

ASHiCS

Automating the Search for Hazards in Complex Systems

SIDS 2012

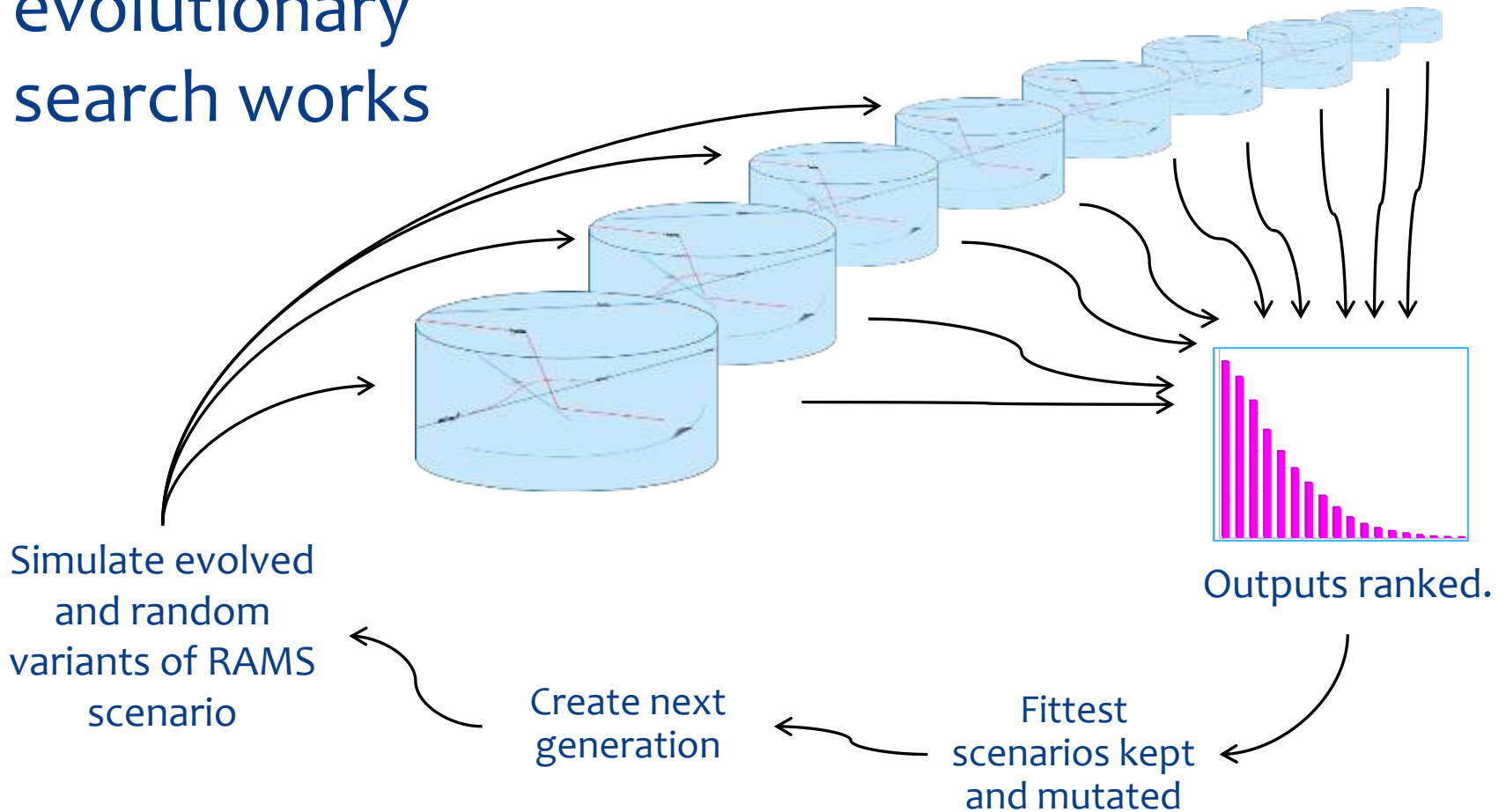
Kester Clegg & Rob Alexander

ASHiCS – searching for risk

- ASHiCS search harness sits around RAMS Plus ATC fast time simulator
- ASHiCS uses heuristics on simulation outputs to find scenarios of high risk for a given air sector
- Weighted heuristics can focus on specific incident types, flight paths or aircraft

