Stochastic simulation of delay propagation

Improving schedule stability at Kenya Airways

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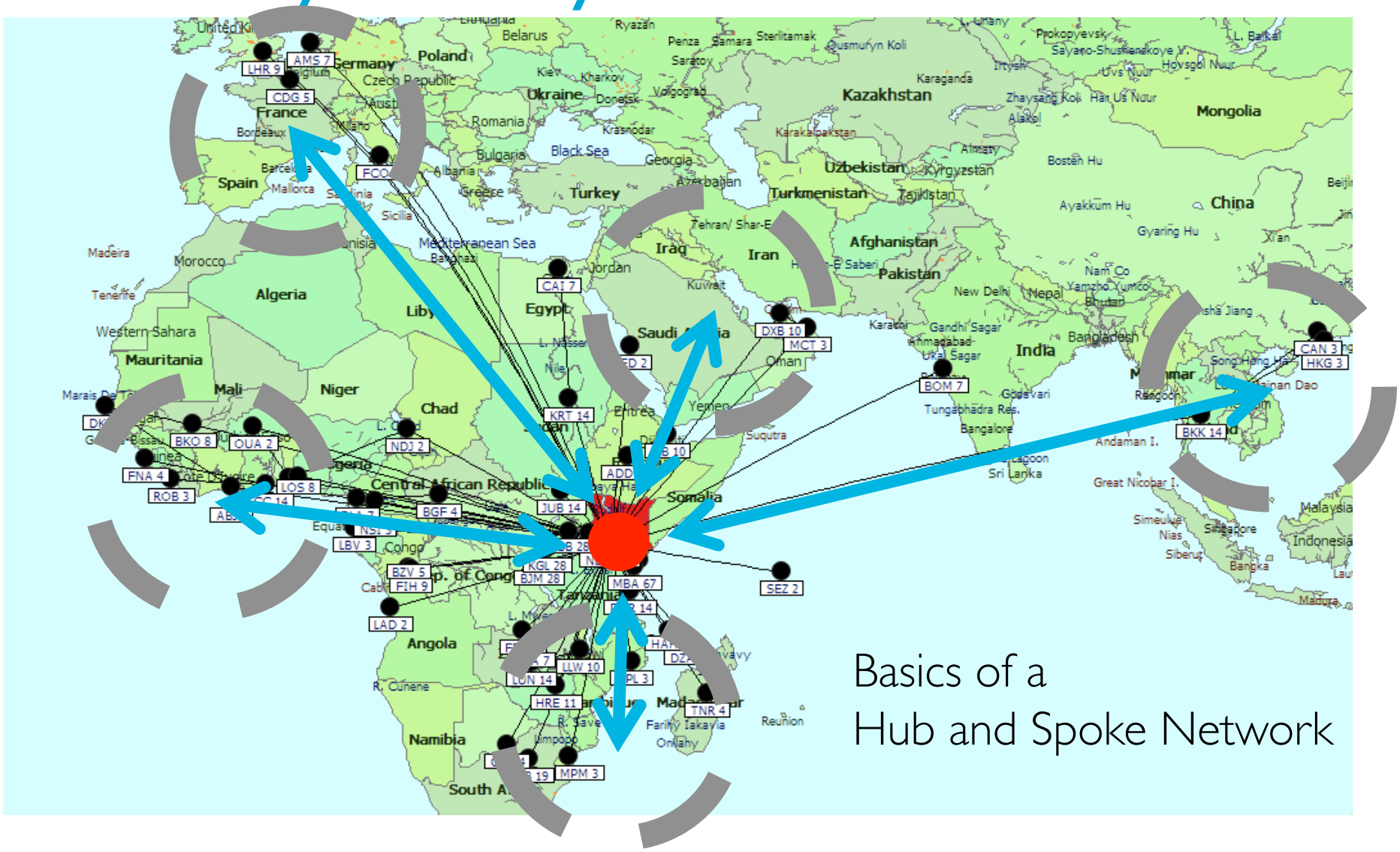
Purpose of the presentation

- Introducing research area
- Discuss the research
  - Model
  - Simulation and Validation
  - Application
- Present conclusions

Kenya Airways connects Africa



Domino effect of delays

Primary Delay: Amsterdam - Nairobi

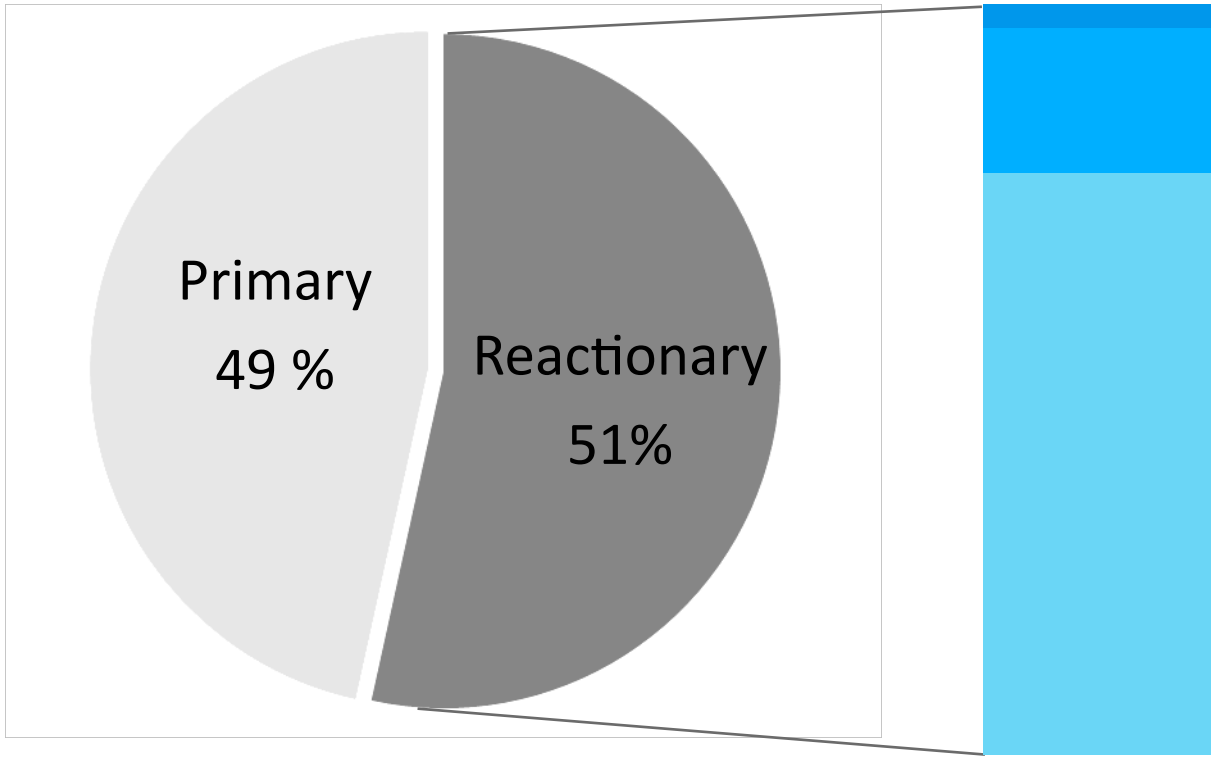
Reactionary Delays

Due to Aircraft: Nairobi - Amsterdam

Due to Transfer Passengers: Nairobi - Brazzaville
Nairobi - Gaborone
Nairobi - Maputo

