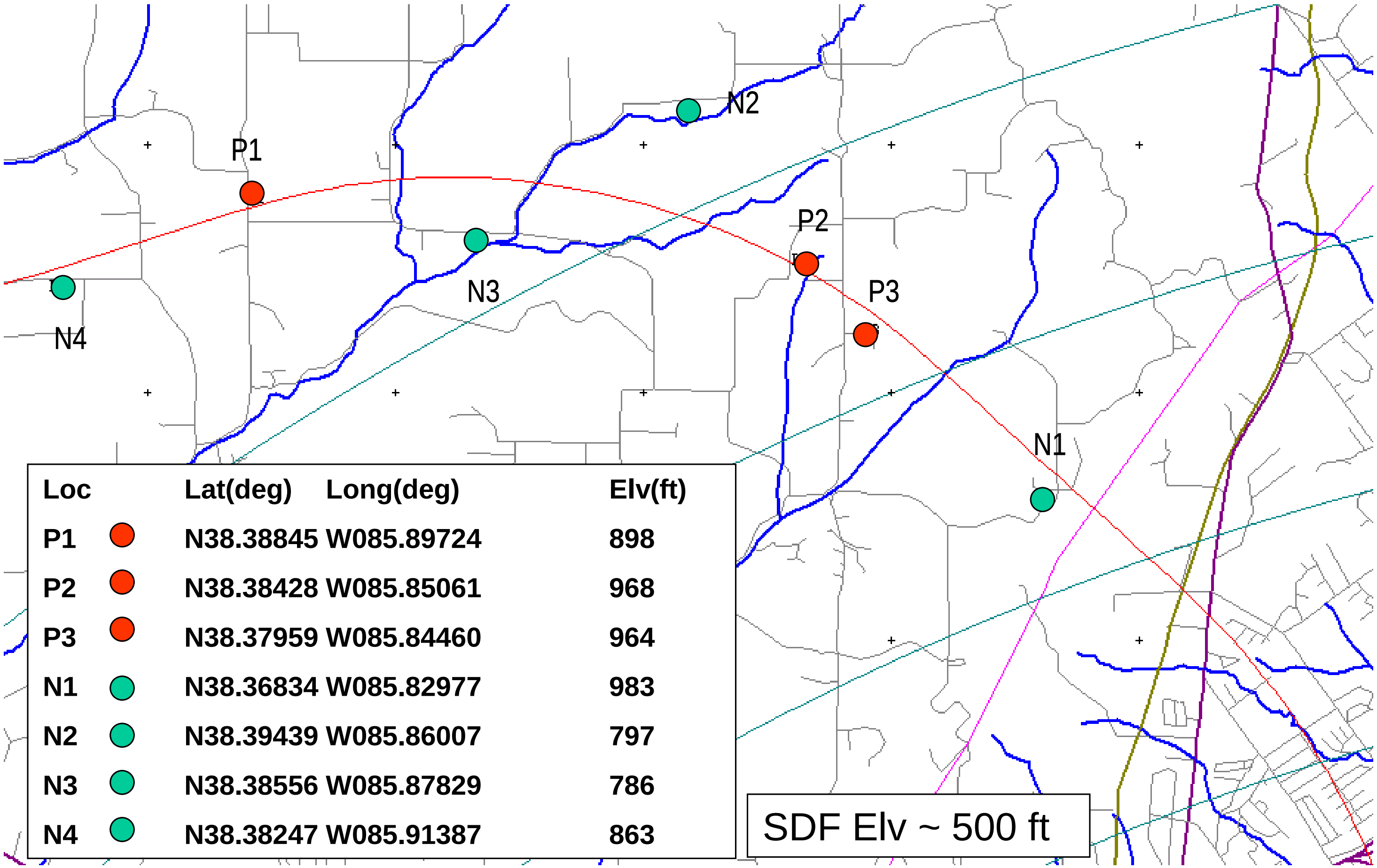


3° Decelerating Approach

Continuous Descent Approach at Louisville International Airport 10/2002

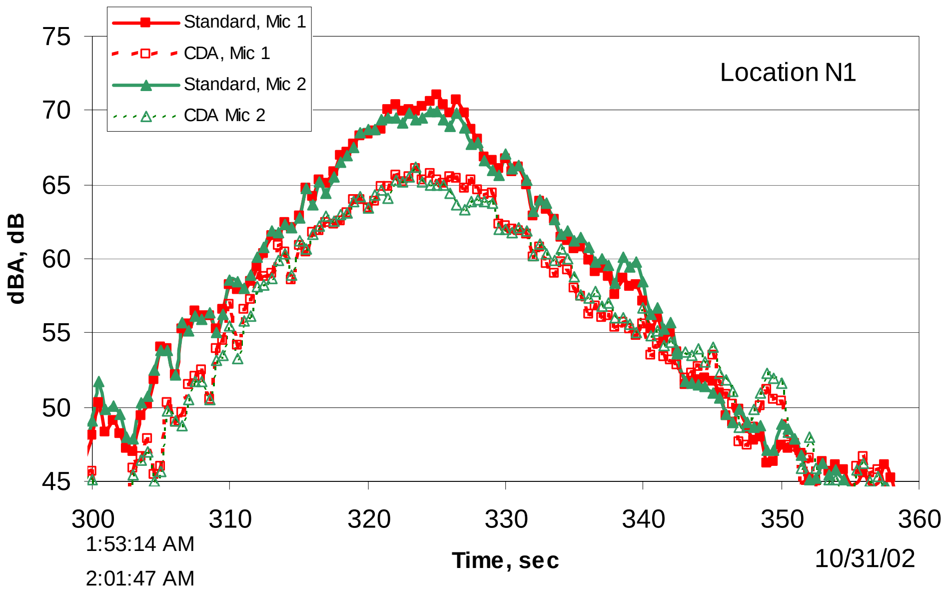


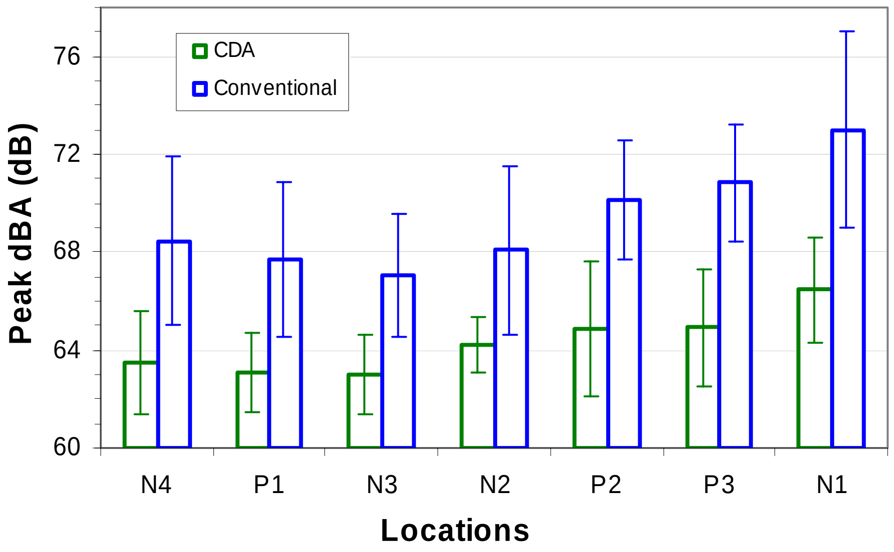
Noise Monitor Locations



Loc		Lat(deg)	Long(deg)	Elv(ft)
P1	🔴	N38.38845	W085.89724	898
P2	🔴	N38.38428	W085.85061	968
P3	🔴	N38.37959	W085.84460	964
N1	🟢	N38.36834	W085.82977	983
N2	🟢	N38.39439	W085.86007	797
N3	🟢	N38.38556	W085.87829	786
N4	🟢	N38.38247	W085.91387	863

