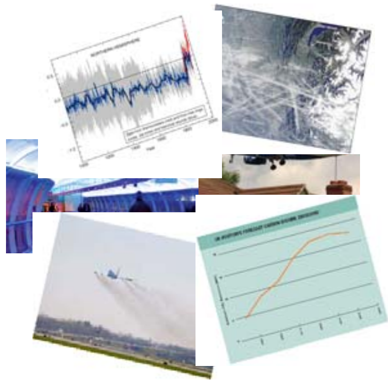
Omega

Aviation in a sustainable world

Professor IanPoll

ICAS Workshop

28th September 2009



Where did it come from?

- An independent academic initiative
- Bid team Manchester Metropolitan University, Cranfield University and Cambridge University
- Independently funded through UK education sources
- Participants selected on a “best in the business” basis.
- Not necessarily “pro aviation”

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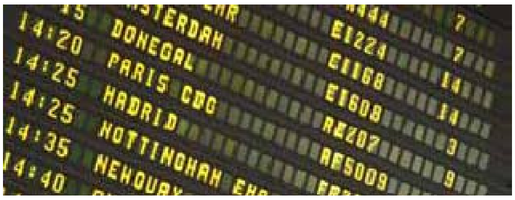
Contents

- Omega status, deliverables and plans
- Topic specifics
  - ❑ Air quality
  - ❑ Noise
  - ❑ Air Traffic Management
- Summary



Omega Phase 1

- Knowledge transfer partnership
- 9 partner universities
- 2 years
- 8 topic areas
- 40 studies
- 18 events
- Forum for innovation, debate and ideas
- 1 purpose – to develop and transfer knowledge to enhance the future sustainability of civil aviation
- Laying foundation for ‘gap filling’ and enabling solutions – longer term solutions

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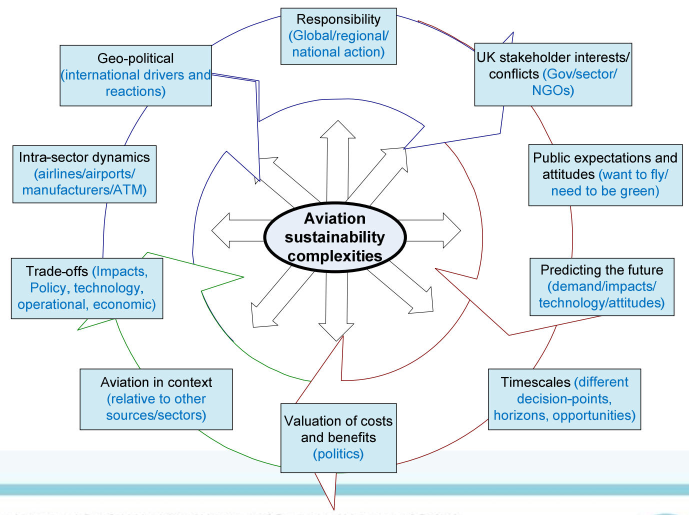
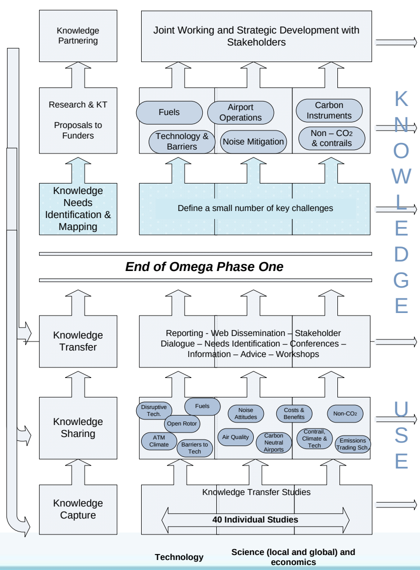
Responding to complexities



Omega status

- Phase 1 completed
- Extracting messages from phase 1 and gap analysis
- Dialogue on priorities
- Define knowledge needs addressing key obstacles
- New programme with stakeholder engagement
- Omega 2 focus: longer-term research, shorter-term studies and KT



