Forecast of Aircraft Retirement Probabilities using Neural Networks

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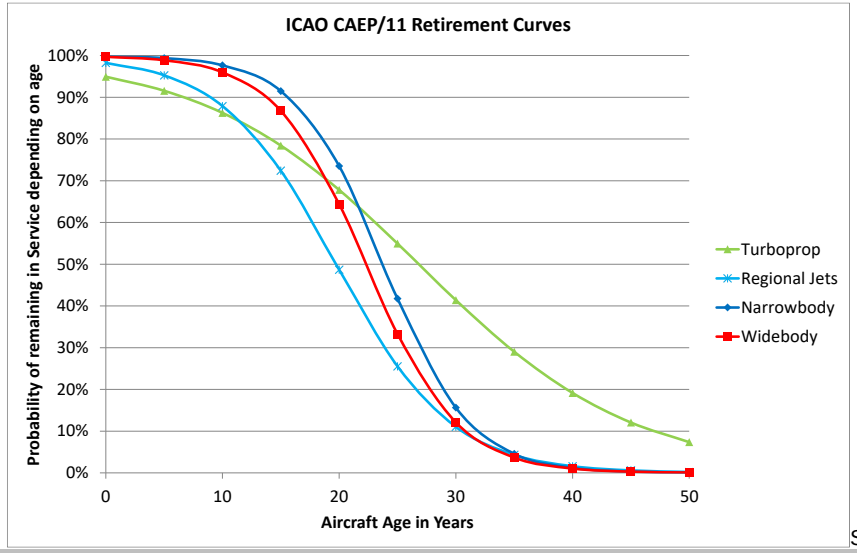
Introduction – Research Question

- Aircraft fleet models use „retirement curves“ (i.e. the survival probability as a function of aircraft age) for forecasting the composition of fleets, retirement and the need for new aircraft
- Typical methodologies to construct retirement curves are logistic regression and proportional hazards (Cox) models



Source: DLR/ICAO

Research objective:

- Integration of various external factors for predicting aircraft survival
- Application of artifical intelligence

