

Analysis of Relationship between Air Traffic Demand, Safety and Complexity in FABEC Airspace

9th SESAR Innovation Days



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Introduction

- By 2021 over 12.3 million operations in European sky
- Challenge for the safety, the en route sector capacity and impact on the environment
- FRA and FAB concepts - crucial 'tools' for solving those issues



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Objective of the Study

- Having in mind changes in the European airspace (such as introduction of FRA and FABs) and constantly growing traffic demand, the following research questions emerged:
- Is there any relationship between traffic demand, air traffic complexity and safety?
- Are there any differences in those relationships between seasons?



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Study Approach (1)

- A showcase methodology on the analysis of FABEC:
 - how **performance indicators** (existing and the new ones) could be used to assess operational and safety performance,
 - advantages and benefits of operational changes/concepts such as FRA,
 - to set **a benchmark** for further assessment of potential benefits of operational environment changes in airspace due to implementation of FRA.



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Study Approach (2)

- Use Case: FABEC airspace
- Traffic: Actual M3 trajectory - EUROCONTROL DDR2
 - above FL195,
 - 2 weeks of 2017 operated traffic:
 - Summer (July 3–9, 2017, with 131.268 flights) and
 - Fall (November 13–17, 2017, with 94.947 flights)

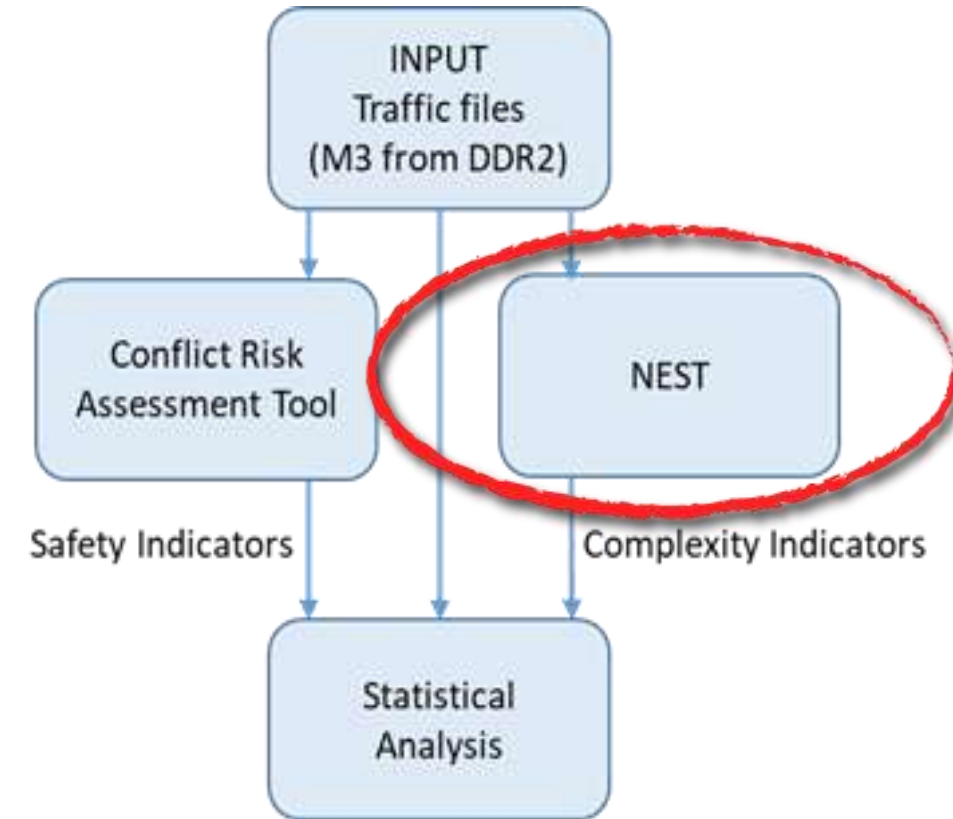


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Study Approach (3)

- **Complexity**
 - a macroscopic view
 - EUROCONTROL methodology:
 - Adjusted density (*assesses the potential interactions resulting from density, including uncertainty in the trajectories and time*)
 - Structural index (*balances the density metrics according to the interaction geometry and aircraft performance differences*)
 - Complexity score



Study Approach (4)

- **Conflict Risk / Safety**

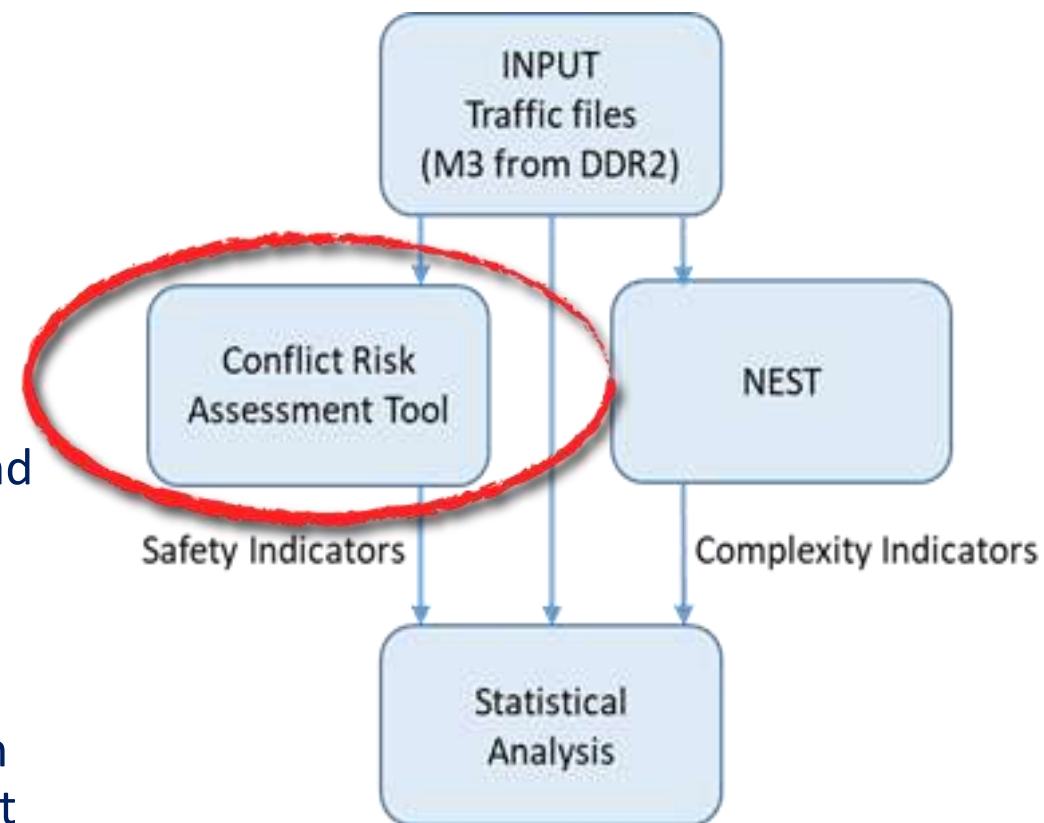
- **Conflict Risk Assessment Tool**

- Separation violation detection module

- used for the calculation of duration, severity and number of PLoS

- Risk of Conflict assessment module

- simulation of flights
 - comparison of the actual separation of a/c with a given separation minima in order to detect PLoS





Safety performance indicators

- Potential losses of separation (PLOS) represent the area of potential safety concern
 - both vertical and horizontal separation minima breached
 - 5NM horizontally and 1000ft vertically, but minima were relaxed for 10% (4,5 NM and 900 ft) to deal with potential position and altitude inaccuracies
- Risk of Conflict / Conflict Risk
 - calculation of "elementary risk" for each conflicting a/c pair considering duration and severity of PLOS
 - Calculation of total risk