Omega 1 Deliverables

- Contrails and non-CO2 impacts
- Carbon offsetting and emissions trading asnalysis
- Emission and vortex measurement and simulation
- Engine design - emission vs. noise tradeoffs.
- Alternative fuels – energy / emissions performance
- Metrics - climate impact and attitudes to noise.
- Tools: Integrated impact modelling, marginal abatement cost modelling, CBA methodologies
- Public attitude surveys
- Airport 'carbon neutrality'

Air quality issues

- Plume dynamics and chemistry to improve modelling
  - Initial dispersion
  - Wake vortex interactions
- Particulate emissions – sources and composition

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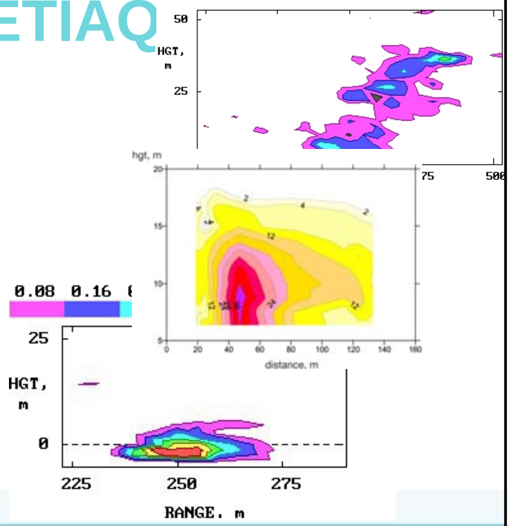
Omega highlights - **AETIAQ**

- Assembled a set of novel instruments yielding rapid physical and chemical data on aircraft plumes
  - Using existing knowledge in a different environment
    - IDOAS, Lidar, Sparcle,
- Three field campaigns
  - Heathrow
  - Cranfield
  - Manchester

Omega Study - **AETIAQ**

- Better characterization of initial plume dispersion and interaction of wake vortices
- Better understanding of plume chemistry e.g. - NO/NO_2 ,HONO
- Particle signatures



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Omega Study – **efflux**

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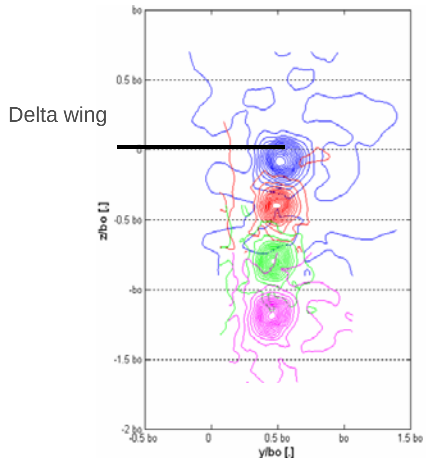
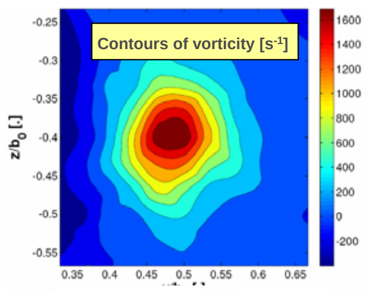
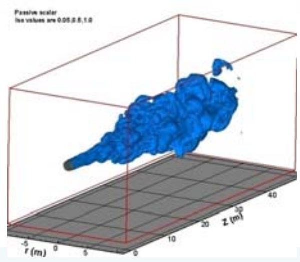


- he trajectory of the plume can be monitored under controlled conditions –

Omega Study - **efflux**



- Study has provided better understanding of:
  - how the exhaust plume evolves
  - the importance of the wake vortex
  - the immediate near-field jet development.
- Shown a number of effects and sensitivities not captured in existing simple jet plume assumptions



Omega Study - **SPARCLE**

- It would be a significant benefit to airports if characteristic markers or “fingerprints,” based on for example, particle size, mass, composition, or a combination of these, could be defined that were unique to individual sources.”