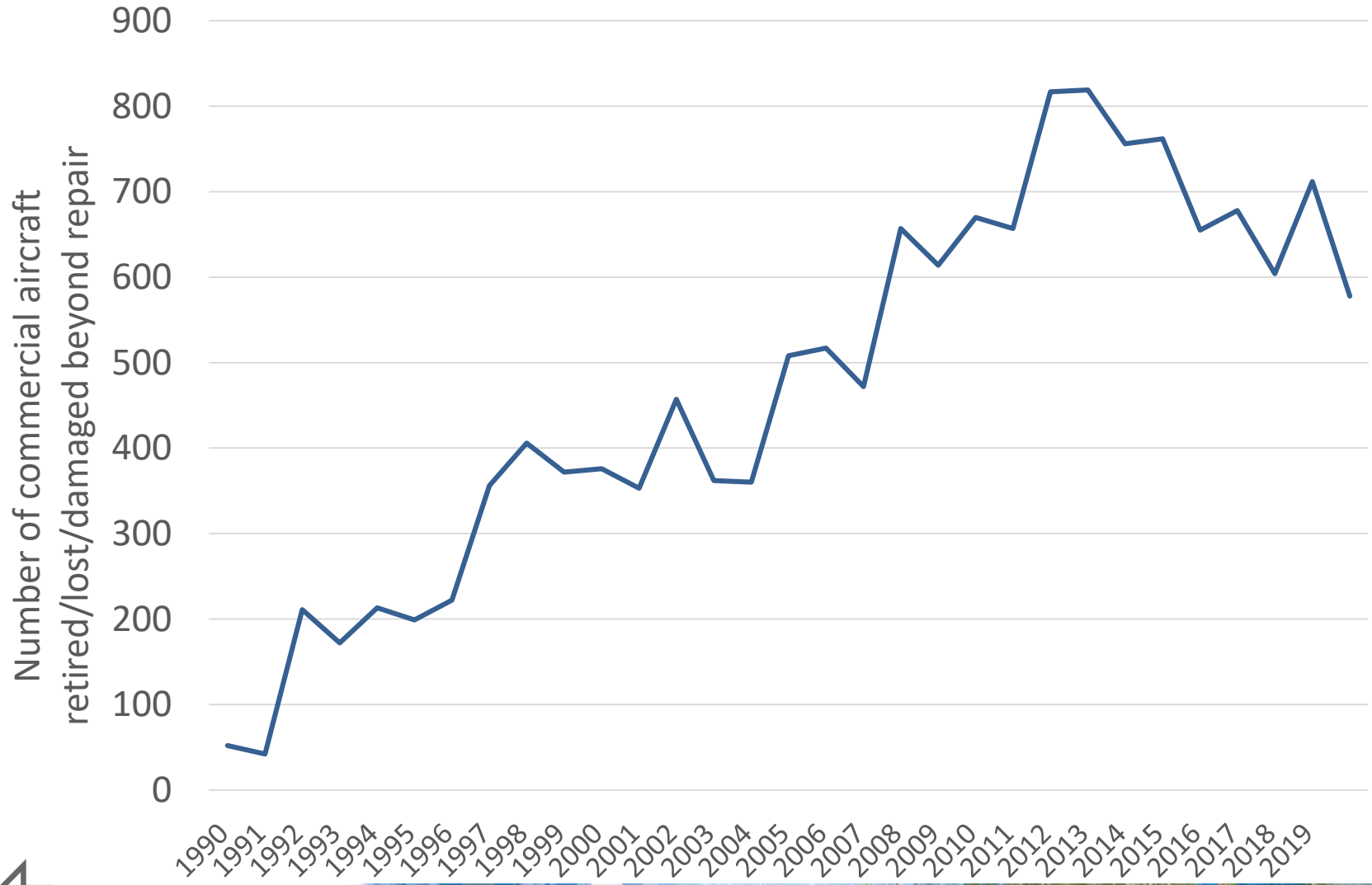
Introduction

- Lifespan of aircraft has increased over the last decades
- High aviation growth rates in the past decade in combination with relatively low fuel prices have motivated airlines to keep aircraft in service for a longer time span than in the 1960s and 70s
- Reverting trend during crisis
  - Normally 2-3% of the global fleet are retired
  - During previous crises retirement rate has increased to 4-5% of the global fleet
- Focus on the influence of economic framework data on aircraft retirement
  - Oil prices
  - Gross domestic product (GDP) per capita
  - Number of annual passengers