Noise Reduction



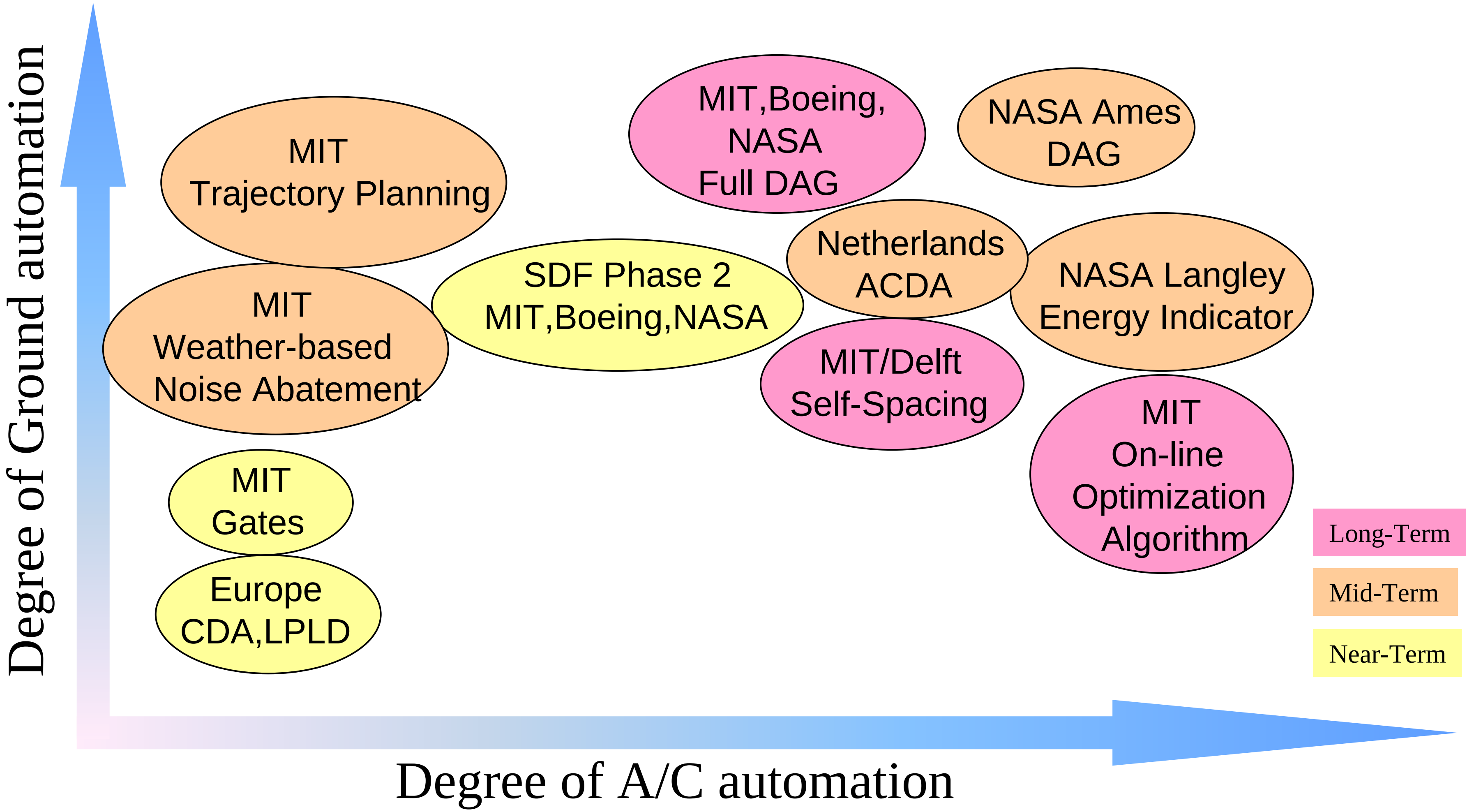


- 3.9 to 6.5 dBA noise reduction
- 400 to 500 lb fuel saving over “conventional” approach
- up to ~100 sec reduction in flight time over “conventional” approach under no wind condition