Delay severity = 4

High share of reactionary delays



2% Crew

20% Passengers

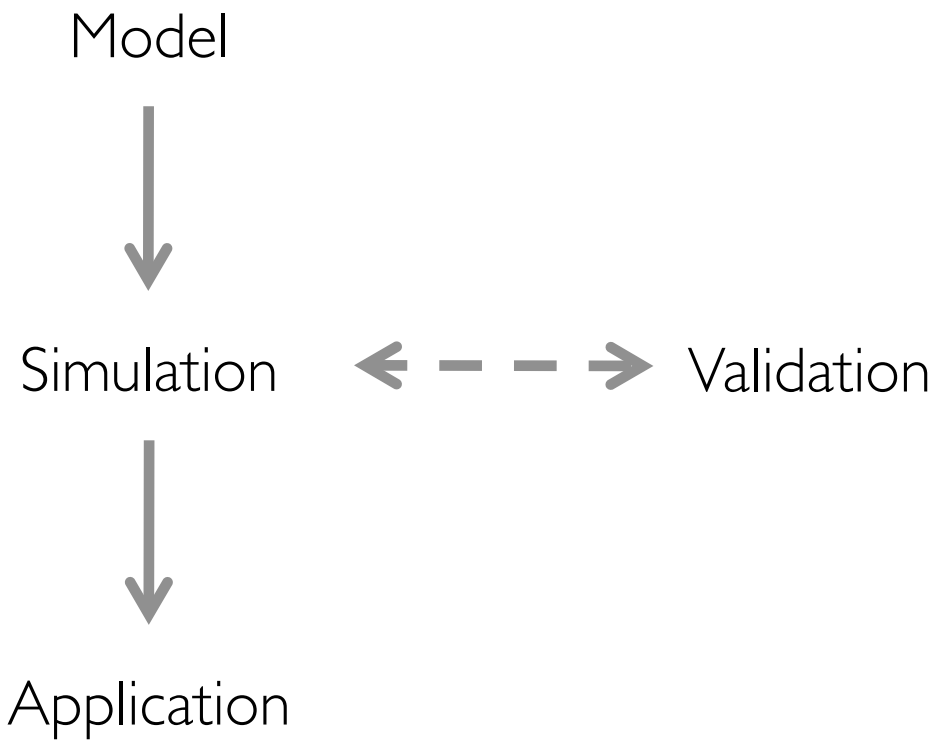
78% Aircraft

Analysis for Kenya Airways
Period: Sep 2010 – Sep 2011

Research question

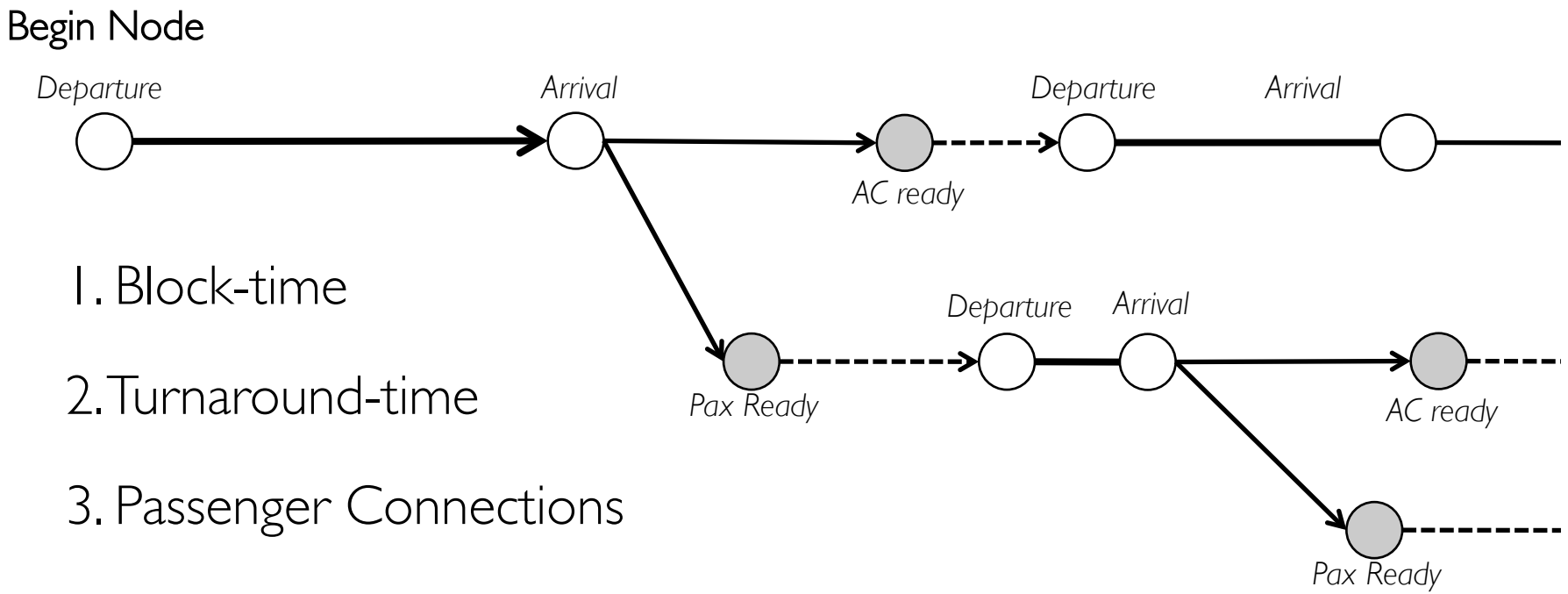
How can the **absorption robustness** *be* **simulated** *for a proposed seasonal flight schedule in terms of* **aircraft** *and* **passengers**, *and how can this be used to aid Kenya Airways in increasing* **schedule stability**?

Overview research



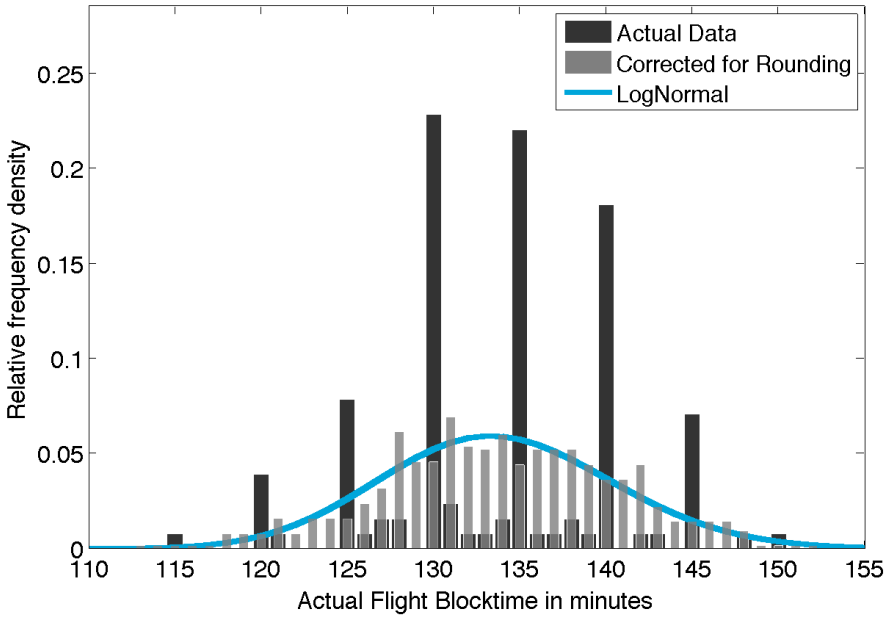
Model overview

- Departs if Aircraft and Passengers are ready
- Continues till all delay is absorbed