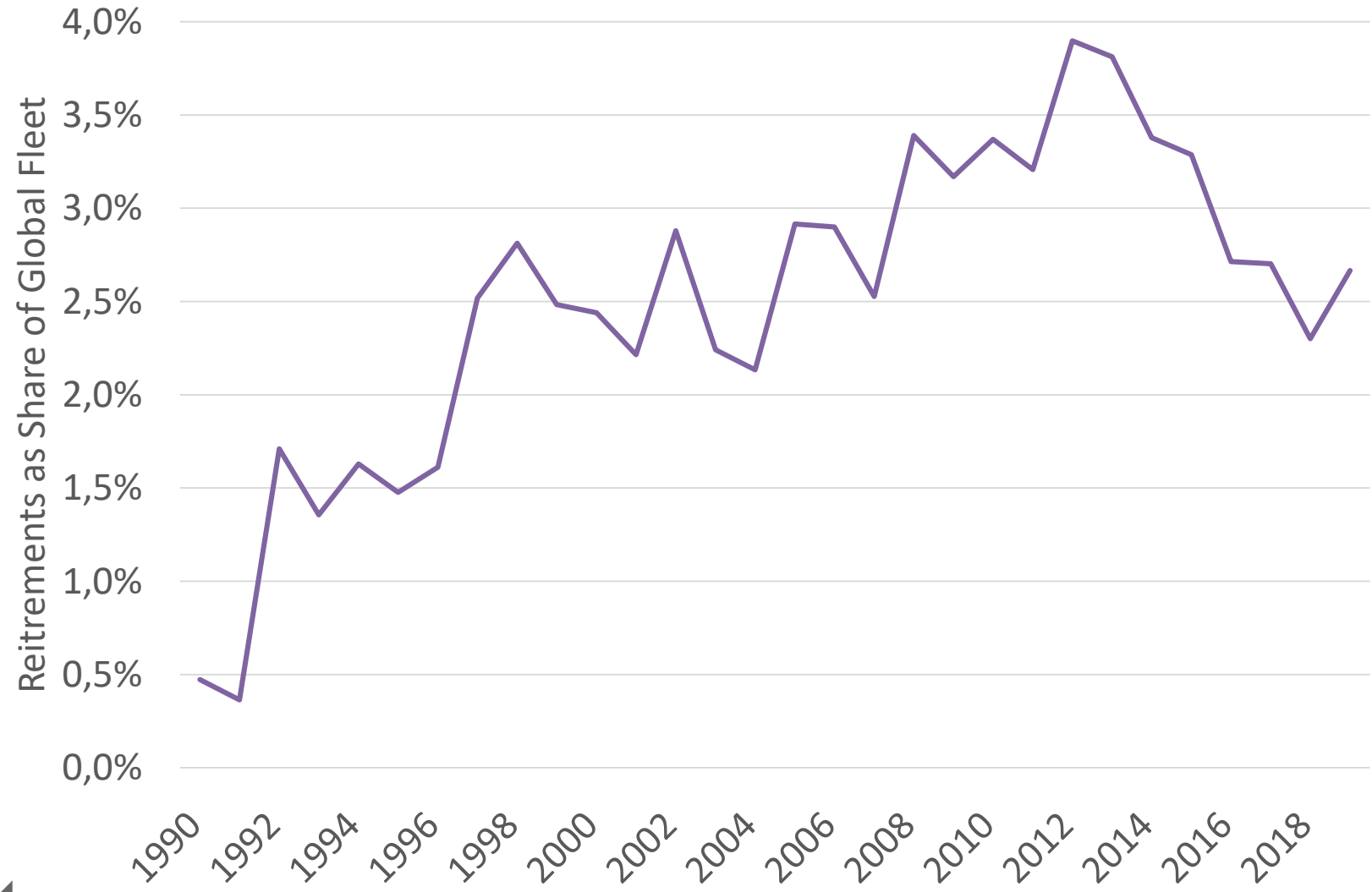
Empirical Trends

- Aircraft retirement is strongly dependent on many factors
  - Availability of more efficient aircraft
  - Fuel prices
  - Demand
- Economic events often show with a short time lag
  - Asian financial crisis (1997/98)
  - September 11 (2001)
  - SARS (2003)
  - Global financial crisis (2007)
- Retirement rate falling since 2013
- Retirement rate reached a low in 2018

Empirical Trends – Absolute Retirement



Empirical Trends – Retirement Share of Global Fleet



Input Data

- Global passenger aircraft fleet
  - Cirium‘s Fleet Analyzer
- Global GDP per capita
  - World Bank
- Crude oil price
  - US Energy Information Administration
- Aircraft passenger volume
  - ICAO

- Historical data from 1960 to 2017

- Scenarios for the next 30 years

Modelling Approach

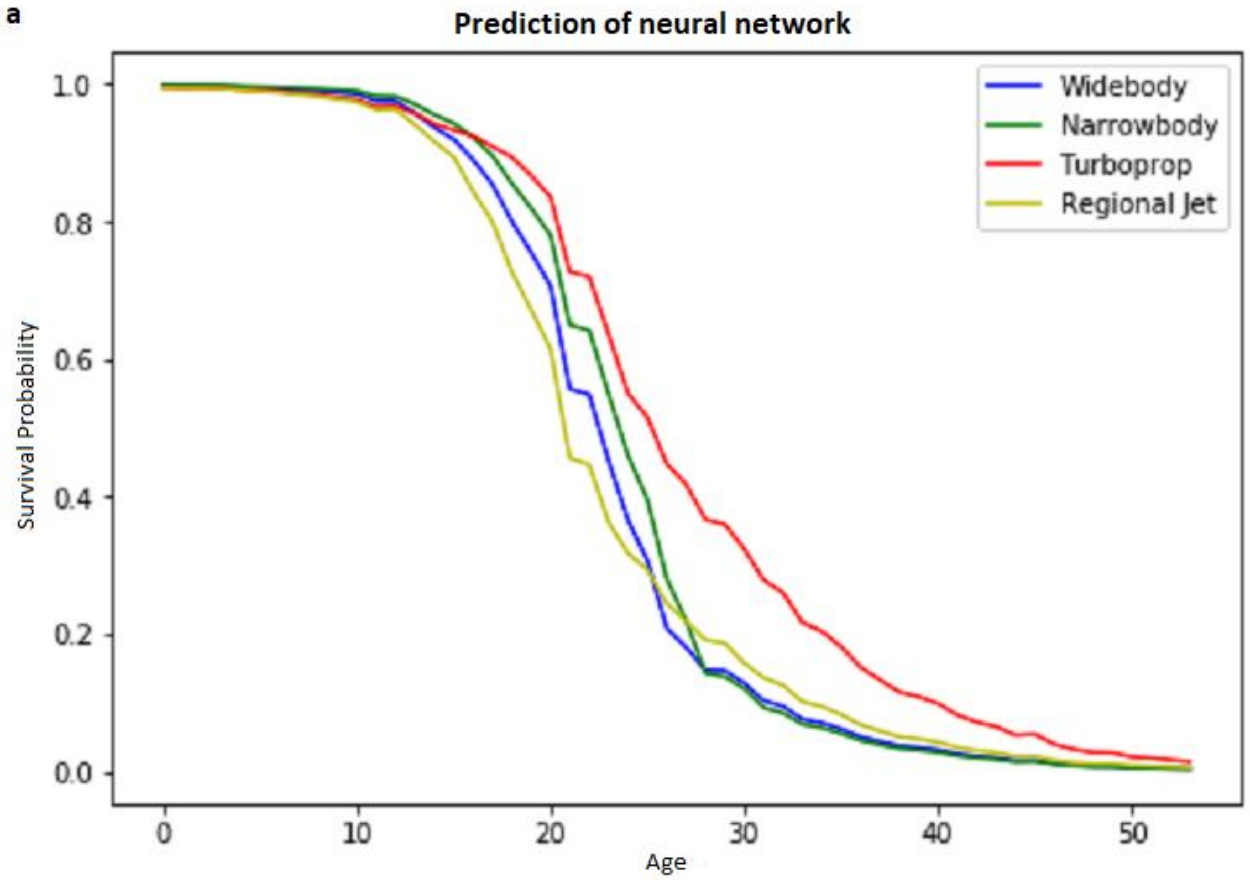
- For each economic data (GDP, oil price, passenger number) 2 forecasts
  - In combination a total of 8 economic scenarios
- For each scenario we train a Neural Network (NN) to predict survival probabilities
- Softmax function gives probability for 2 classes
  - „active“
  - „retired“
- Rather small NN and short training periods to avoid overfitting