TRB’s Airport Cooperative Research Program (ACRP) Report 6 (2008)

Omega Study - **SPARCLE**

- Existing SPARCLE instrument for *stratospheric* measurements of “aerosol finger prints”
- Knowledge transfer required to make this design work in the polluted troposphere.
- Handle higher number densities.
  - ~10 per cc in stratosphere.
  - ~10^3 per cc in the troposphere.
- Optimised for the particulate sizes and compositions that would be encountered in an airport environment.

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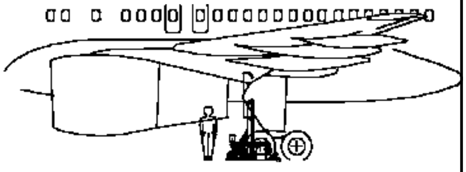
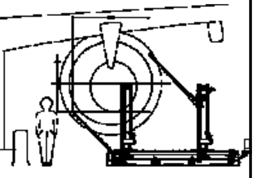
Omega Study - **SPARCLE**

- New instrument shown to have the ability to distinguish between, for example, brake particles and tyre particles. The instrument provides a new capability to:
  - Provide PM compositional information over the PM10 range.
  - Provide PM compositional information measurements over the PM2.5 range.
  - Provide second time scale measurements required for transient aircraft exhaust, tyre and brake emissions.
  - Provide essential particle by particle composition and size data to enable source fingerprint data to be obtained.
  - Assist source attribution studies

Omega study - **Alfa**



- Collection of equipment to facilitate on wing exhaust measurements (757 – 777)
- Rake, probe, standard measurements, aerodyne mass spectrometer
- Funded by Northern Way (Science City) – Omega measurement expertise support (secondment from DLR)



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Air quality next steps

- Bring together the empirical and theoretical work
- Work with regulatory modelling community to incorporate the better understanding that Omega has developed
- Deployment of Alfa rig
- Improved dynamic calibration of models

Noise issues

- Emerging technologies
- Trade-offs
- Attitudes
- Metrics

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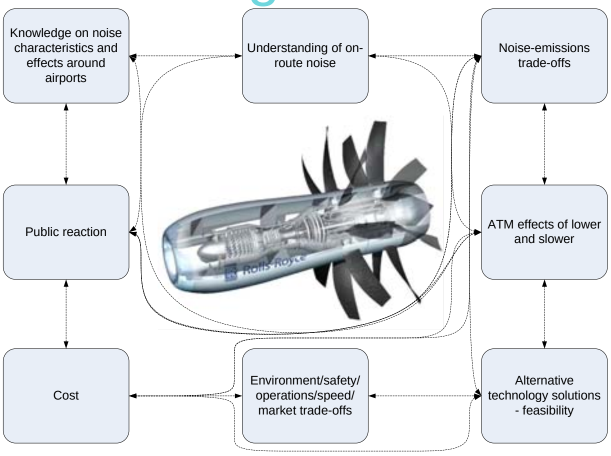
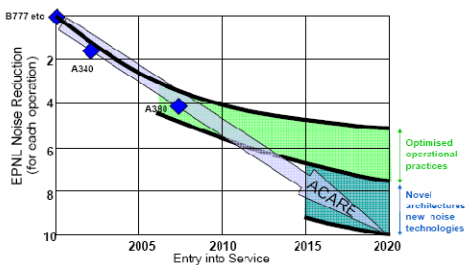
Open rotor engine



rivers and conflicts – reduce .–v-

AOR engine noise modelling

- Need understanding of physics of the noise generation mechanisms
- State of the art Generic Open Rotor Noise Prediction Tool has been developed and incorporated into a whole aircraft noise prediction code
- Allows us to estimate how noise is affected by aircraft design and operations
- Such a framework is essential for operators, regulators and optimisation studies



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Comparative noise analysis

- Comparative aircraft analyses (AOR & Turbofan) have been made in terms of certification noise at a conceptual design level
- AORs will be quieter than the aircraft they replace
- Noise benefit will be less than for a future generation turbofan
- Developing 'auralisations' of AOR configurations relative to turbo-fans