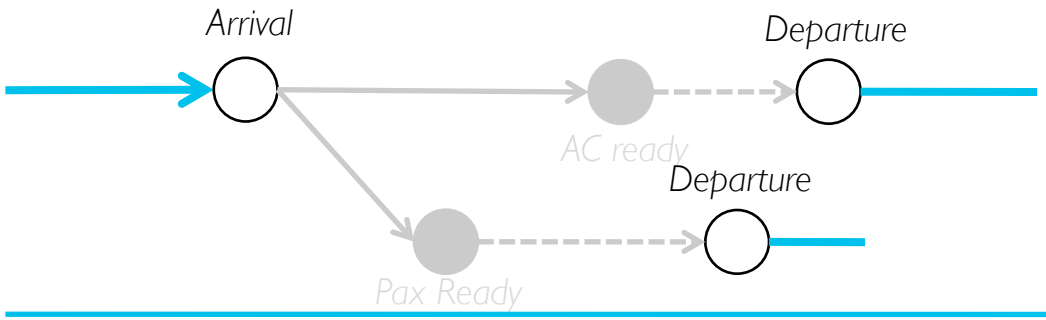


1. Block-time

- Approximation depends on:
  - Route and direction
  - Aircraft type
  - Season

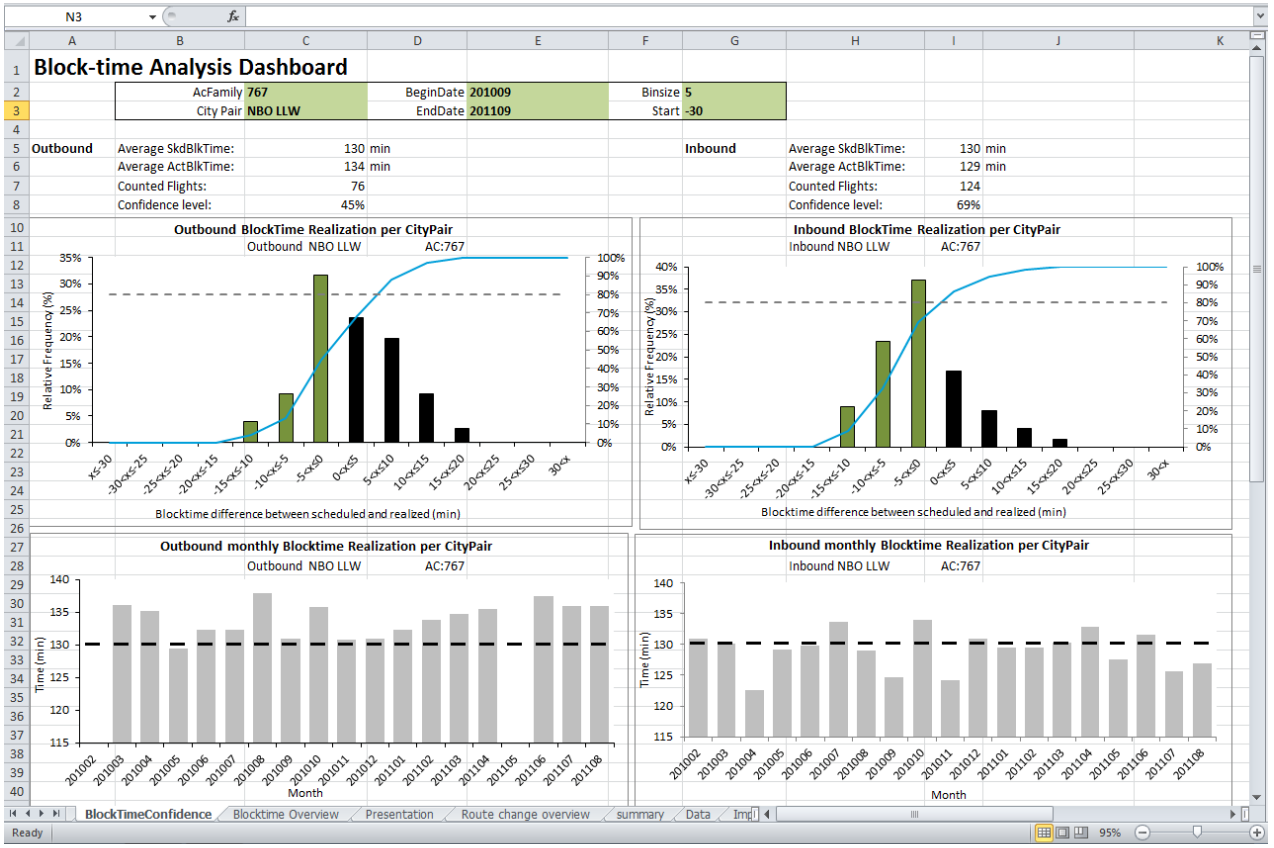


Nairobi – Lilongwe, Boeing 767-300 (summer)



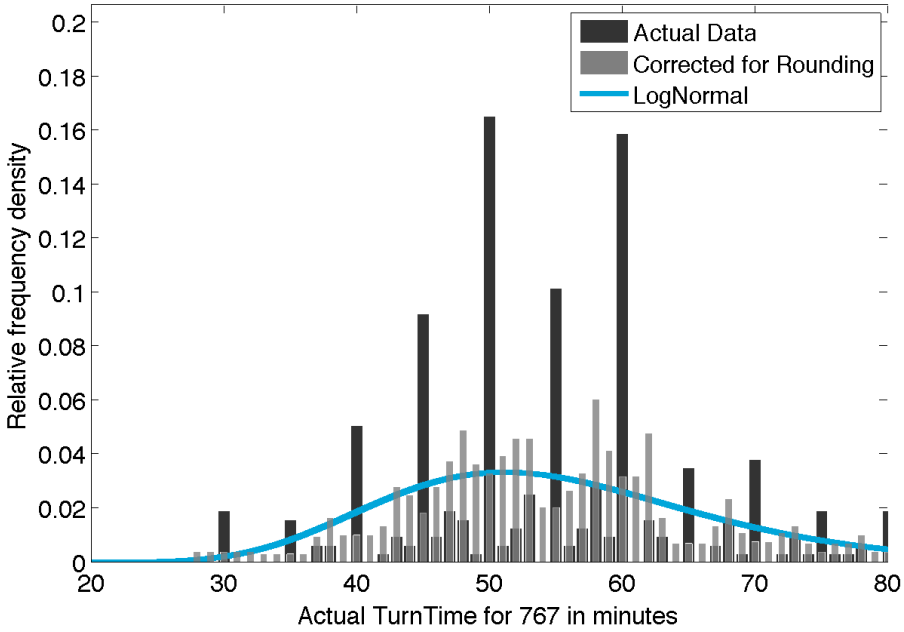
Block-time Analysis Module

- Dashboard to measure and adjust scheduled times

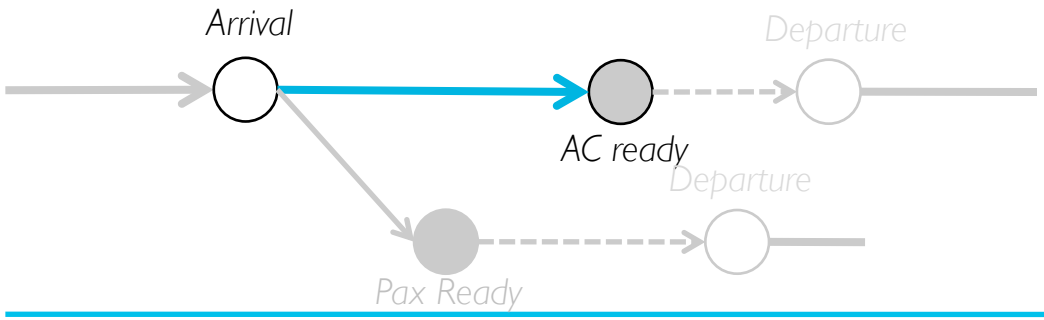


2. Turnaround-time

- Minimum Turnaround-time depends on Aircraft Type
- Dataset: A/C Reactionary delayed flights