ASHiCS

How ASHiCS evolutionary search works

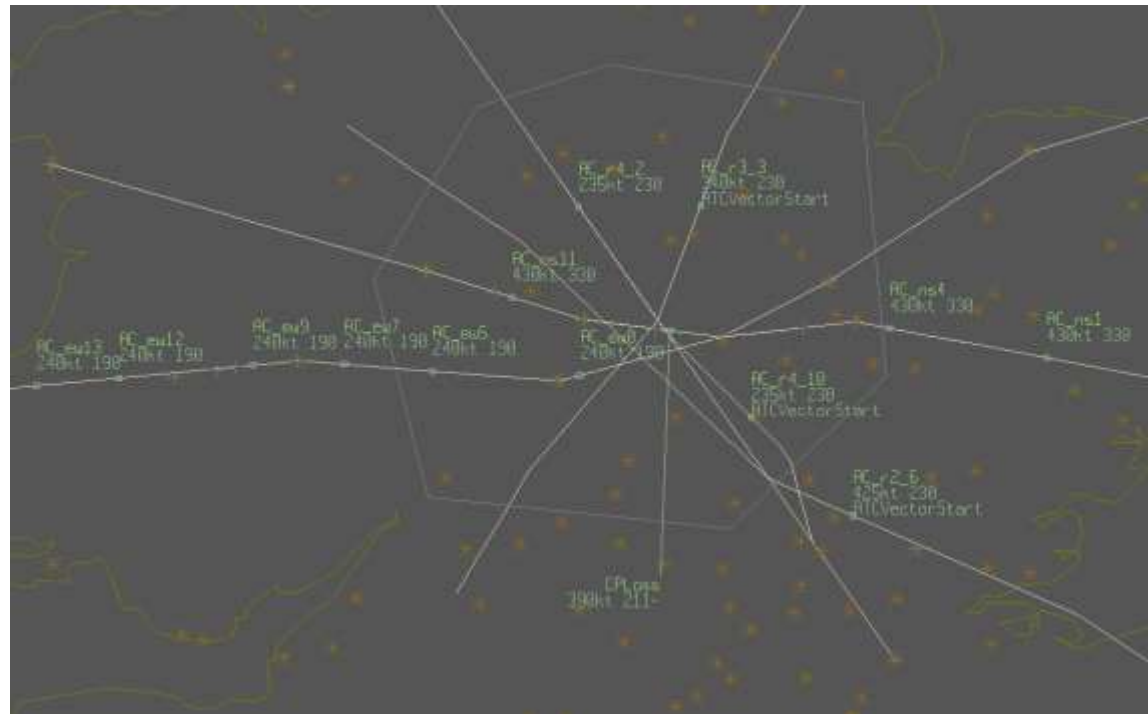


ASHiCS – Fitness ranking criteria

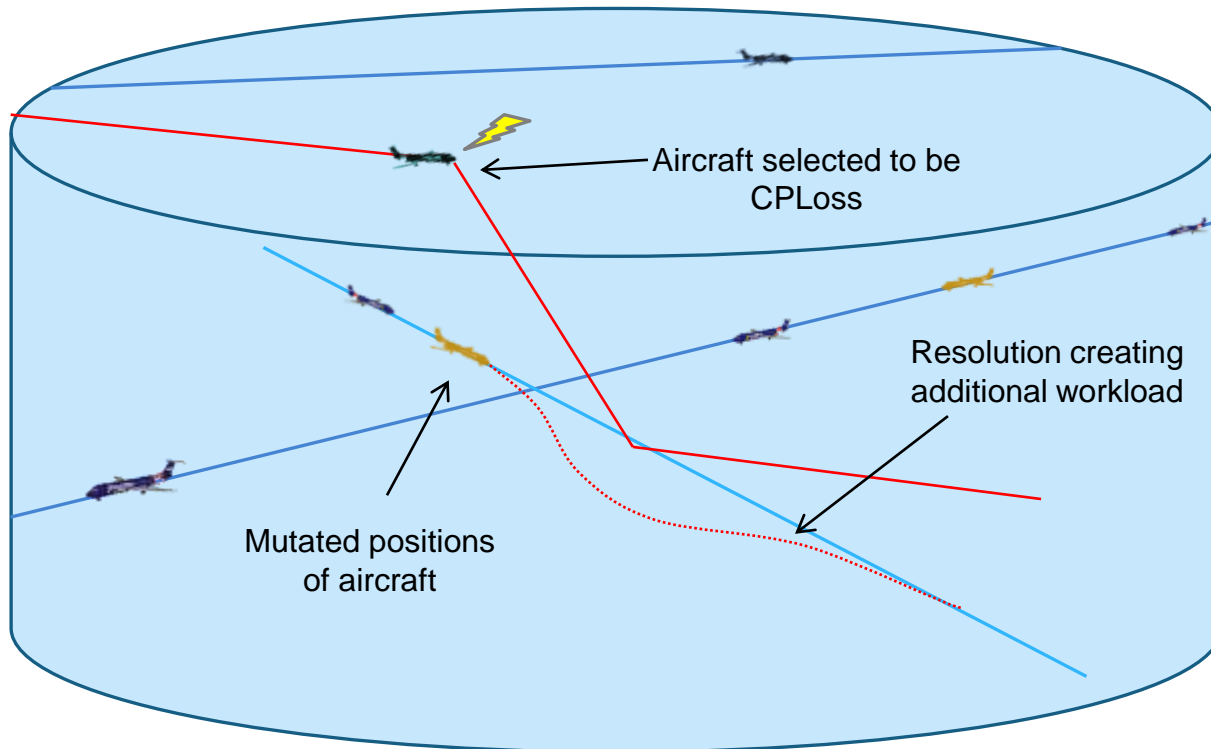
- ASHiCS is looking for **high risk** or **hazardous** scenarios
 - ‘Basket’ of risk measures give compound fitness score
 - No. of conflicts
 - No. of resolutions
 - Lowest conflict separation percentage for worst conflict
 - Total task workload
 - Weighted heuristics
 - Conflicts with CPLoss
 - Multipliers to offset certain values (CSP raised, taskload lowered, etc)
- Recently added NASA complexity measures...

Stage 2 Scenario

- RAMS Plus ATC simulator
- En-route air sector
- 2 principal flight paths, 3 minor flight paths
- Mixture of flight levels and aircraft