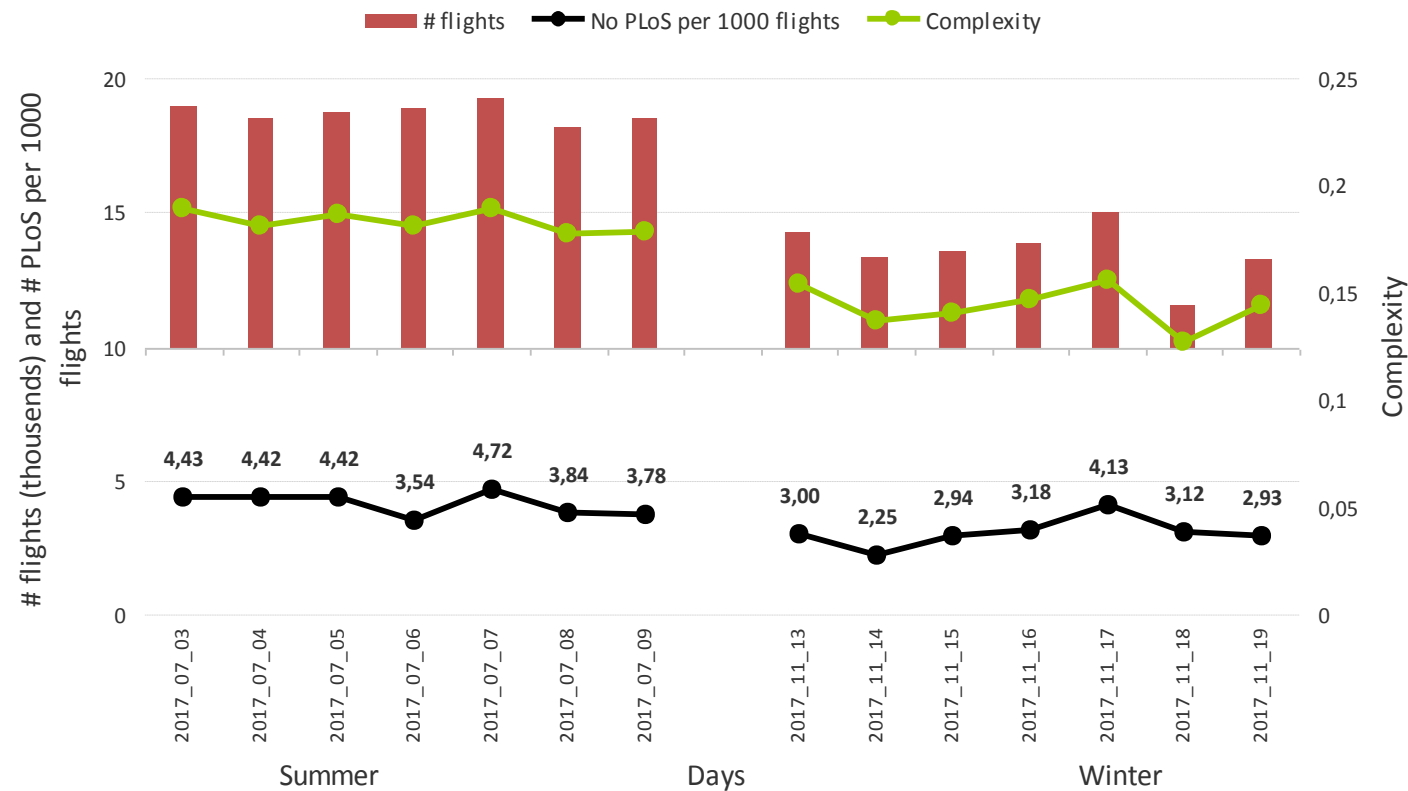


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Complexity and safety indicators overall analysis (1)

- No PLoS per 1000 flights is lower in winter



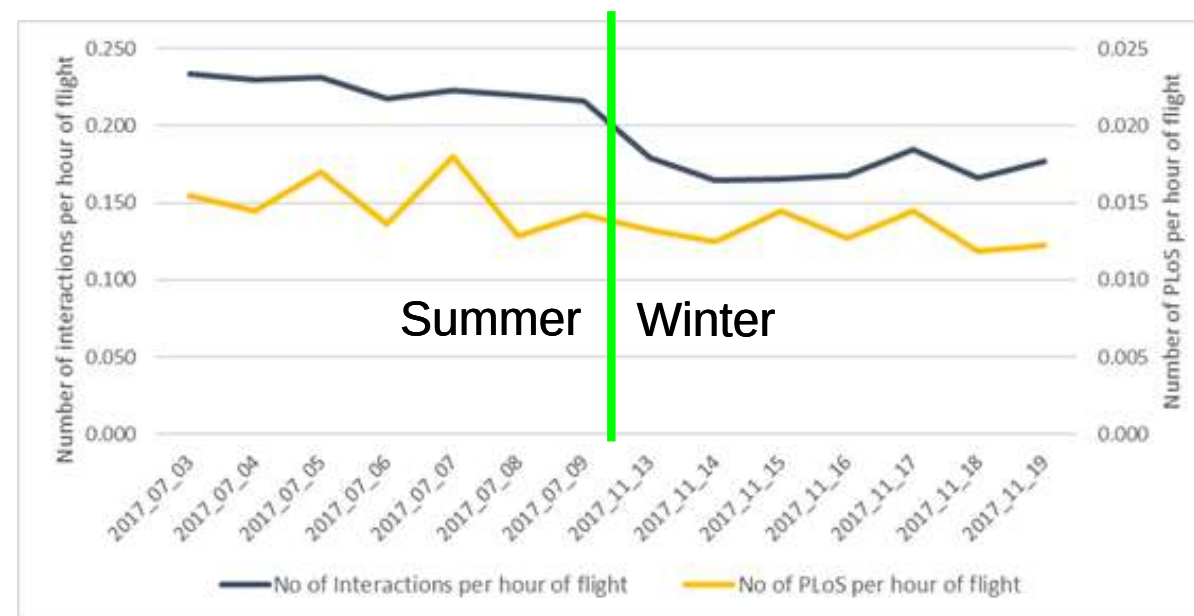
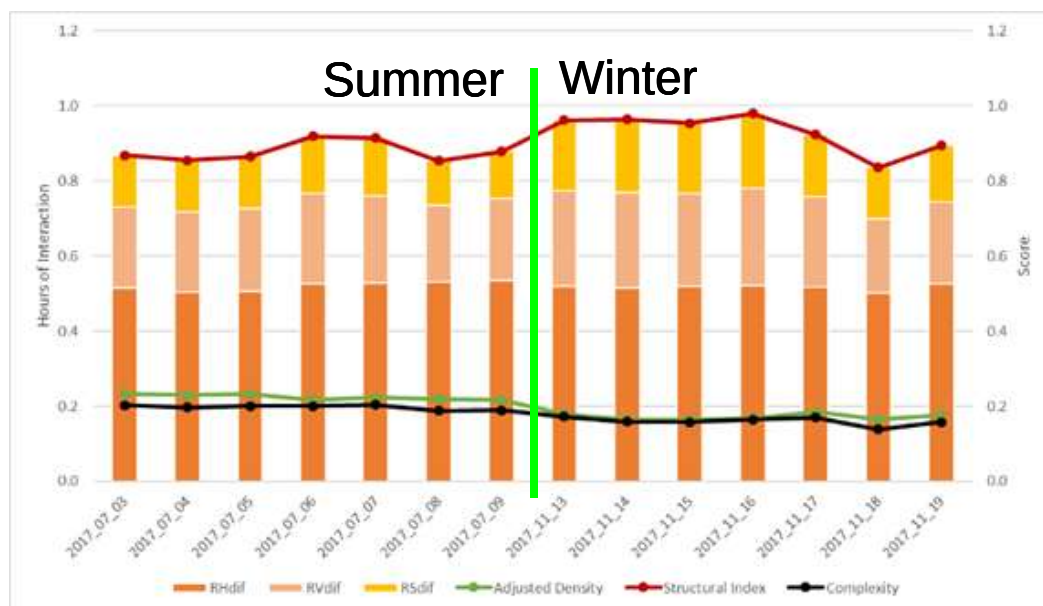
Complexity and safety indicators overall analysis (2)

- Daily changes in complexity are following the changes of daily traffic demand
- The changes in daily number of PLoS and conflict risk do not follow strictly the changes in daily traffic demand

Season	Traffic	Complexity	No PLoS	Risk
Summer vs. Winter	↑ 22 to 37%	↑ 17 to 29%	↑ 33 to 63%	↑ 28 to 65%

Complexity and safety indicators overall analysis (3)

Season	Total no of interactions	No of interactions per hour of flight	No PLoS per hour of flight
Summer vs. Winter	↓	↑ 23% (0.224 vs 0.172)	↑ 13% (0.015 vs 0.013)



PLoS probability

- the probability of separation losses in FABEC is **reducing in winter**



15,11 in 1000

PLoS per 1000 flights



13,07 in 1000

PLoS per 1000 flights

Correlation between traffic, complexity and safety indicators (1)

- Increase in traffic → the higher complexity → higher number of PLoS and conflict risk

Both Seasons (R^2)	Complexity	PLoS	Risk of Conflict
Number of Flights	+0.9807	+0.8819	+0.8008
Complexity	-	+0.9138	+0.8296

- ATCo task load will increase, leading to a higher ATCo workload



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Correlation between traffic, complexity and safety indicators (2)

- Strong correlation between the daily No flights and Complexity
- Positive correlation between No flights and conflict risk is not significant in both seasons

Summer (R ²)		Complexity	PLoS	Risk of Conflict
Number of Flights		+0,7163	+0,3716	+0,3114
Complexity		-	+0,6980	+0,5144
Winter (R ²)		Complexity	PLoS	Risk of Conflict
Number of Flights		+0,9022	+0,5005	+0,2207
Complexity		-	+0,5640	+0,2843