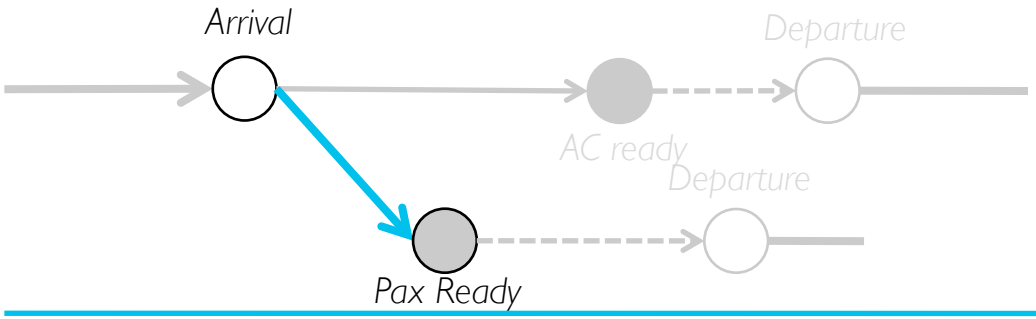


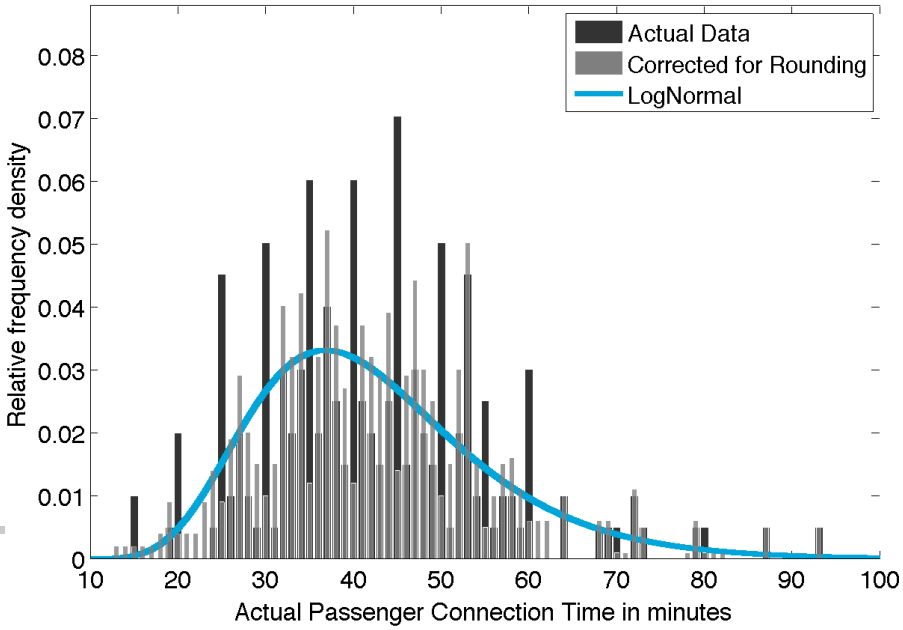
Boeing 767-300



3. Passenger Connections

- Critical connection
  - Number of passengers
  - Downstream frequency
- Minimum Connection-time depends on # pax
- Dataset: Load Reactionary





Groups > 10 pax

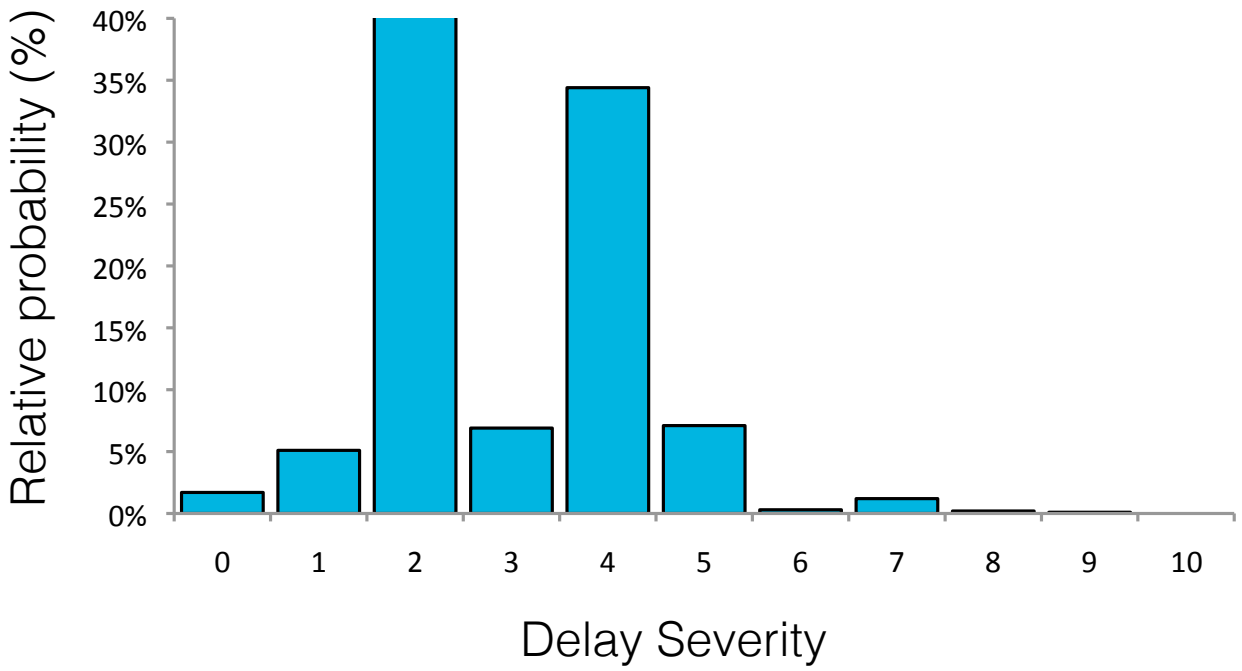
Flight delay severity simulation

- Illustrated for flight KQ0550 to Brazzaville

Flight delay severity simulation

- Simulating the likely outcomes per delay

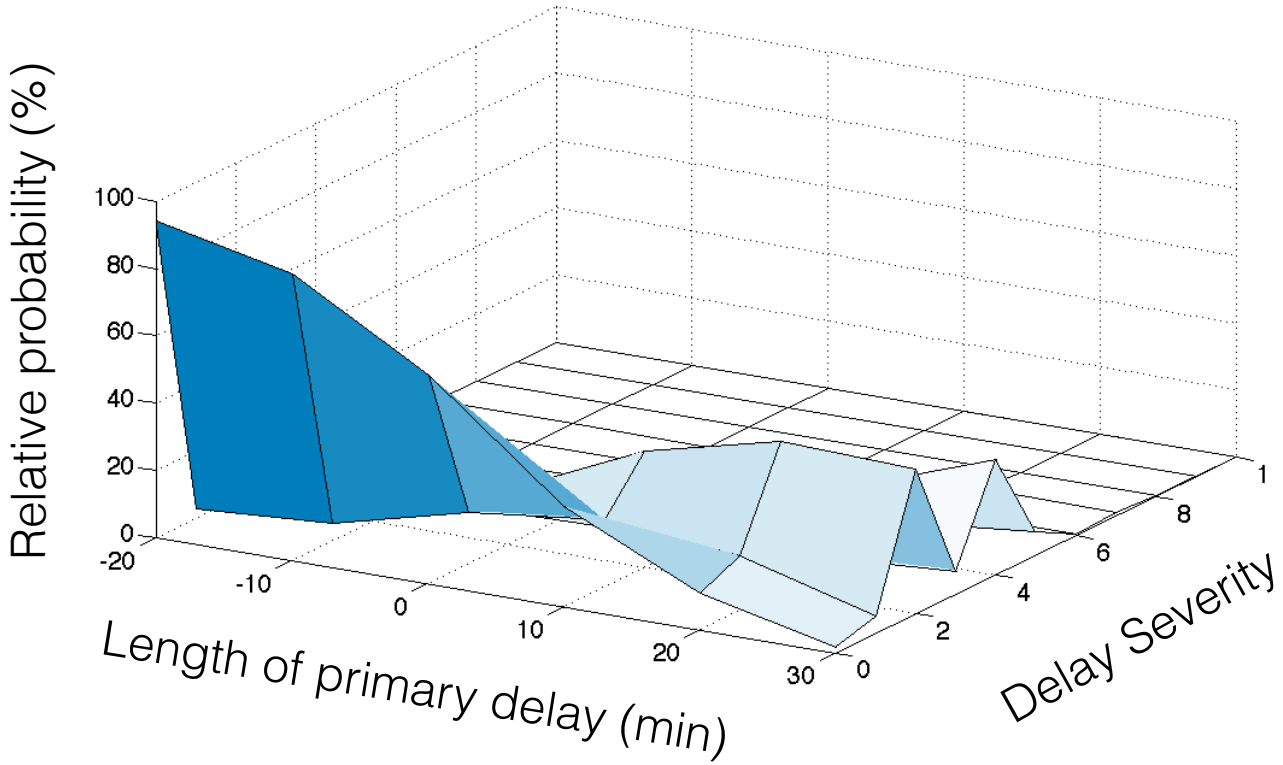
  30 minute delay for flight KQ0550 to Brazzaville:



Delay Severity Curve

- Visualize the possible impact for a range of delays

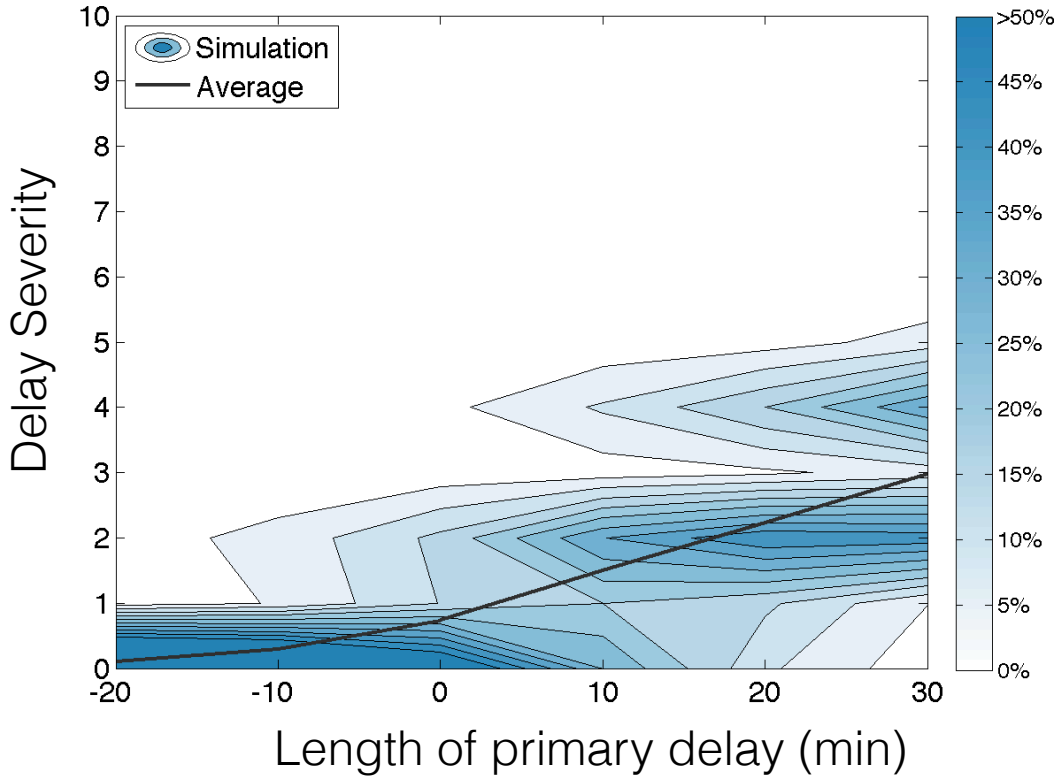
  Flight KQ0550 to Brazzaville:



Delay Severity Curve

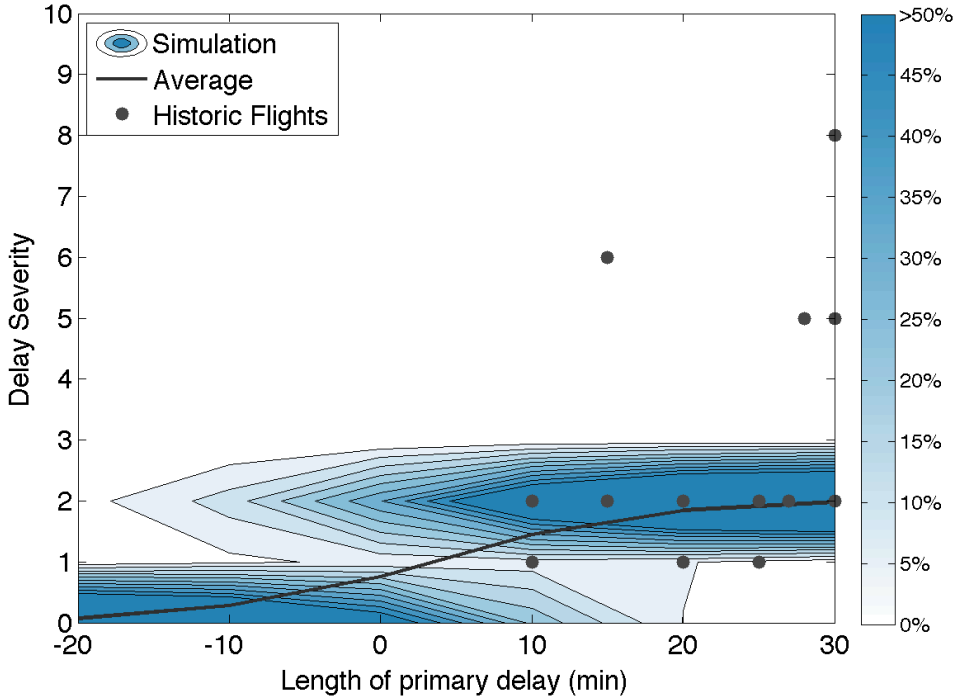
- Visualize the possible impact for a range of delays

  Flight KQ0550 to Brazzaville:



Empirical validation

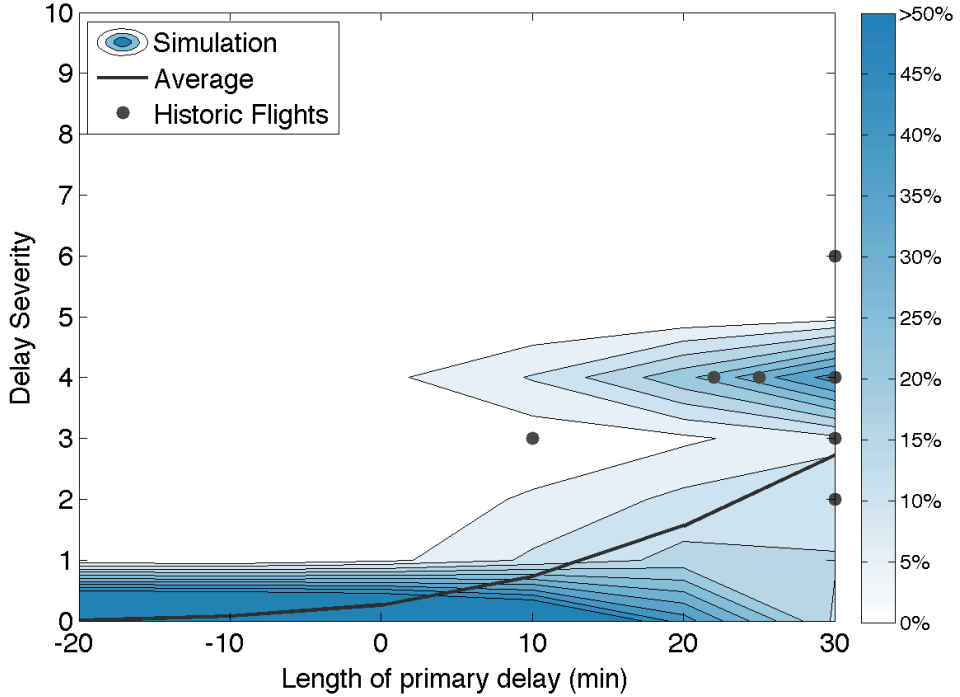
- Overlay with historical data to validate findings
  - Due to aircraft rotations
  - Due to pax connections
  - Complex combination