- Random emergency cabin pressure loss incident (CPLoss)



Worst case for CPLoss



- We look for high workload, high number of conflicts
- Aircraft fixed on flight paths but entry times are mutated to generate conflicts
- CPLoss emergency event triggered by fixed waypoint

Issues when searching for risk...

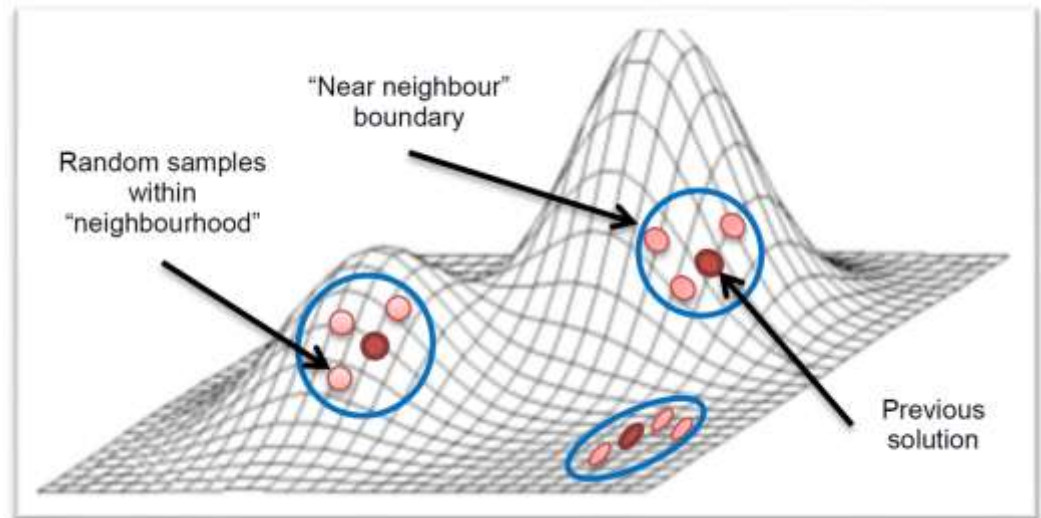
- High risk scores may not point to a specific incident that exceeds safety margins
- Search will always find some level of risk
 - Need for targeted heuristics
- What does a compound risk measure discover?
 - A ‘bad’ scenario – how bad? In what way was it bad? Did you target a specific event of interest? What did you miss?
 - Have you discovered a freak traffic configuration? What is the neighbourhood of related configurations like?