PLoS severity and duration

- PLoS severity (related to the breach of separation) depends on the minimum spacing between the pair of aircraft ($S_{\min}$) and the applied separation minima ($Sep_{\min}$)

$$\text{Severity} = (Sep_{\min} - S_{\min}) / Sep_{\min}; \text{ where } 0 \leq \text{Severity} \leq 1$$

- in 80% of cases severity is 1, which means that both aircrafts were at either the same flight level or at the same point in the horizontal plane
- Results of PLoS duration analysis show that majority of PLoS are short, up to 30 sec (roughly two-thirds)
 - almost 90% do not last more than 1 min

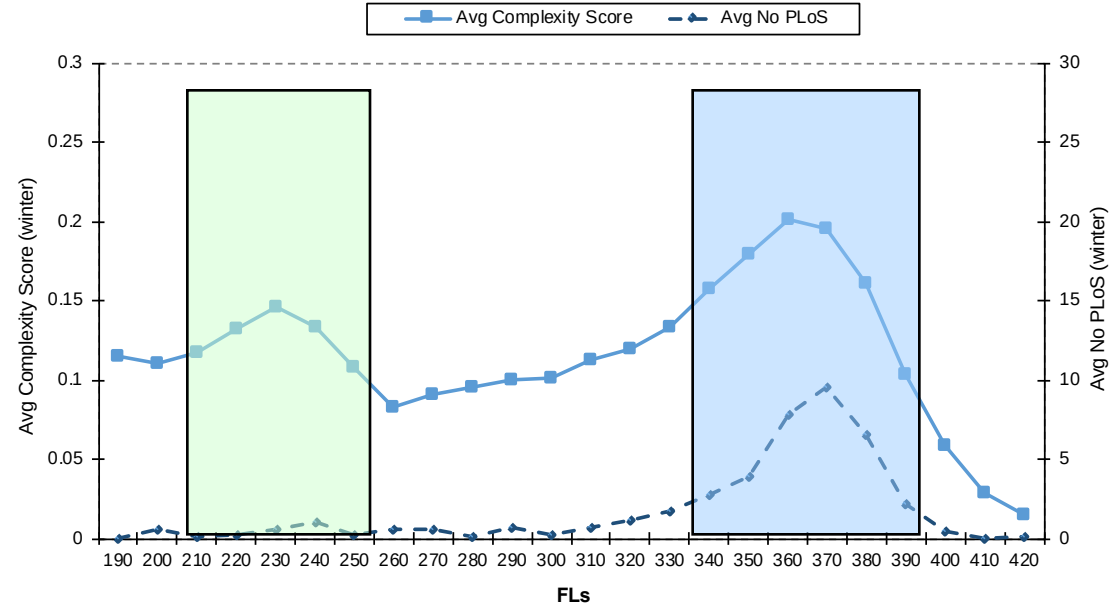
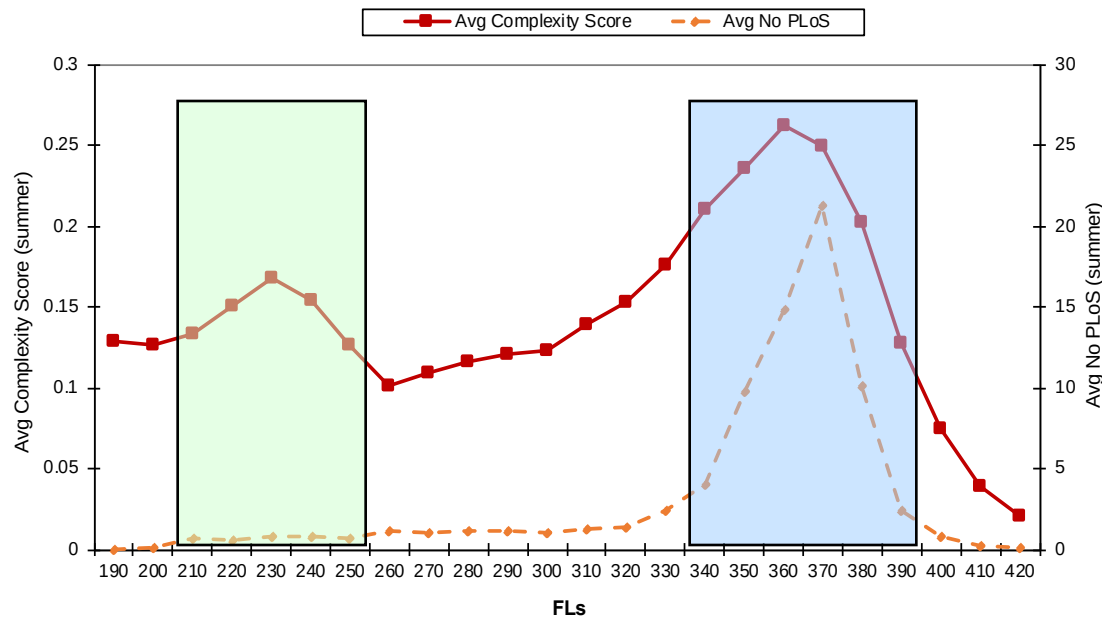


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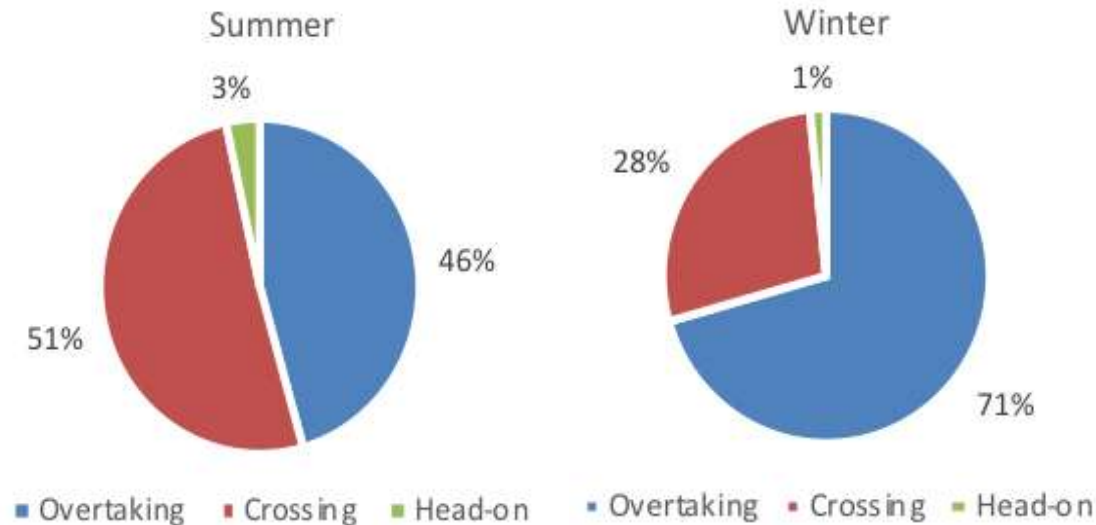
Complexity and safety per flight level

- Traffic seasonality is influencing higher complexity values; moreover, the number of PLoS evidently contributes to higher complexity values



Geometrical characteristics of PLoS (1)