Flight KQ0500 to Douala

Empirical validation

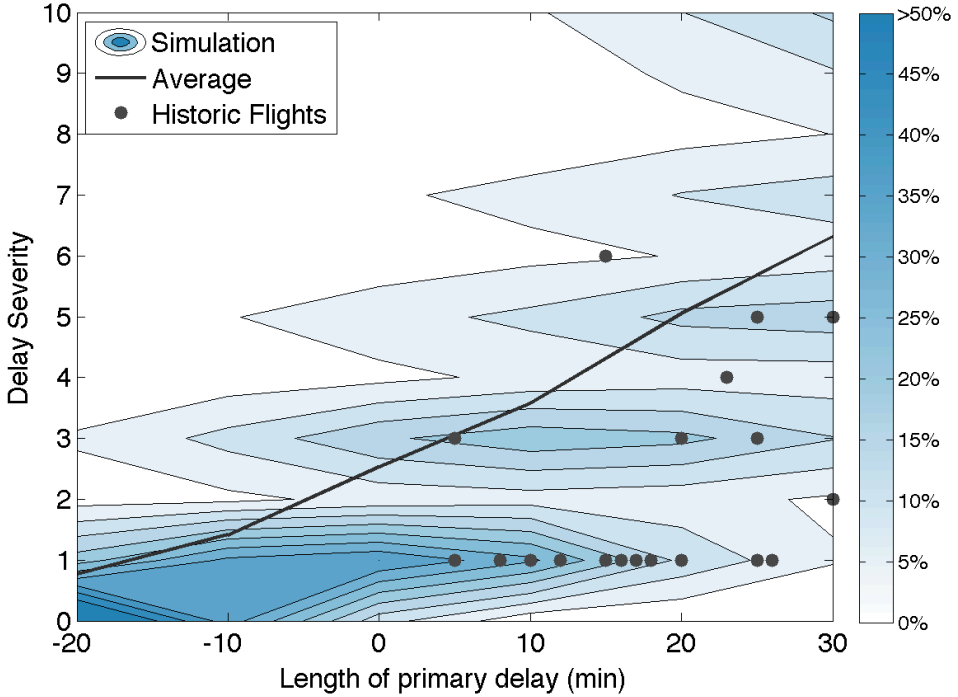
- Overlay with historical data to validate findings
  - Due to aircraft rotations
  - Due to pax connections
  - Complex combination



Flight KQ0555 from Kinshasa

Empirical validation

- Overlay with historical data to validate findings
  - Due to aircraft rotations
  - Due to pax connections
  - Complex combination



Flight KQ0702 from Harare to Lusaka

Application of simulation

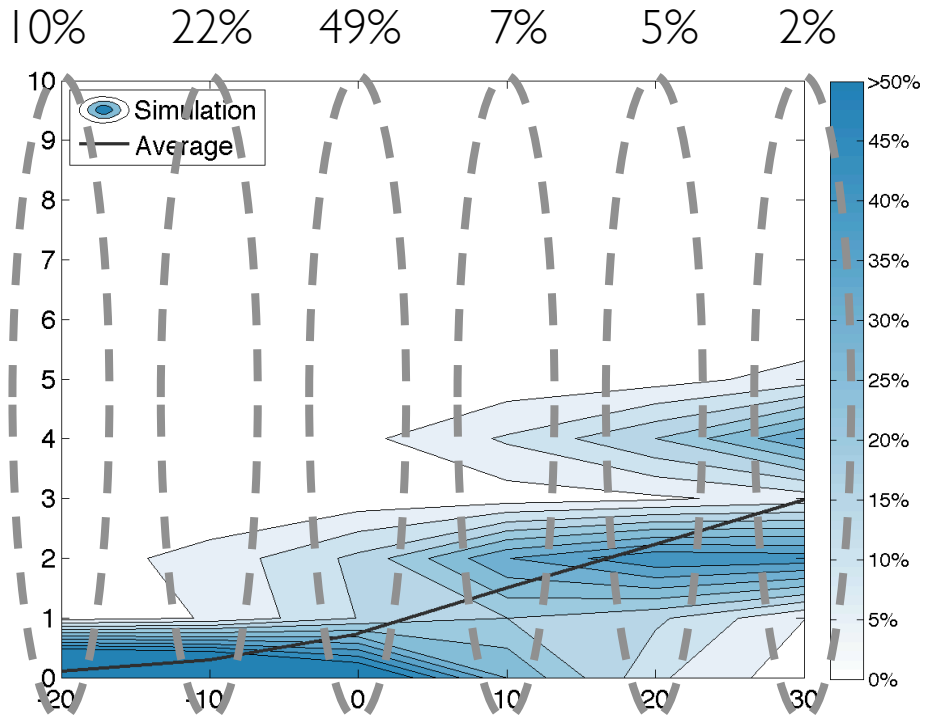
Compare flights

Improve Critical Flights

Comparative study
against Baseline Schedule

Compare Flight Robustness

- Expected Delay Severity = 1.03
- Weighted average according to P(delay)