ASHiCS – search landscape

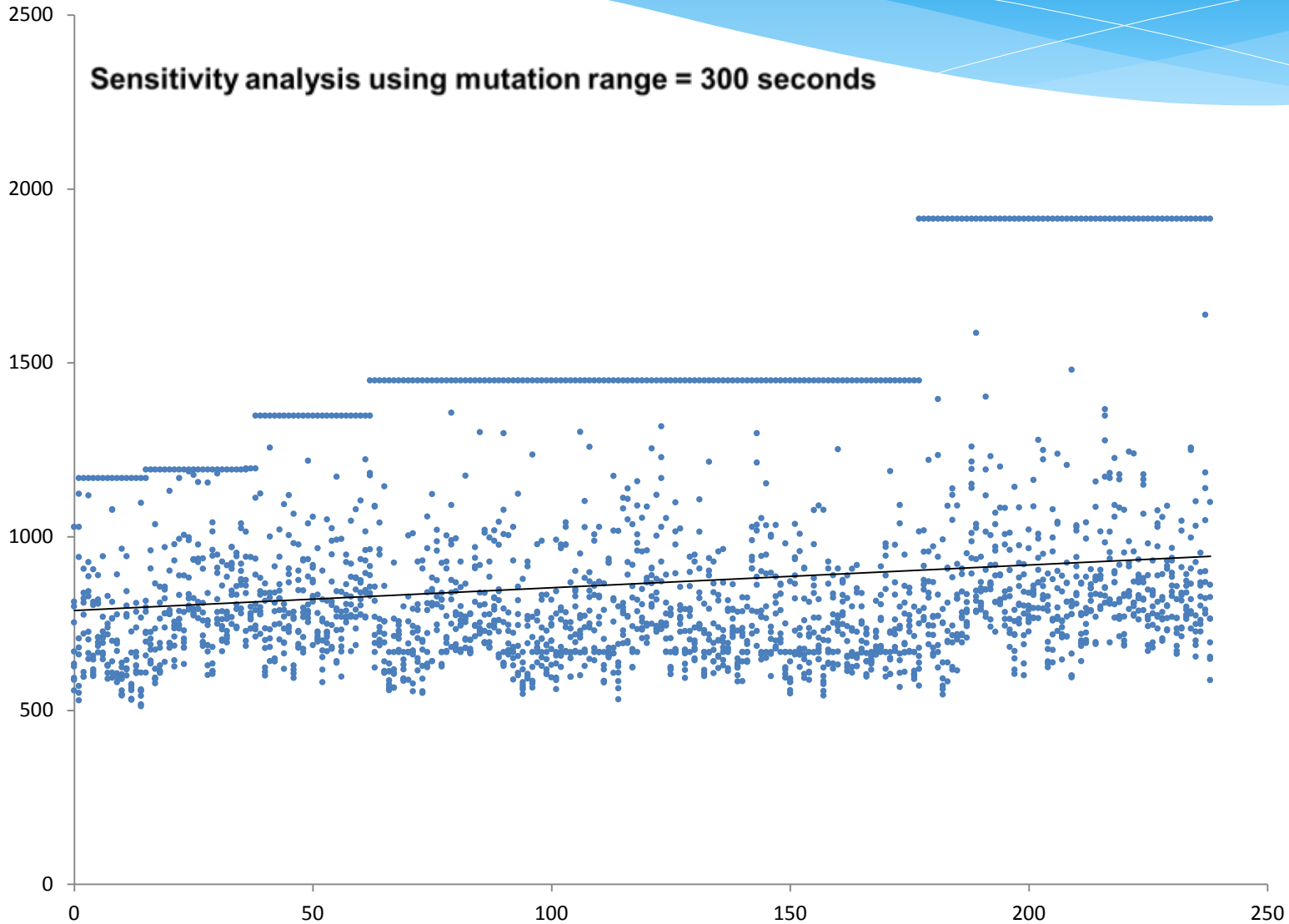
- We needed to find out more about the context of our search results
 - Cost of tackling risk (via implementation of safety barriers) = *cost of outcome X frequency of event*
 - Are we finding rare events?
 - Are many results similar wrt safety analysis?
 - Same event, slightly different configuration...
 - Same safety barriers might cover most permutations