	Cumulative Certification Noise Values	Chapter 3 Margin	Chapter 4 Margin
Chapter 3 Limit	288.8		
Chapter 4 Limit	278.8		
Year 2000 Turbofan	276.0	-12.8 EPNdB	-2.8 EPNdB
1990 8 X 8 AOR*	303.6	+14.8 EPNdB	+24.8 EPNdB
1990 11 X 8 AOR*	278.8	-10.0 EPNdB	0 EPNdB
Future 11 X 8 AOR (projected)	266.8	-22 EPNdB	-12 EPNdB

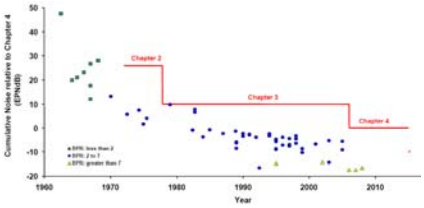
***AOR Noise Certification Predictions calibrated against Hoff for a circa 1990s AOR**

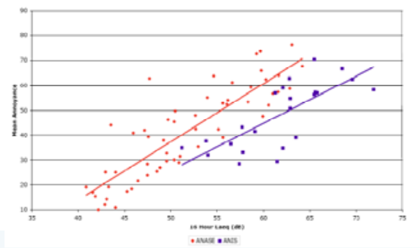
Aircraft noise and emissions optimisations

- Discussions with a variety of stakeholders has established the need for a relatively simple optimisation tool incorporating noise and emissions
- Architecture for an integrated tool determined – to be developed in next stage of Omega

Public attitudes to noise

- Study reviewing attitudinal research over 30 years
- Reduction in "noise at source" are not matched by public attitude
- Public sensitivity to aviation noise & frequency of aircraft flights
- Significant remaining uncertainties mainly due to lack of consistency methodologies over time
- More work needed to understand changing attitudes





Noise – Metrics

- Averaged indicators provide a 'fair' and defensible justification for policy planning choices
- Local communities remain concerned given their experiences and expectations of noise at a given location/time
- Demand for information on number, timing and magnitude of events

- Noise exposure – more confident
- Noise disturbance – too difficult!
- dB(A)Leq/Lden – provide overview of total dose but…
  - ❑ Single events?
  - ❑ Frequency?
  - ❑ Timing?

Survey comments:

"Leq contours of little value."

"Not sure whether the numbers on the graph (are) showing number of planes flying or noise levels – don't understand abbreviations."

"Leq16 hours fails to give info on peaks of noise at any time."

"What does Agglomeration mean?"

"Any average noise metric is confusing without further info."

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Noise – targets and performance

We found:

- Need a common understandable language before sensible targets can be set
- Local communities seem to be most disturbed by the unexpected
- Managing expectations – metrics must relate to experiences
- Describe rather than evaluate noise exposure

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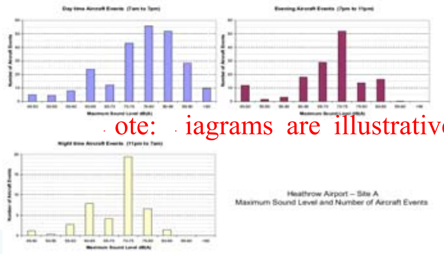
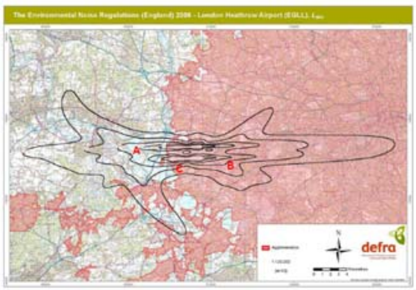
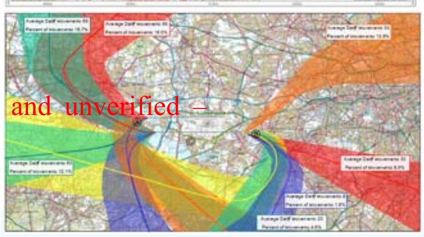
Noise metrics