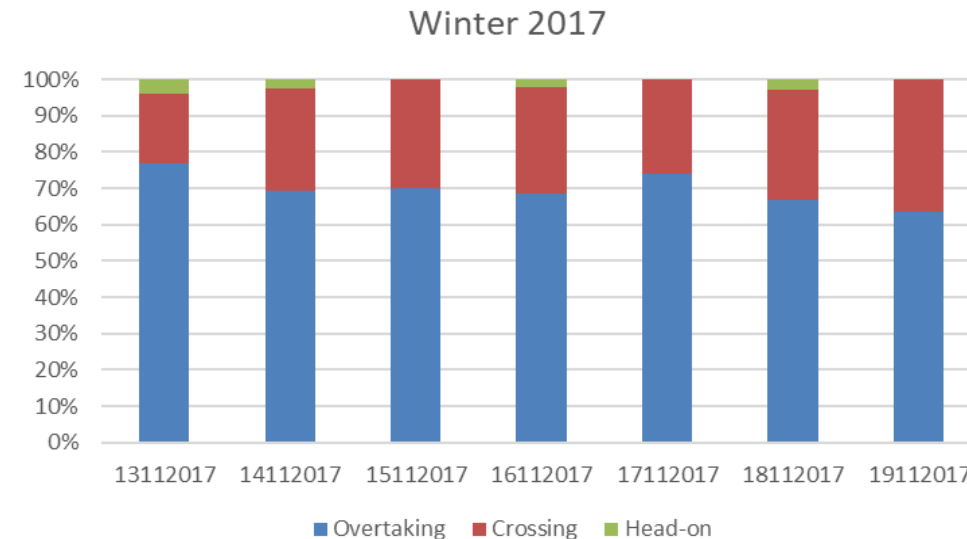
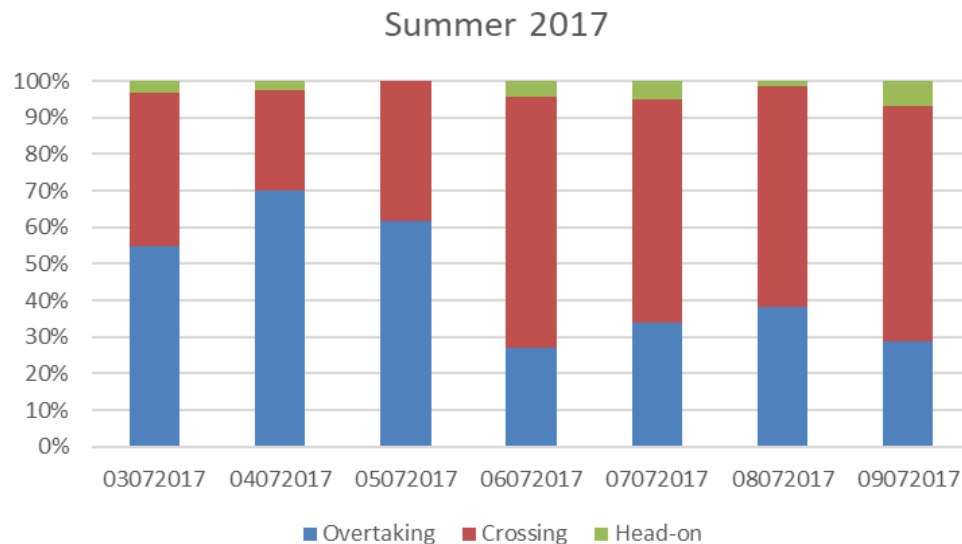
- In summer sample percentage of overtaking and crossing PLoSs is almost similar (51 vs. 46%) while in winter there are more overtaking PLoSs (71%)



- overtaking (difference between headings is $\pm 70^\circ$)
- crossing (difference between headings is in a range between ± 70 and $\pm 160^\circ$) and
- head-on encounters (difference between headings is in a range between ± 160 and 180°)

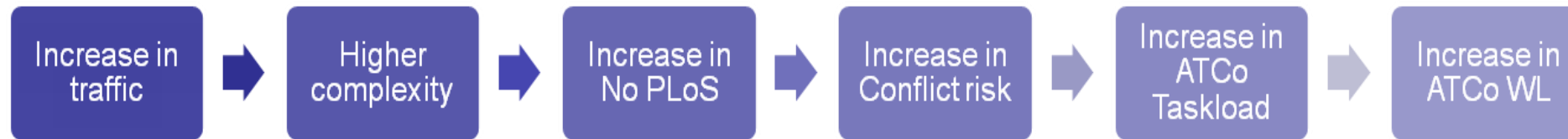
Geometrical characteristics of PLoS (2)

- Daily values show that share of encounter types are more stable during the winter which could be related to more uniform traffic flows during winter months (e.g. no seasonal and charter flights)



Conclusions and Further work (1)

- Small-scale analysis showed that changes in traffic demand do influence complexity and safety performance



- **Set a benchmark** for future monitoring of safety and operational performance during FRA implementation



Conclusions and Further work (2)

- Further analysis will investigate whether dispersion of traffic after FRA implementation
 - is enough to create complexity decrease and
 - whether change in complexity have not compromised safety and ATCo workload
- Further improvement will include:
 - increased traffic sample, complexity per sector, traffic type, vertical profiles, workload, etc.



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Thank you!

See you hopefully
in Rome
with new results



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Back Up slides

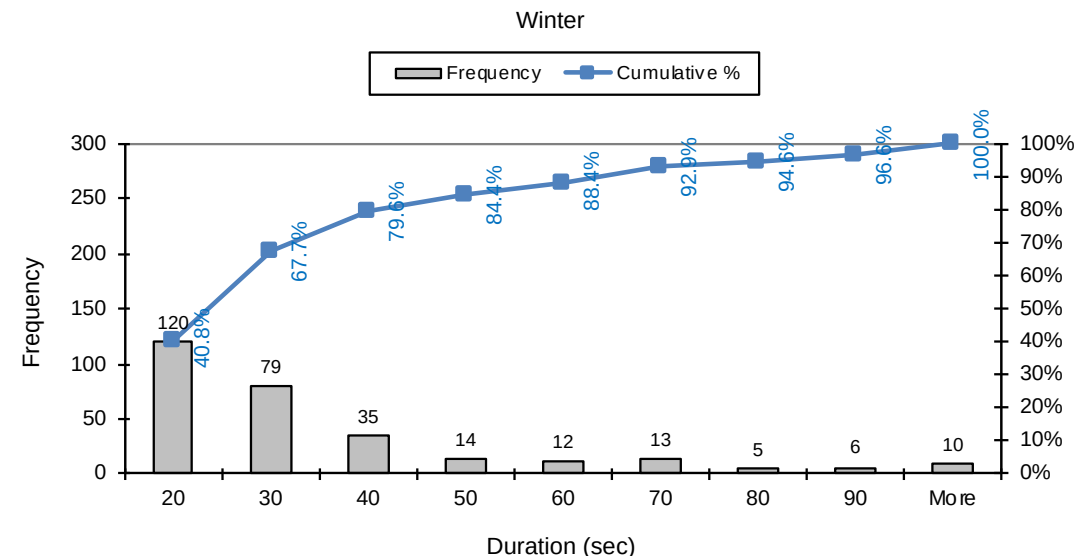
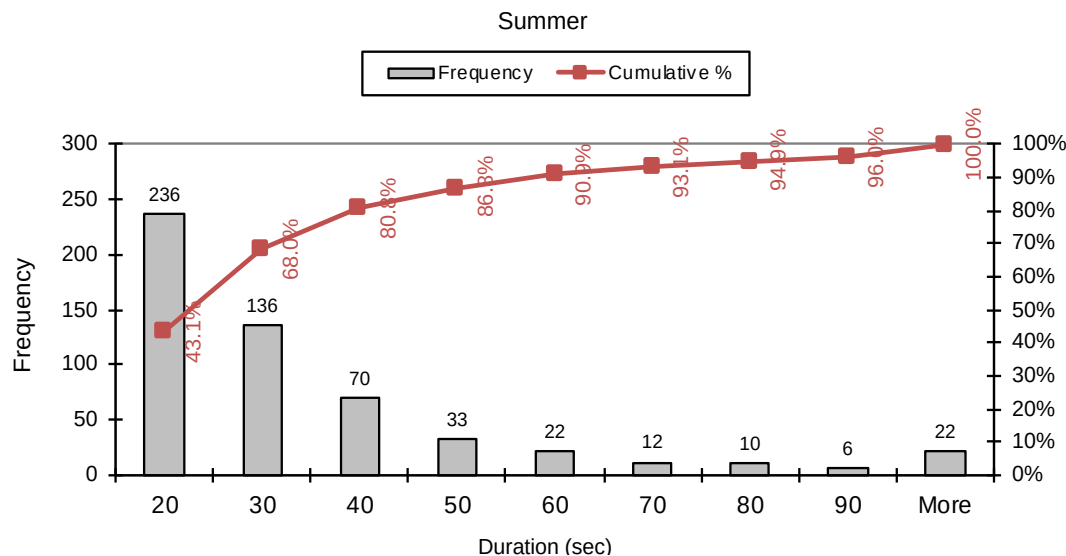