ASHiCS – search algorithm

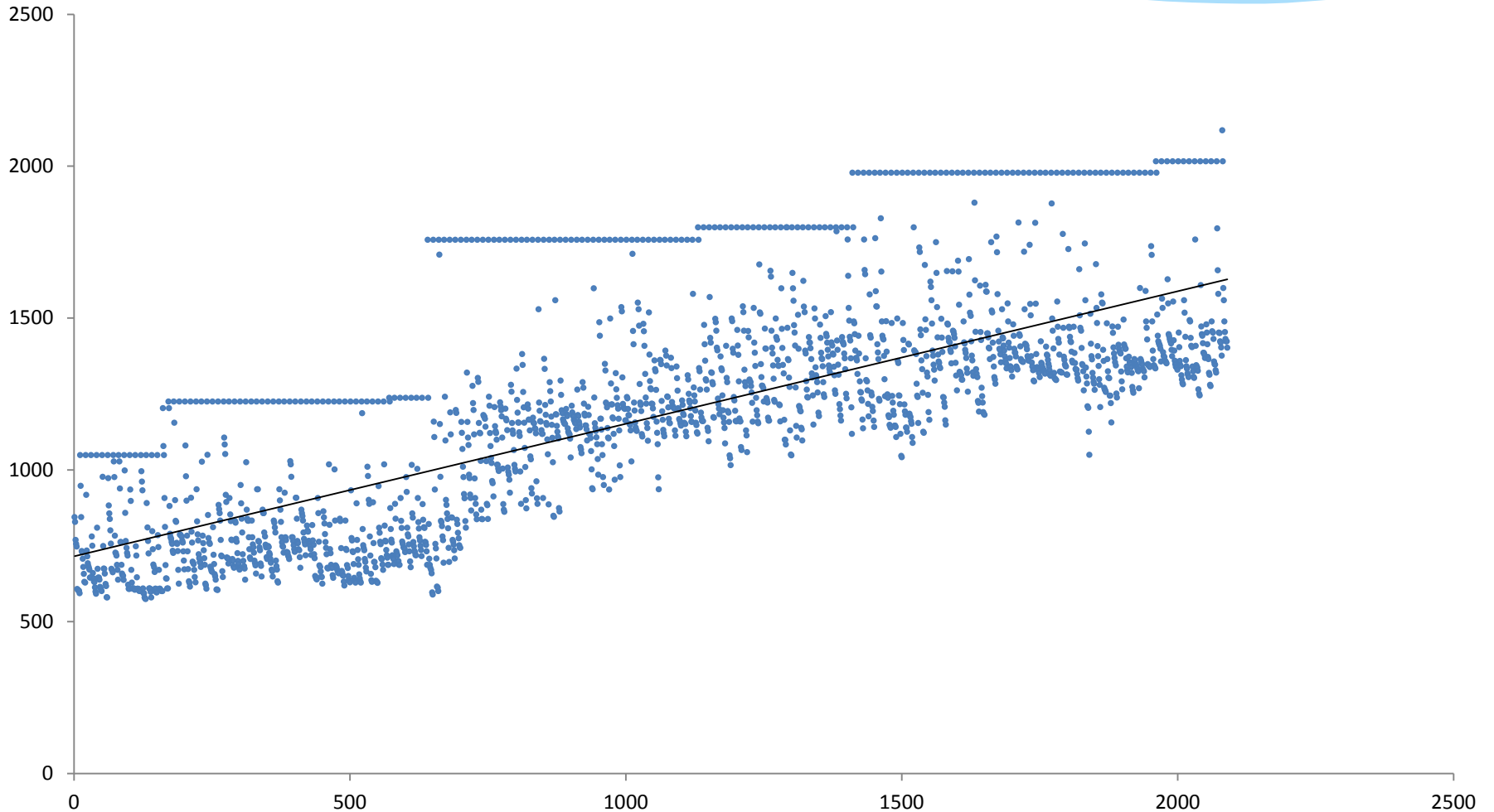
- Random hill-climber
- ‘Near neighbour’ sampling
- Gradual fitness improvement