Implementation Challenges

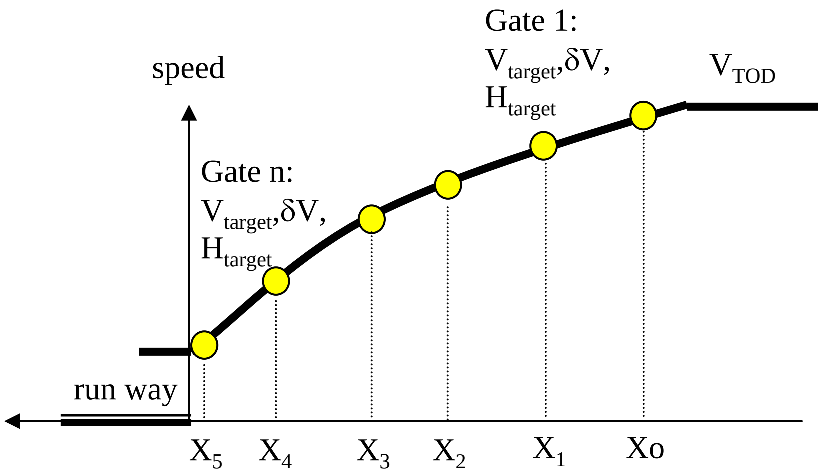
- **Air traffic control considerations**
  - Aircraft deceleration rate is sensitive to system uncertainty
  - Uncertainty (atmospheric, pilot response) in operational environment results in significant variability in aircraft performance
  - Controllers increase separation to account for variability
  - Increased separation results in lower throughput
  - End result: currently used only in low-traffic environment
- **FMS VNAV and auto-throttle logic design**
  - Delay in pilot response causes auto-throttle to provide disproportionately large thrust for speed envelope protection
  - VNAV logic creates level flight segment to arrest acceleration

Possible Solutions



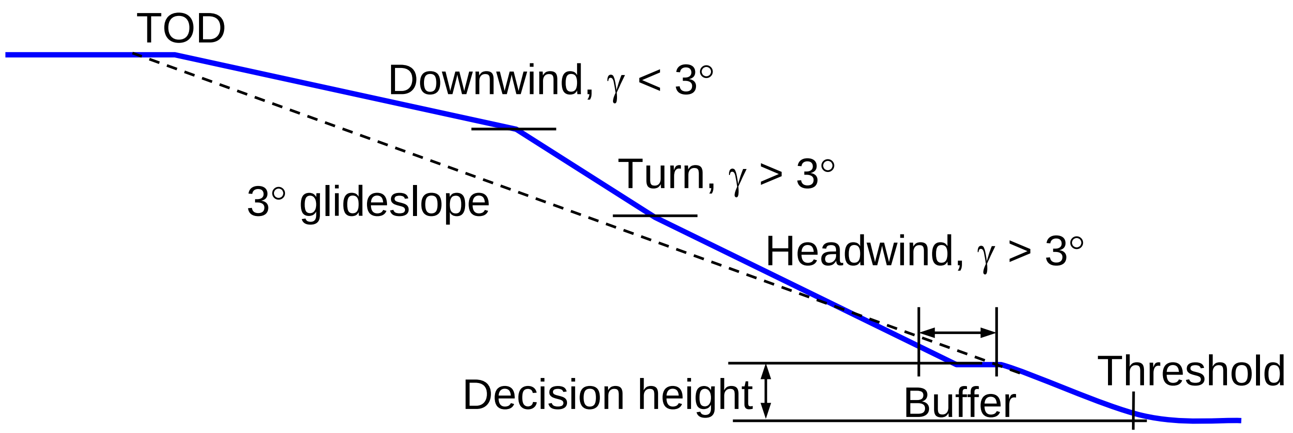
MIT Gates

- **Objective**
  - Provide pilots a means to manage a/c deceleration and meet targets without adding airborne automation
- **Approach**
  - Develop gates (altitude and speed checkpoints) using Monte-Carlo simulation (static solution) or ground based automation (to incorporate details of current weather, etc.)
  - Provide gates to pilots as a feedback mechanism
  - Pilots adapt given flap schedule based on deviations at gates
- **Key Feature**
  - Comparable performance to other forms of guidance that require change in aircraft equipage