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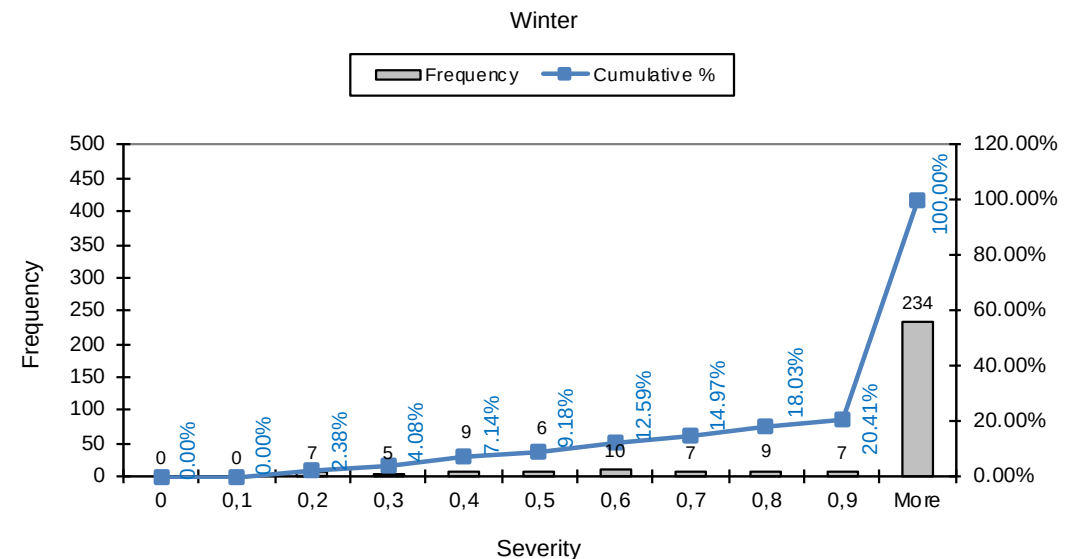
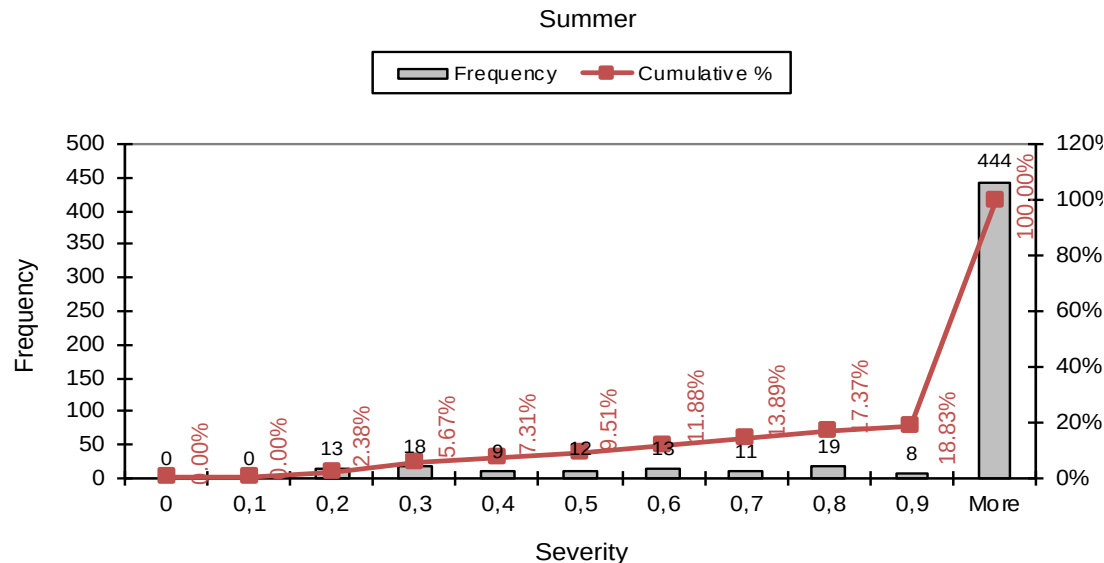
Analysis of potential losses of separation (1)

- Results of PLoS duration analysis show that majority of PLoSs are short, up to 30 sec (roughly two-thirds, i.e. 372 cases), while almost 90% do not last more than 1 min.



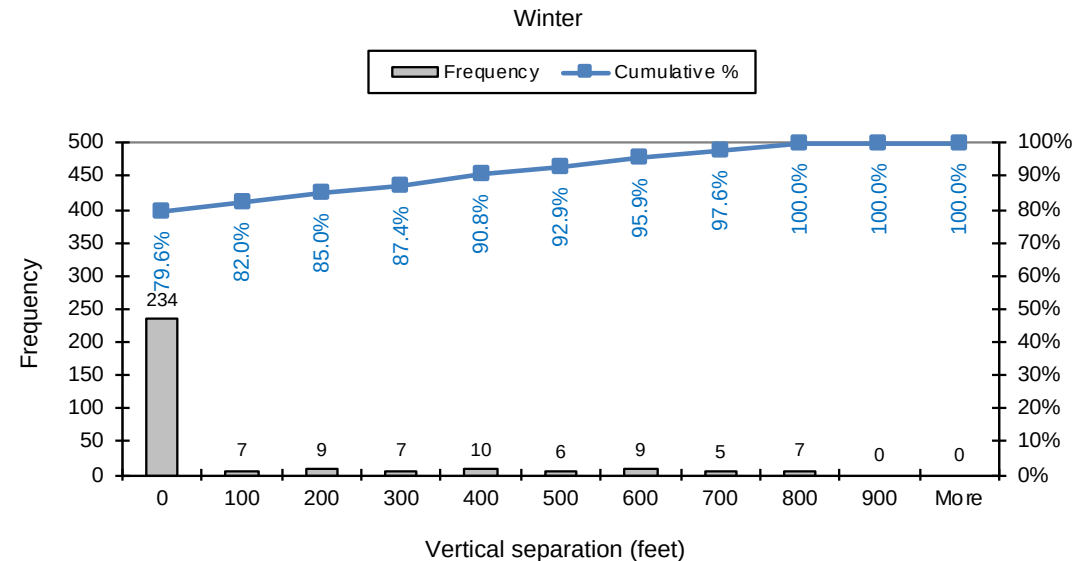
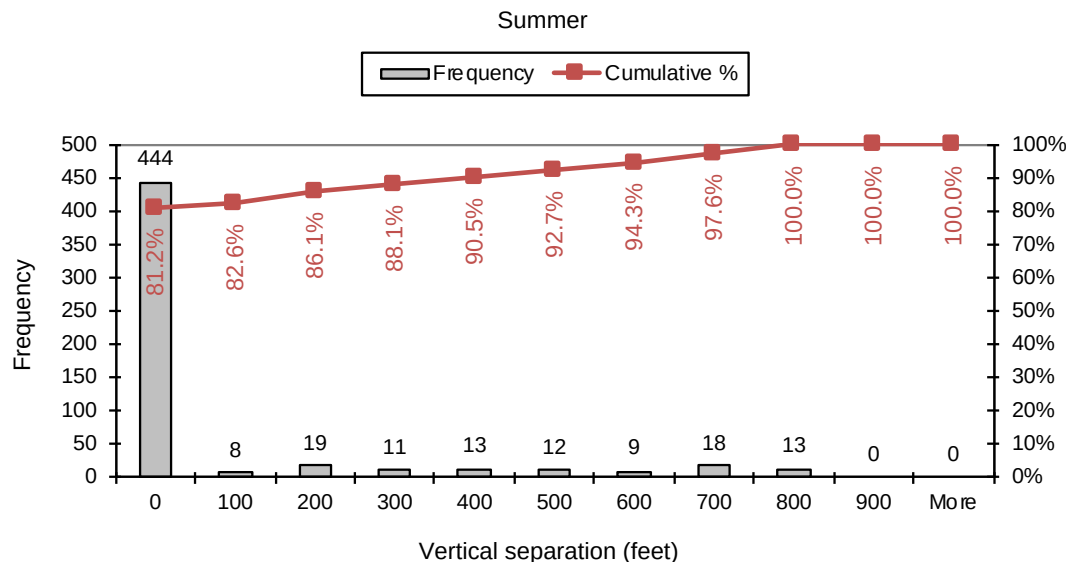
Analysis of potential losses of separation (2)

- Results of PLoS severity analysis show that in 80% of cases severity is 1, which means that both aircraft were at either the same flight level or at the same point in the horizontal plane.