Modelling Approach

- We tried different network shapes and decided to use a network with
  - input layer
  - hidden layer (20 neurons, ReLU activation function)
  - output layer (2 neurons, Softmax activation function)
- The network is trained over 20 epochs
- The result passed a Kolmogorov-Smirnov test on a test dataset

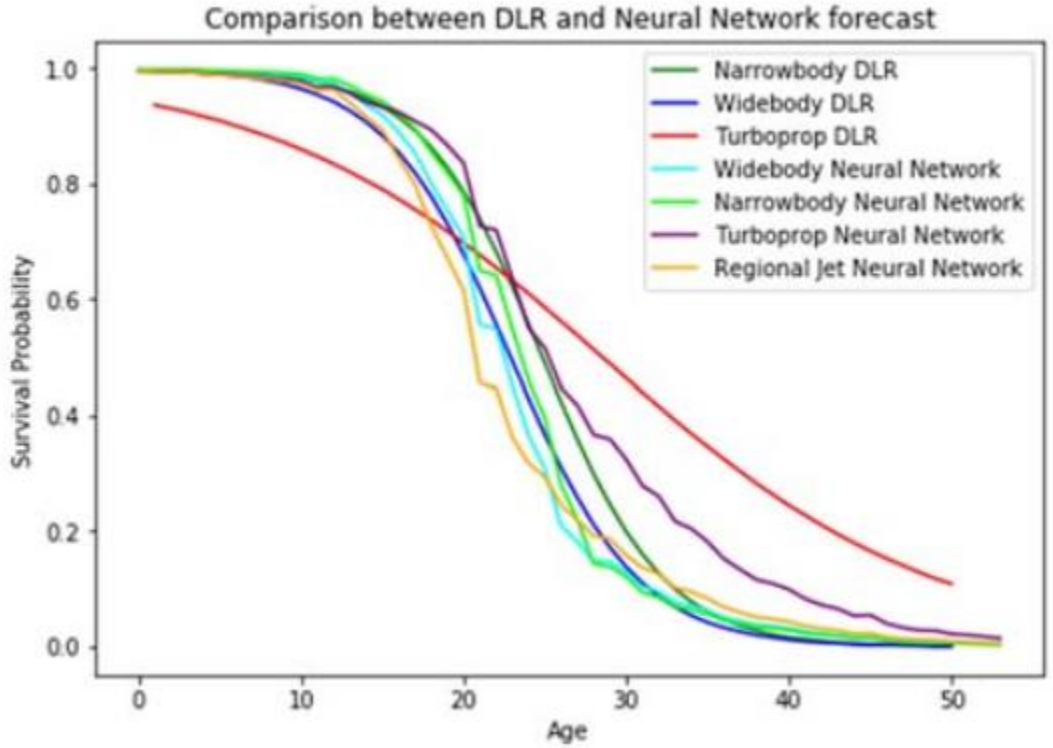
Result

- Arrangement of survival probabilities creates retirement curve
  - Dummy plane each with different build year



Results

- Comparison with a different approach at German Aerospace Center (DLR)



Conclusion

- Novel approach of forecasting retirements of aircraft
- Capable of integrating external factors and finding new dependencies between parameters with the help of artificial intelligence
- More data = better result
- In the future:
  - Try out different economic data (and differently shaped networks)
  - Split model into separate networks for each aircraft type to increase efficiency
  - Integration into DLR capacity constraint forecast model
  - Re-formulation of model to predict aircraft retirement for a specific future year, depending on external factors

Thank you for your attention!

If you have questions, feel free to ask them now