ASHiCS

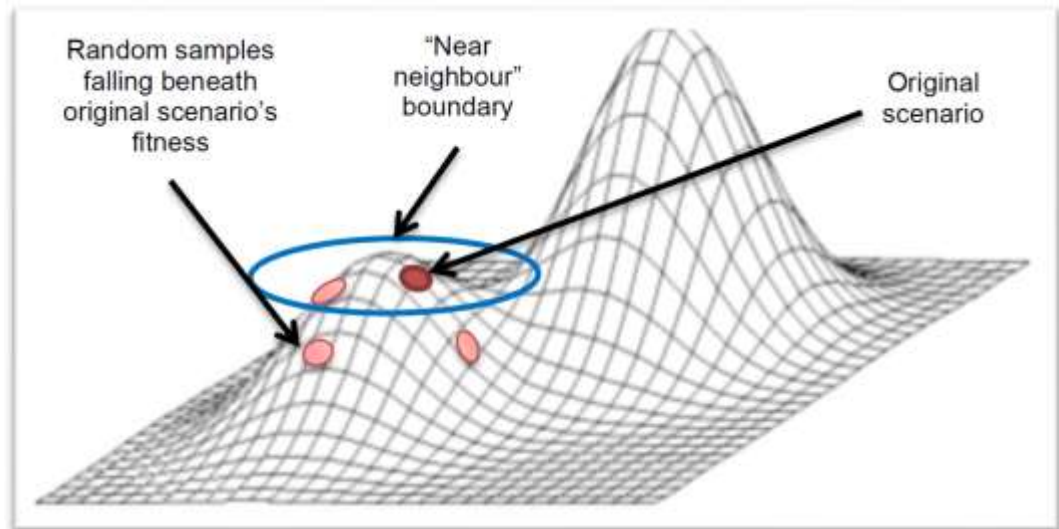


Sensitivity analysis using mutation range = 30 seconds



ASHiCS – search landscape

- Mutation range critical on this landscape
- Too large a mutation range makes it hard to climb fitness peak