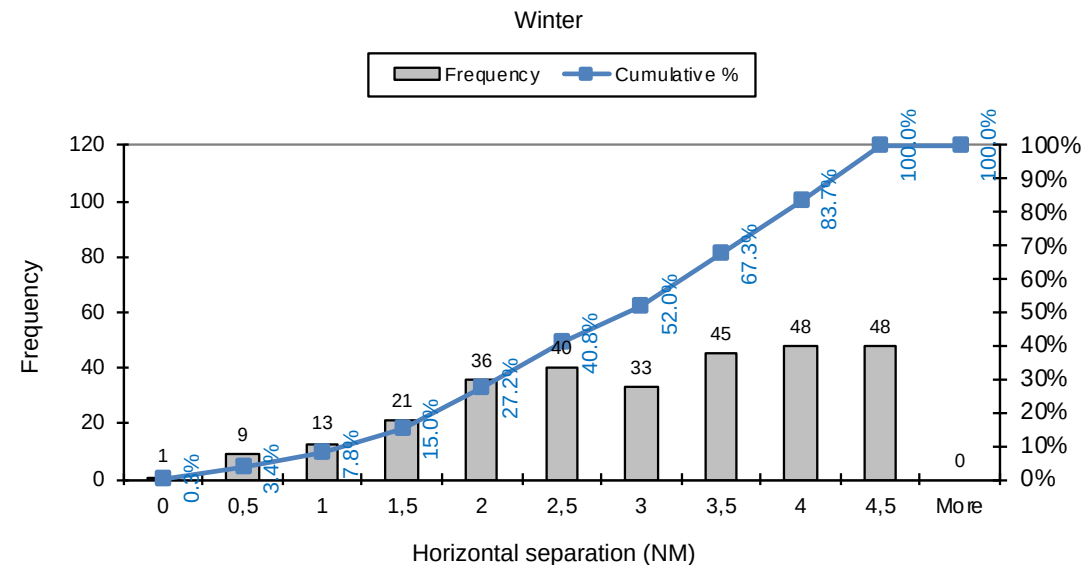
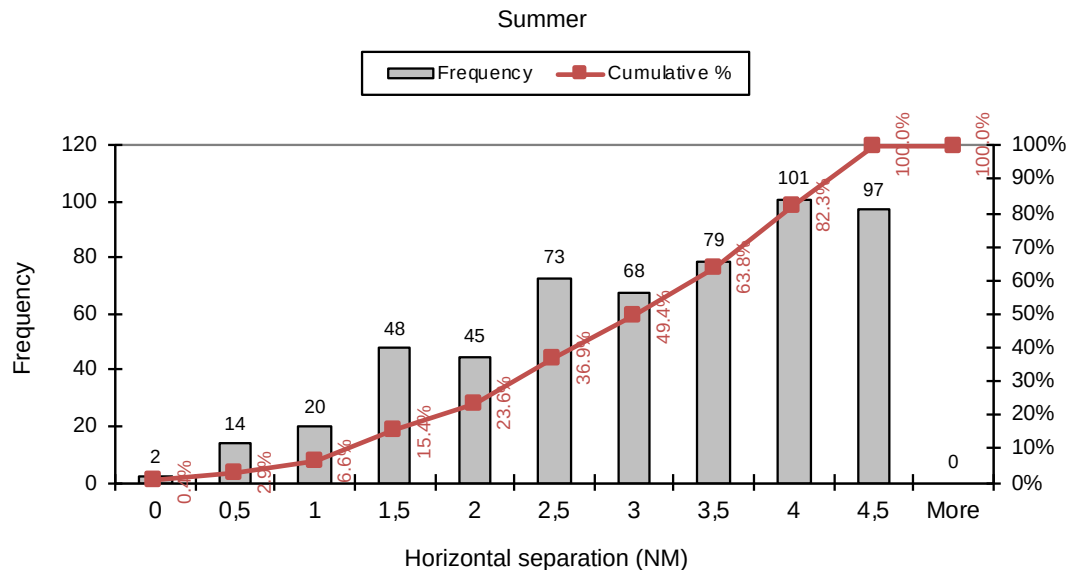
Analysis of potential losses of separation (3)

- The results of the distribution of minimum vertical separation at the CPA show that almost 80% of PLoSs are at the same flight level or are separated vertically up to 100 ft.



Analysis of potential losses of separation (4)

- The results of horizontal distribution show that roughly 50% of PLoSs have breach of less than 3 NM.