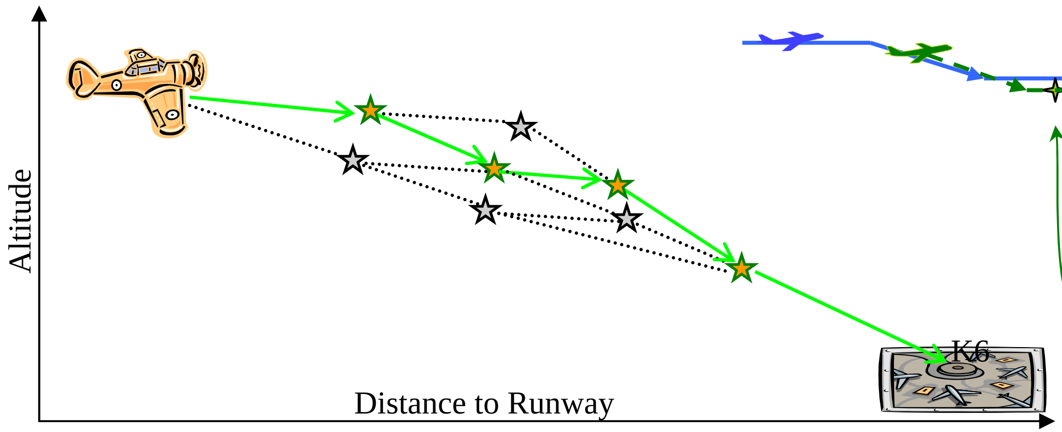
MIT Trajectory Planning

- **Objective**
  - Improve trajectory using Satellite Landing System (SLS) technology
- **Approach**
  - Sensitivity analysis to determine key factors affecting performance
  - Searching design space for best parametric procedure and control logic
  - Airborne trajectory planning: lateral vectoring, weather, a/c configuration
- **Features**
  - Flexible flight track allowing lateral vectoring
  - Variable glideslope to minimize noise impact and assure safety

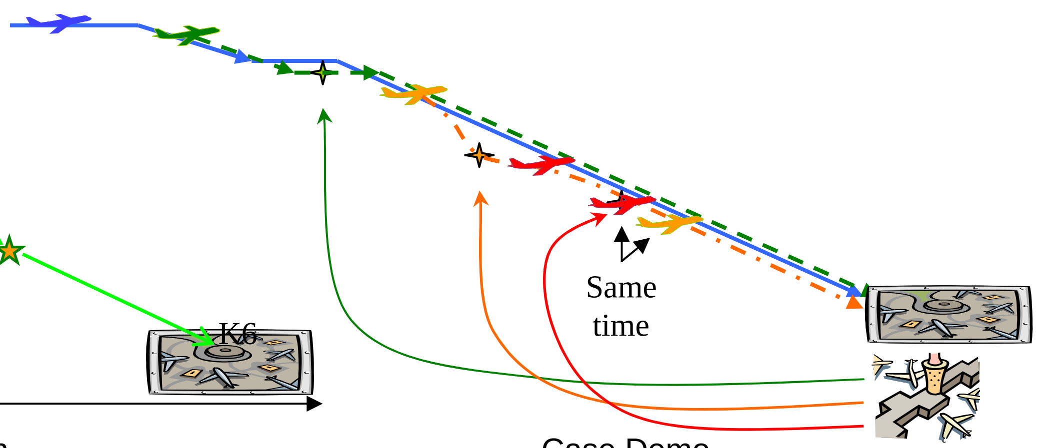


MIT Online Optimization Algorithm

- **Objective**
  - Real-time optimal noise abatement trajectory generation and control
- **Approach**
  - Dynamic programming for paths generation
  - Linear and nonlinear optimization over noise
  - Receding horizon control for real-time adaptation
- **Key Features**
  - ATC controller retains control during approach
  - More friendly and flexible NAP trajectory for pilots