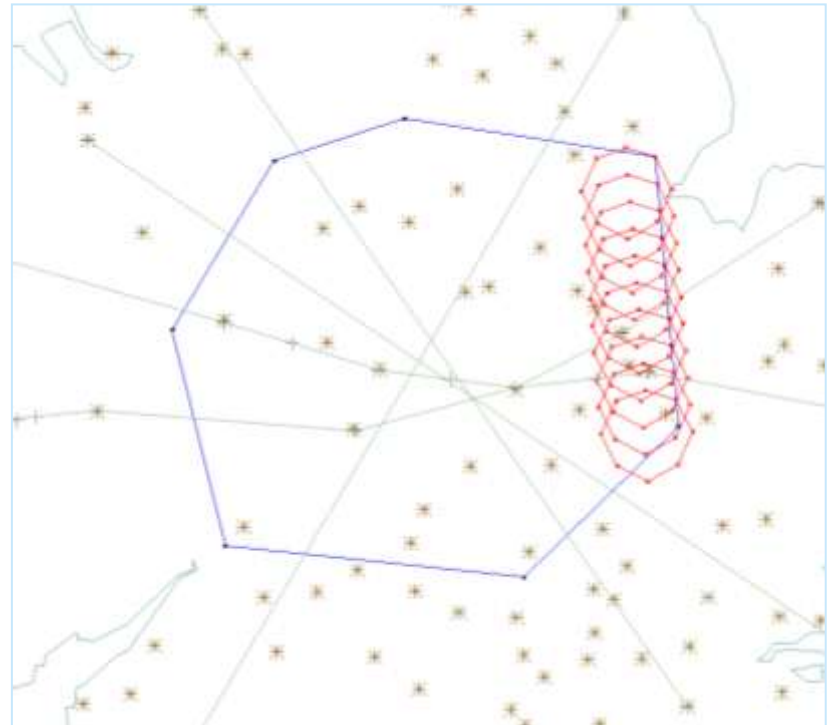
ASHiCS – conclusions

- High fitness peaks in the risk landscape are very sensitive to parameter adjustments
- We attempted dimension reduction to help with context (without success)
 - Problem is that exhaustive search is impossible
 - On-going work, perhaps PCA may help?
- We still can't answer frequency question
 - How many high risk variants of a scenario are there?
 - Hard to help with quantitative safety analysis – best we can say is that high risk variants exist

ASHiCS – future work

Adding greater complexity to Stage 2

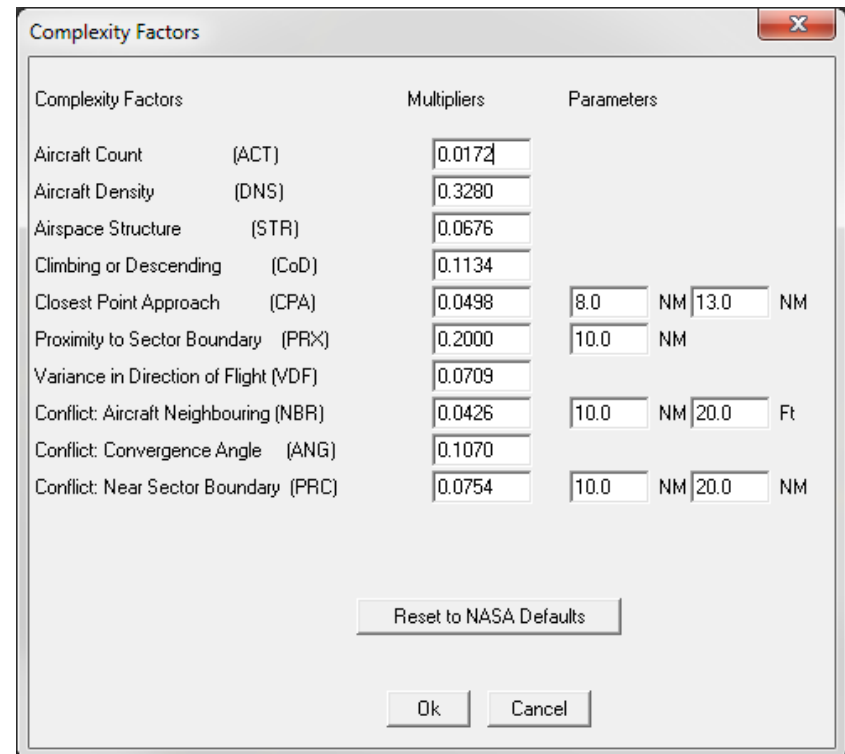
- Thunderstorm implemented as series of time limited restricted zones
- Search selects start point, speed & direction of storm
- Currently aircraft vectored around storm



ASHiCS – future work

Measuring increased complexity

- RAMS has NASA complexity factors
- Originally intended for MSP, but can be applied to single sector
- Gives an additional compound measure for fitness function
- Greater complexity = greater risk? Similar issues as before?



The screenshot shows a dialog box titled "Complexity Factors" with a close button (X) in the top right corner. The dialog is divided into three columns: "Complexity Factors", "Multipliers", and "Parameters".

Complexity Factors	Multipliers	Parameters
Aircraft Count (ACT)	0.0172	
Aircraft Density (DNS)	0.3280	
Airspace Structure (STR)	0.0676	
Climbing or Descending (CoD)	0.1134	
Closest Point Approach (CPA)	0.0498	8.0 NM 13.0 NM
Proximity to Sector Boundary (PRX)	0.2000	10.0 NM
Variance in Direction of Flight (VDF)	0.0709	
Conflict: Aircraft Neighbouring (NBR)	0.0426	10.0 NM 20.0 Ft
Conflict: Convergence Angle (ANG)	0.1070	
Conflict: Near Sector Boundary (PRC)	0.0754	10.0 NM 20.0 NM

At the bottom of the dialog, there is a "Reset to NASA Defaults" button, and "Ok" and "Cancel" buttons.