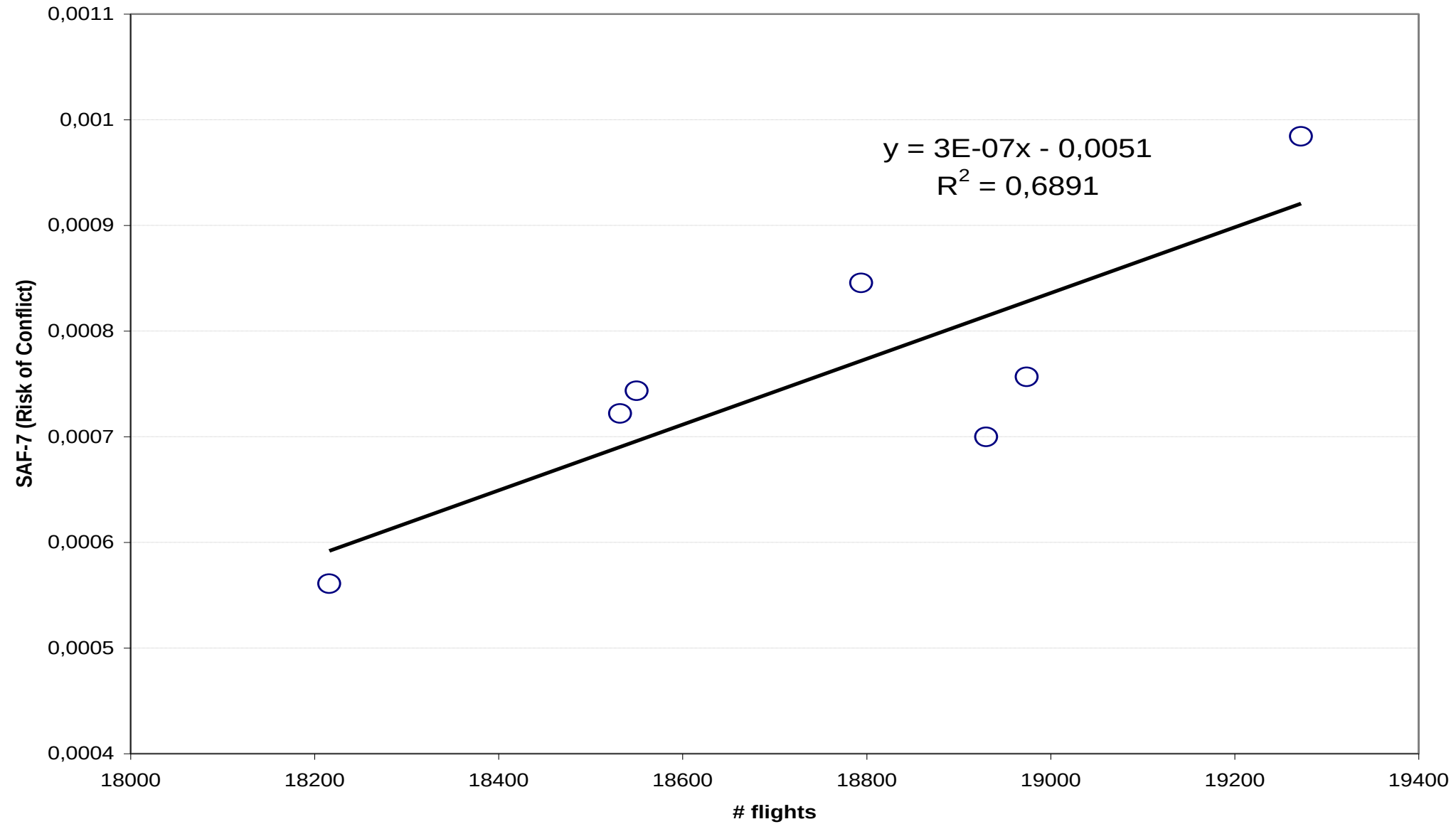


Summer 2017



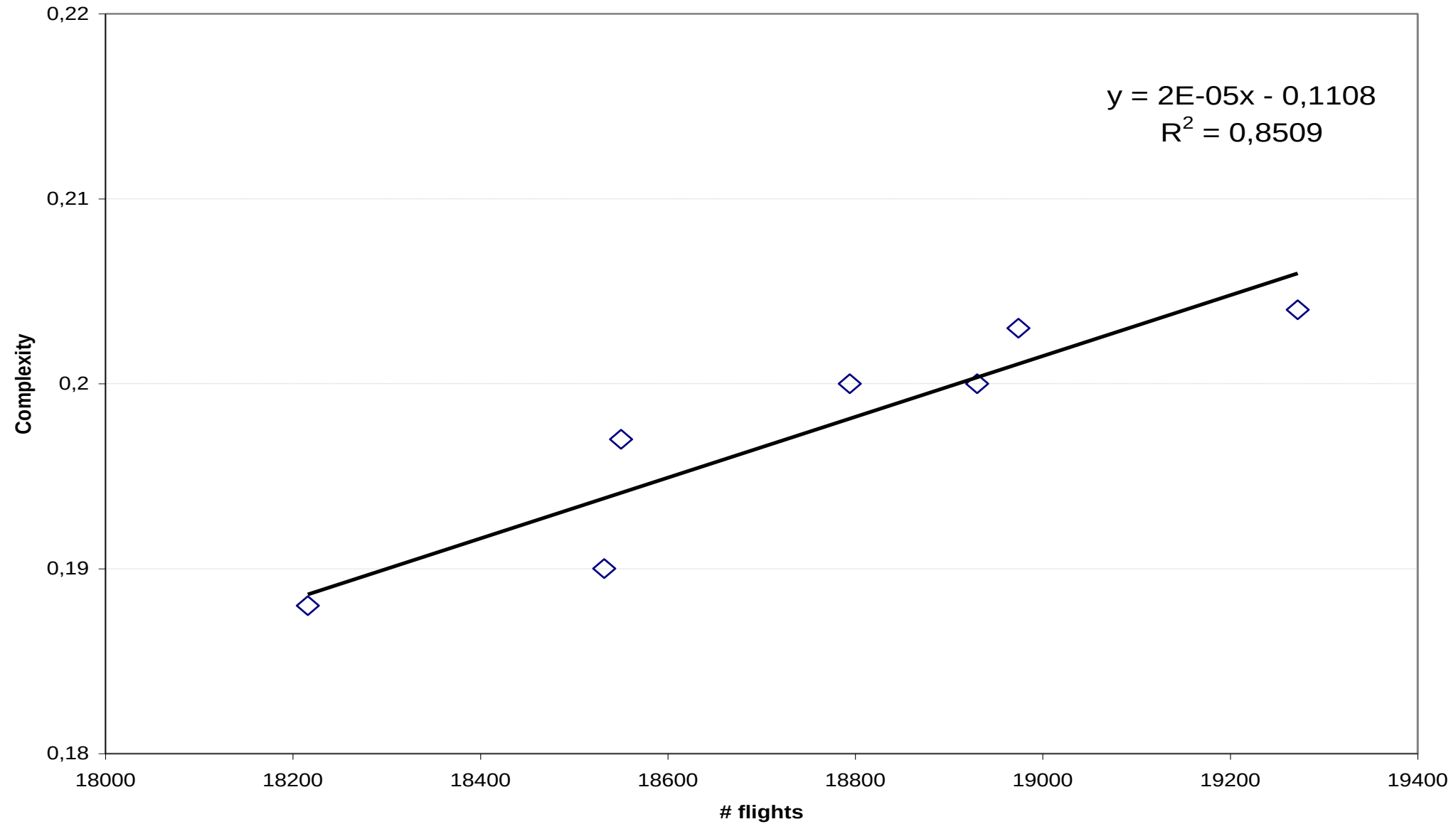
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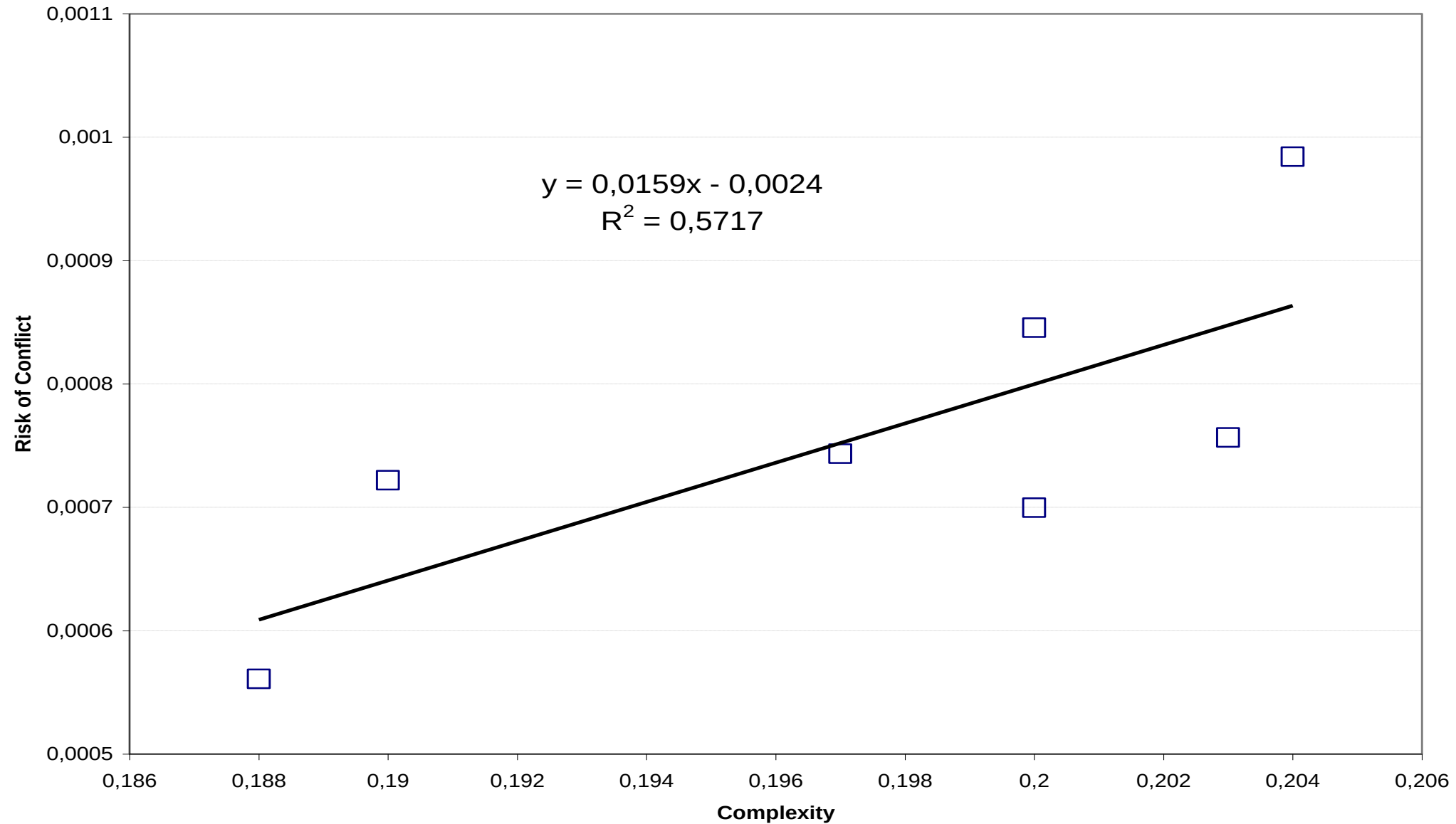
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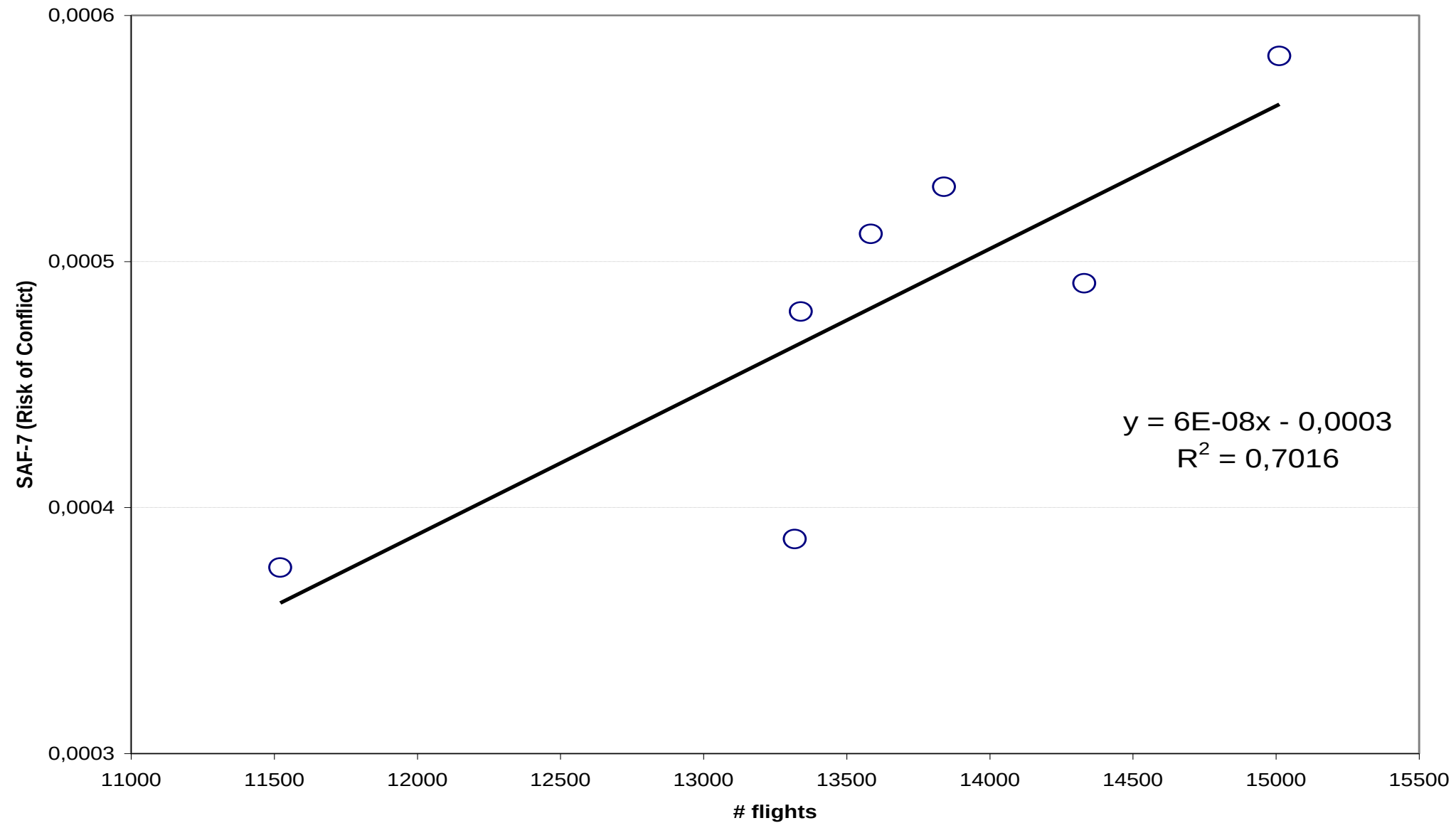