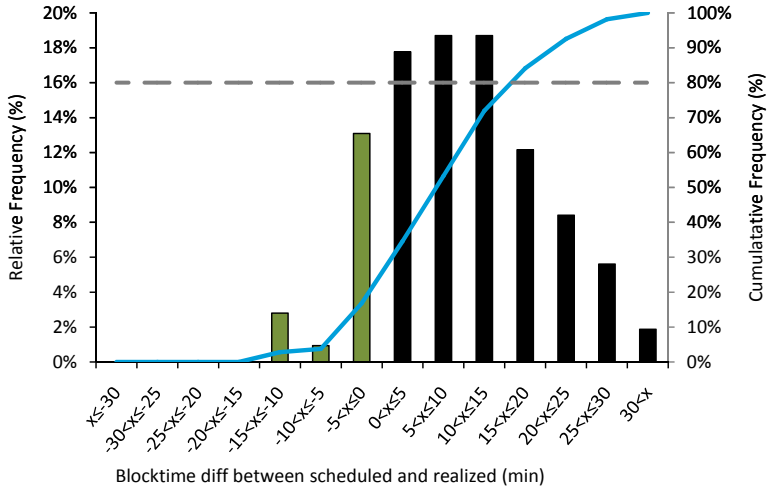


Flight KQ0550 to Brazzaville

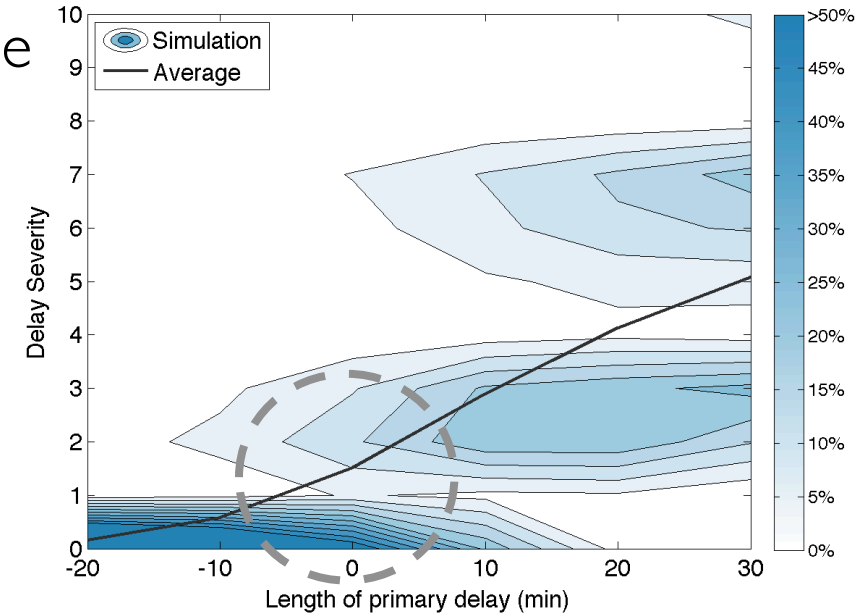
Case Lagos: Analysis of Critical Flight

High expected delay severity of 2.1 to 2.4

- Lower regions due to Block-time
- Higher regions due to Pax Connectivity



19% Inbound Block-time confidence

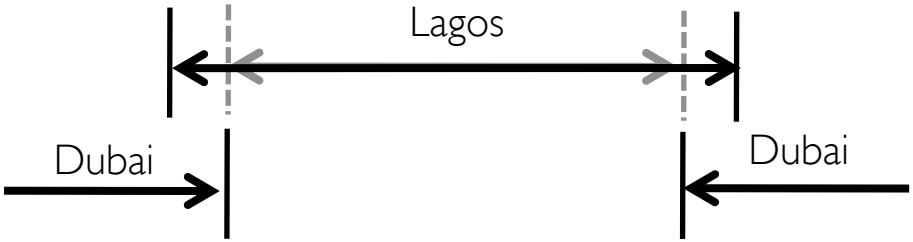


Flight KQ0532 to Lagos

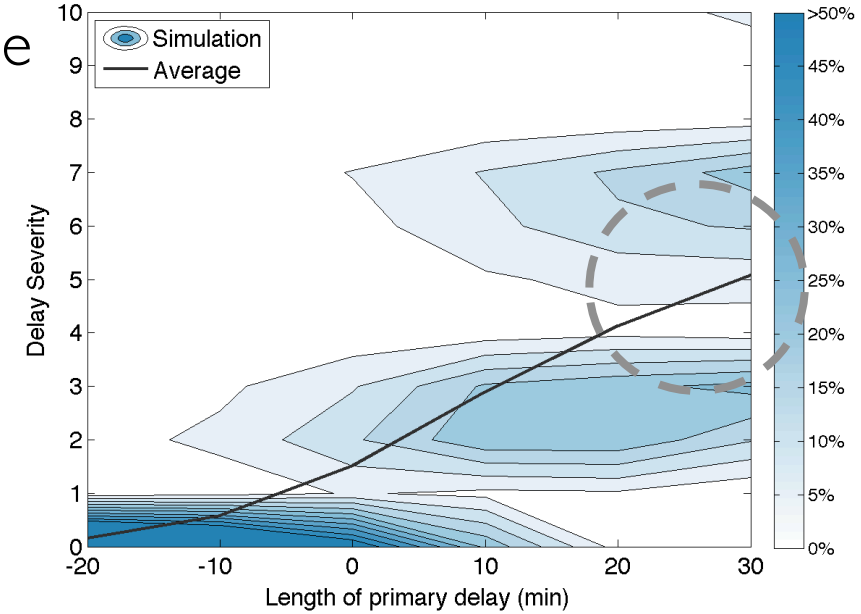
Case Lagos: Analysis of Critical Flight

High expected delay severity of 2.1 to 2.4

- Lower regions due to Block-time
- Higher regions due to Pax Connectivity



Inter-locked passenger connectivity with Dubai

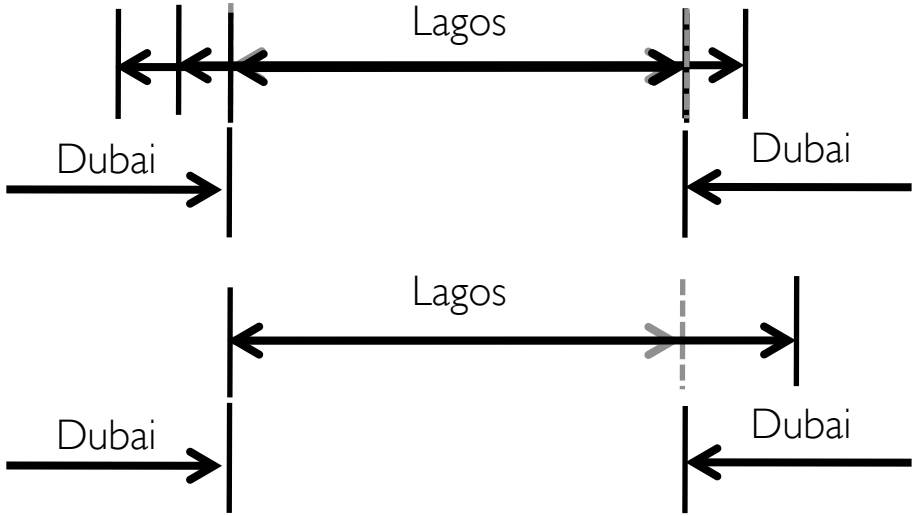


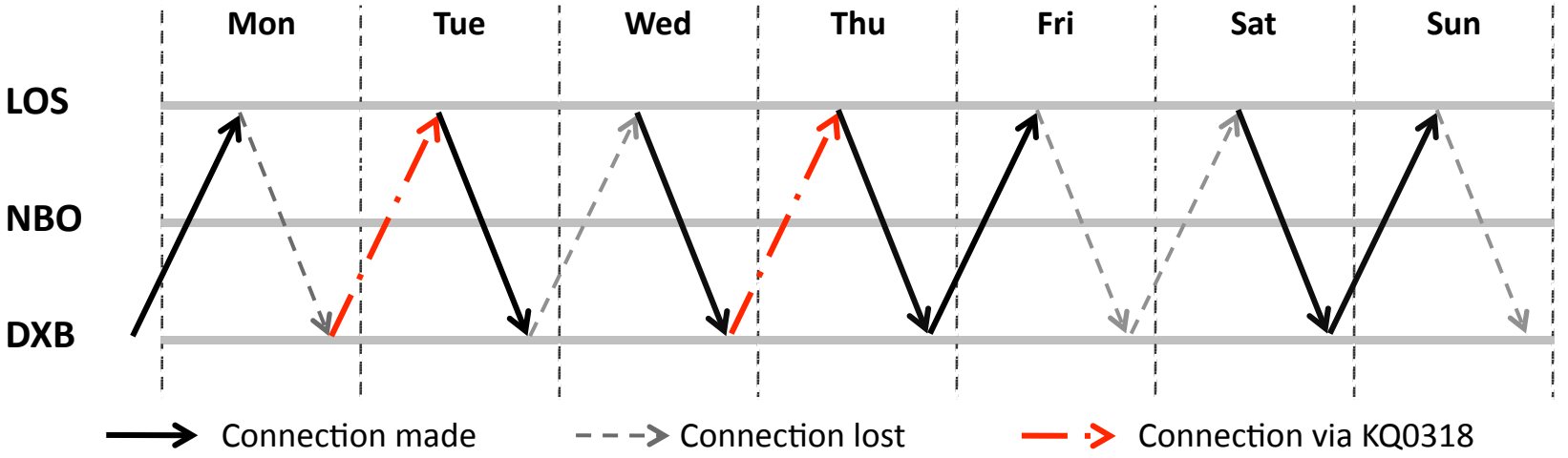
Flight KQ0532 to Lagos

Case Lagos: Proposal

Solution:

1. Increase rotation
2. Alternate connectivity

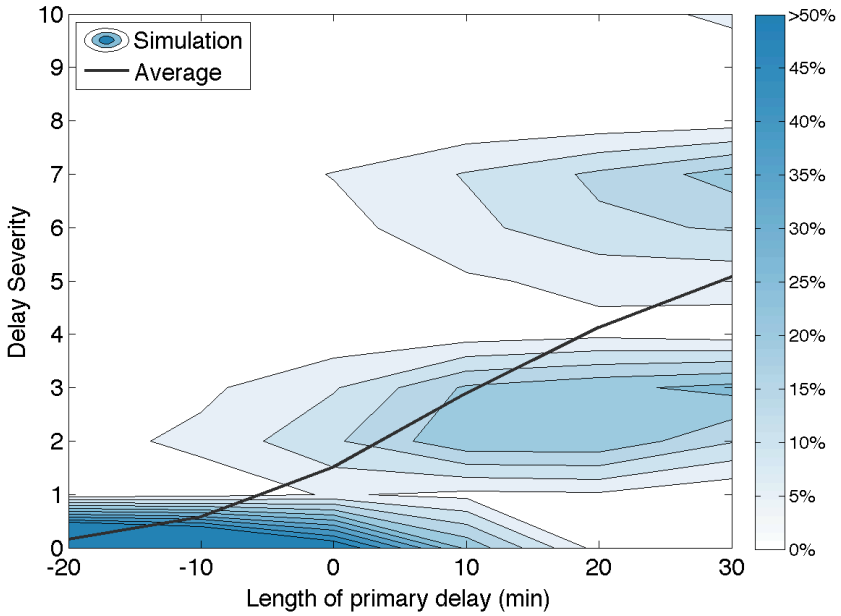




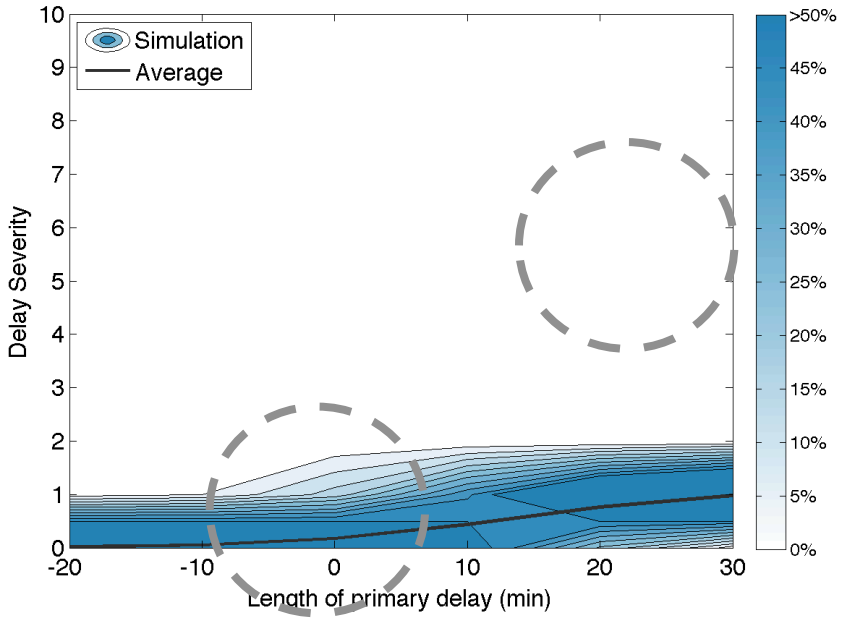
Case Lagos: Proposal

Implementation:

By February 2012 due to Aircraft availability of the Boeing 767's



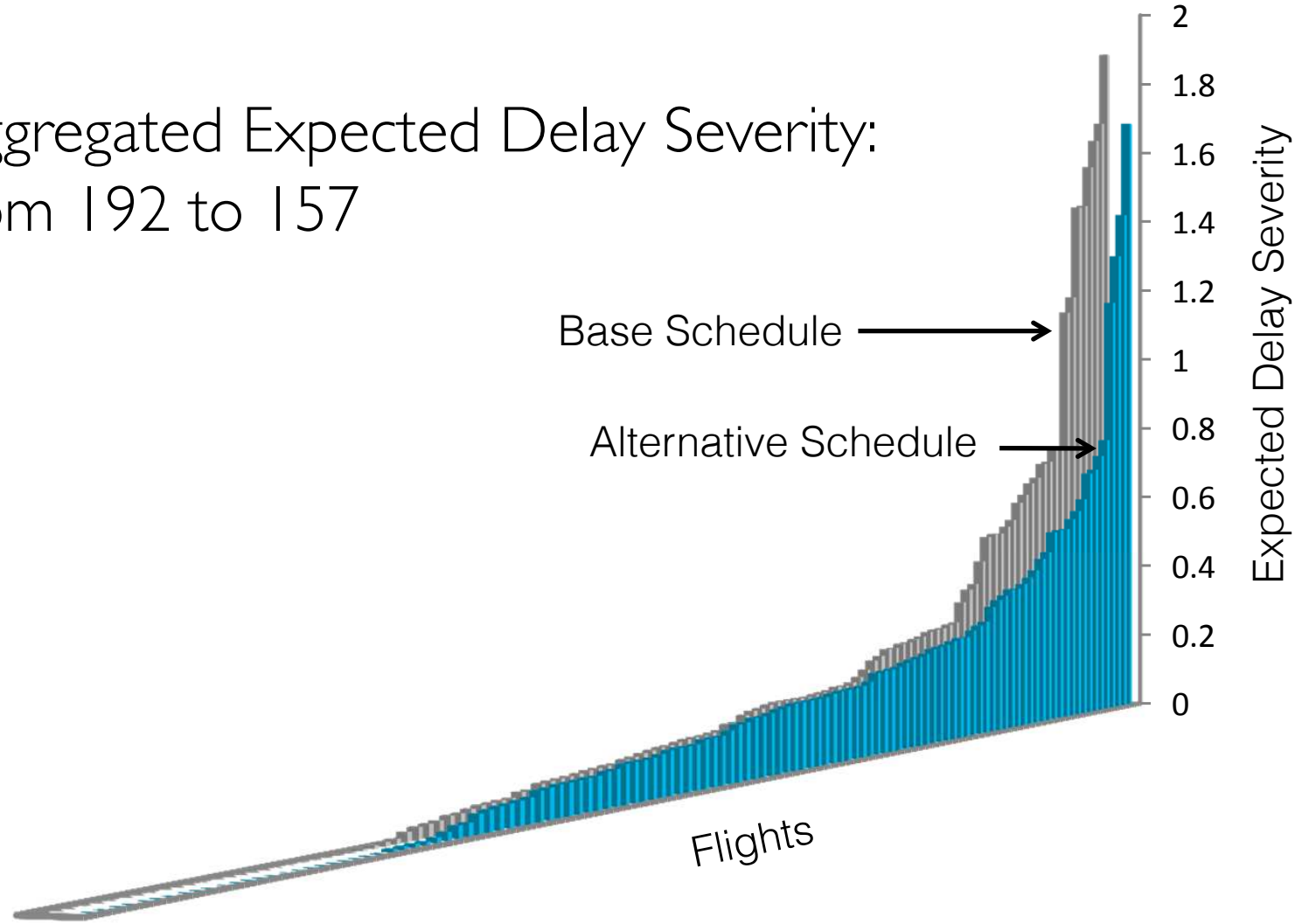
KQ0352 to Lagos
Base



KQ0352 to Lagos
Proposal

Overall improvements made

- Aggregated Expected Delay Severity: from 192 to 157



Academic conclusions

- Extended traditional Delay Propagation model:
  - Passenger connectivity
  - Stochastic Estimation
- Introduced the Delay Severity Curve
- Validation with empirical data
- Expected Delay Severity as metric

Deliverables for Kenya Airways

- Block-time analysis module
  - Implemented per Aug 2011
  - Advised on 27 of 125 flights, implemented per Sep 2011

- The stochastic simulation of delay propagation
  - Prototyping phase
  - Implementation requires automated database connections
  - Alternative flight timing for Lagos due Feb 2012

Directives for future research

- Extension to a generic simulation (Discrete Event)
- Integration of Cost Reference Model (Cook, 2011)
- Combine into an optimization research
- Incorporate Passenger Connection Saver