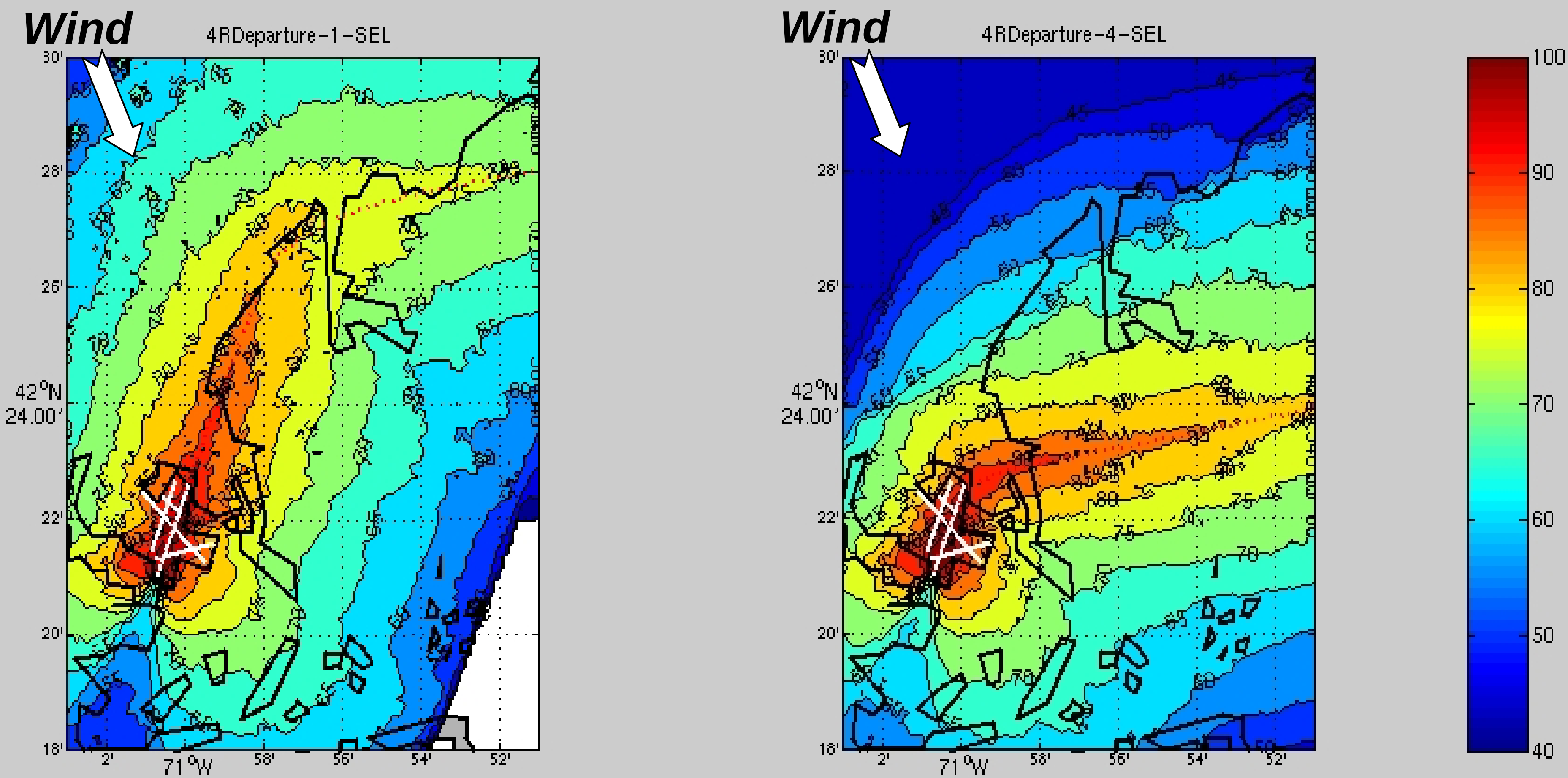


Dynamic Programming Path Selection



Case Demo.

MIT Weather-based Noise Abatement



Scenarios / dB SEL	60 < 70	70 < 80	80 < 90	90 < 100	> 100
Standard departure	405,887	235,083	43,825	5,764	192
Optimal departure	293,745	94,574	18,882	5,320	143

Summary

- **Noise is an impediment to growth of air transportation**
- **Advanced flight guidance technologies (GPS, RNAV) enable flexible operational procedures for noise reductions**
  - Simulation work
  - Flight demonstration test at Louisville
- **Implementation challenges: inability of controllers to separate and sequence a/c for maximum throughput and safety**
- **Current work:**
  - Develop candidate architectures and ground and airborne decision support tools
  - Evaluate controller/pilot performance through simulation and flight test
  - Develop appropriate solutions for near, medium, and long term
  - Develop procedures for Louisville and London Heathrow

Next Steps at Louisville (SDF)

- **Controller-in-the-loop Study**
  - Understand limitation of controller and pilot performing CDA
  - Quantify ability of controllers to predict future separation violations
  - Develop “model” of appropriate control actions – course and fine control
- **Controller Tools Study**
  - Quantify benefit to controllers of support tools
  - Develop improved model of controller actions given different tools
- **Crew Model Study**
  - Determine impact of advanced FMS and displays on pilot and aircraft performance (given controller models)
  - Develop improved model of pilot performance
- **Procedure Design and Full Distributed Simulation Study**
  - Develop procedures for Louisville
  - Evaluate performance and implementation issues of procedures