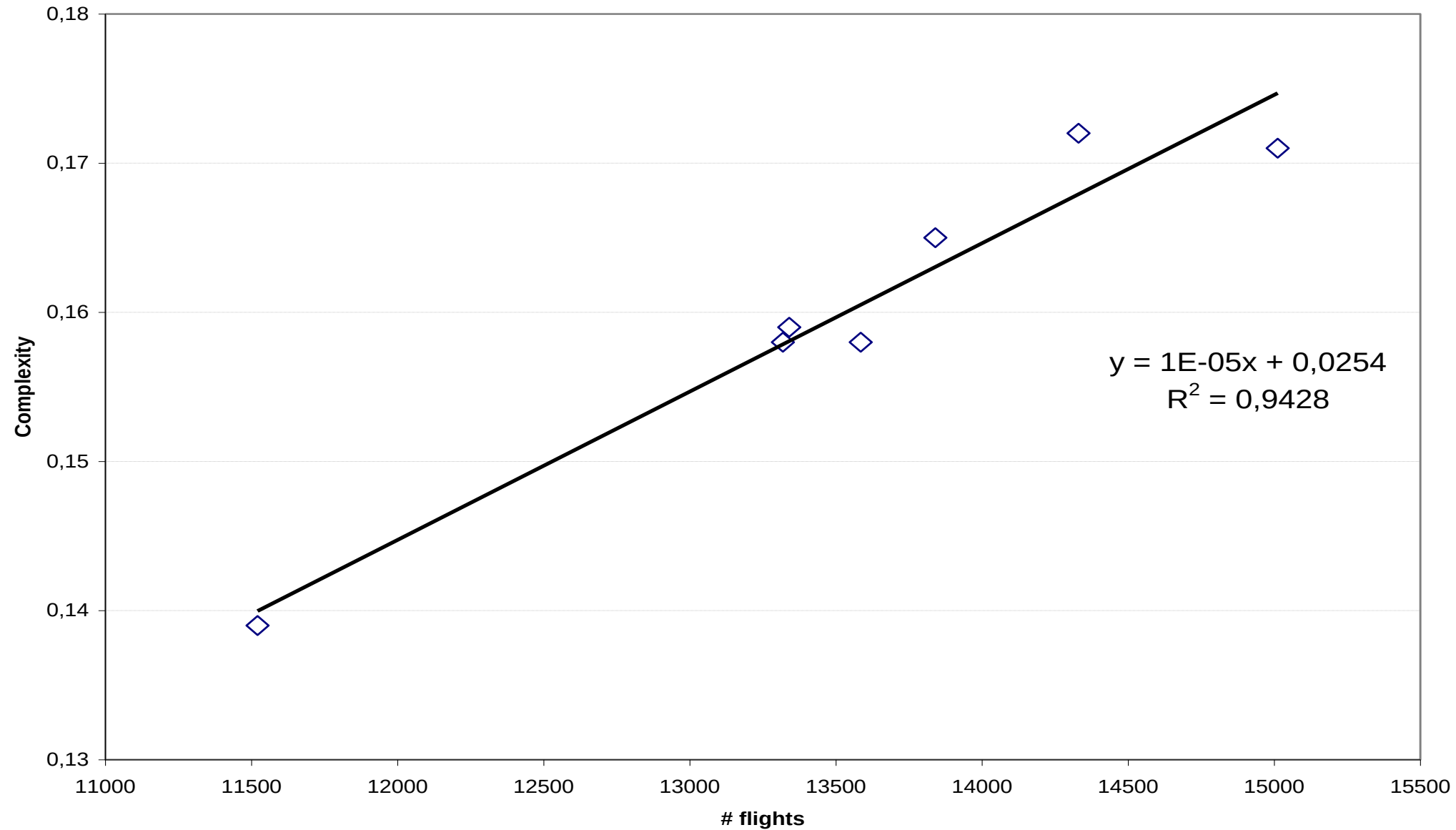
Winter 2017

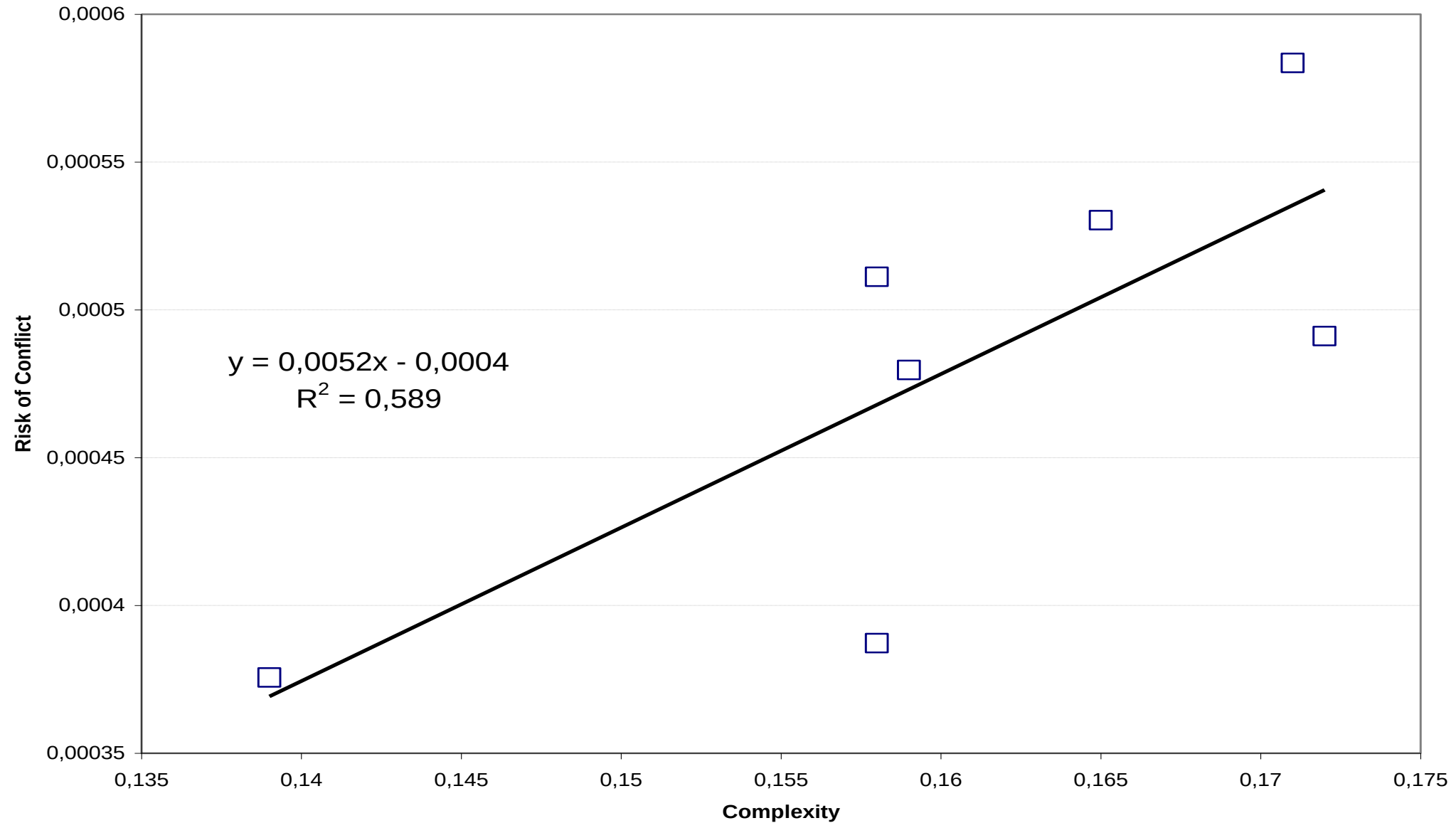


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Summer+Winter 2017

Red dots – Winter
Blue dots - Summer



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