- Omega study participants found flight distribution illustrations the most attractive and simple location histograms most informative and easiest to understand







ote: iagrams are illustrative and unverified –

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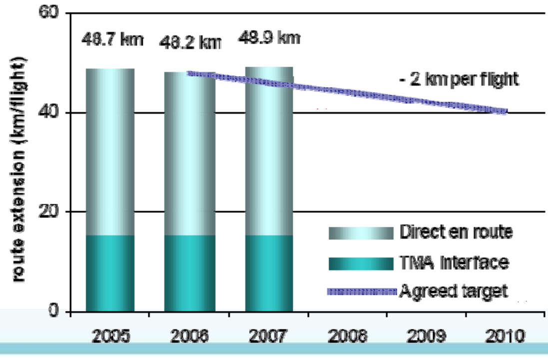
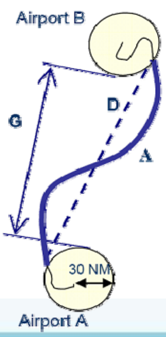
Noise next steps

- Resolve uncertainties about attitudes
- Examine supplementary metrics
- New technology effects, e.g. AOR auralisations
- Enhance interdependency modelling
- Mitigation effectiveness

“Flight Inefficiency”

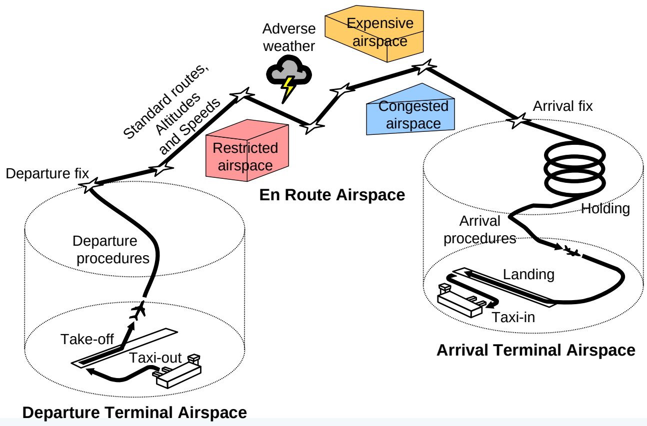
- Concept commonly used as ATM performance indicator
  - Quantify difference between “ideal” and “actual” performance
  - Focus has been on average route extension over great circle



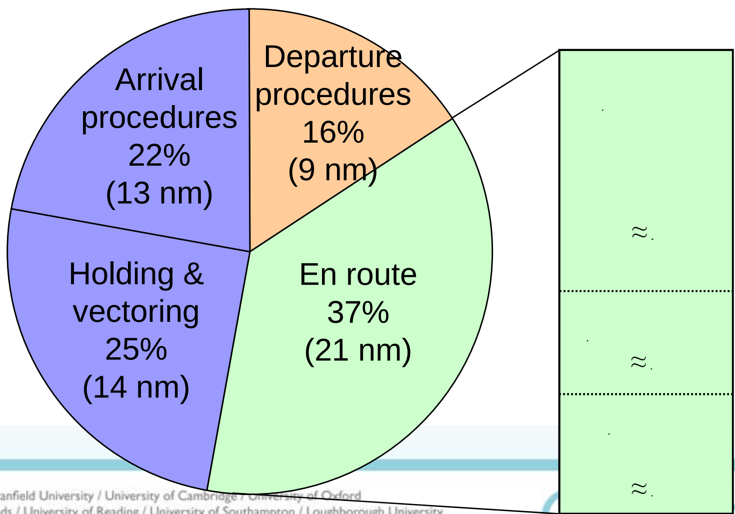


Sources of Flight Inefficiency

- Constraints to aircraft flying their 4D optimal trajectory
  - Lateral track
  - Altitude profile
  - Speed profile



Track Extension by Flight Phase



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Omega studies

List of all Omega studies:

Study	Title	Topic area
1	Characterising Near Surface Aircraft PM	Local Air Quality
2	AETIAQ - Aviation Emissions and their Impact on AQ	Local Air Quality
3	Aircraft Plume Analysis Facility (ALFA)	Local Air Quality
4	Community Responses to Aircraft Noise	Noise
5	Potential Carbon Offsetting to Mitigate Climate Change Implications	Mitigation policies
6	Global Temp Change Implications of Projected Aviation Growth	Climate change
7	JETCLIM	Climate change
8	Study of Advanced Open Rotor Powered Aircraft	Noise
9	Contrails - adding to a Climate Model	Climate change
10	Sustainable Fuels for Aviation	Alternative fuels
11	Environmental Costs of Aviation - Literature Review	Mitigation policies
12	Prioritisation of Airframe and Engine Technologies	Aircraft systems
13	Dispersion of Aircraft Efflux in Proximity to Airports	Local Air Quality
14	Estimating Marginal Costs of Environmental Abatement for Aviation	Mitigation policies
15	ICARUS	Demand
16	Emissions and Impacts of Supersonic Bizjets on Atmosphere (EIBIS)	Climate change
17	AIR-ETS - Emissions Trading	Mitigation policies
18	Strategies for Low Carbon Future	Aircraft systems
21	Mapping	n/a
22	Metrics	Climate change
23	Fuel Efficiency Performance	Aircraft systems
24	Environmental Aspects of Fleet Turnover Retirement and Life Cycle	Aircraft systems
25	Climate related ATM	Aircraft operations
28	Business models	Mitigation policies
30	People Issues	Demand
34	Influence of Implementation of Composite Materials	Aircraft systems
35	OMEGA Alternative Aviation Fuels Data Centre	Alternative fuels
36	Balancing Noise Costs Against Reduced Carbon Emissions in Advanced Open Rotor Engines	Noise
37	Control Strategies for a Cleaner Exhaust	Aircraft systems
38	Aviation Exhaust Modification to Cloud Forming Potential	n/a
39	Environmental Effects of Aircraft Operations and Airspace Charging Regimes	Aircraft operations
40	Economic benefits of aviation	Demand
41	Opportunities for reducing aviation-related GHG emissions: a system analysis for Europe	Mitigation strategy

Omega summary

- Phase 1 completed
- Overview report available
- Completed studies mainly on the web
- Currently distilling key messages from activities
- Planning Omega-2
- Seeking greater collaboration with PARTNER in next phase

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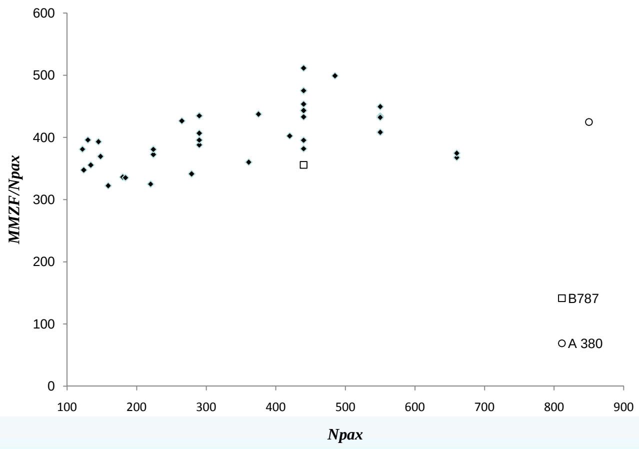
Key Conclusions

- The essential question of "what is aviation is doing to the environment?" is not fully answered.
- Before engineering solutions can be produced the community must know what the political requirements for aviation are and the precise environmental targets e.g. is climate change more important than local air quality? What metrics should be used to define environmental impact?

- When addressing any issue relating to environmental impact it is necessary to adopt a total (global) system view (science, engineering, economics, social and political).
- In aviation, the majority of the waste occurs in inefficient operations. Technology on the aircraft does not address this central problem.

An observation



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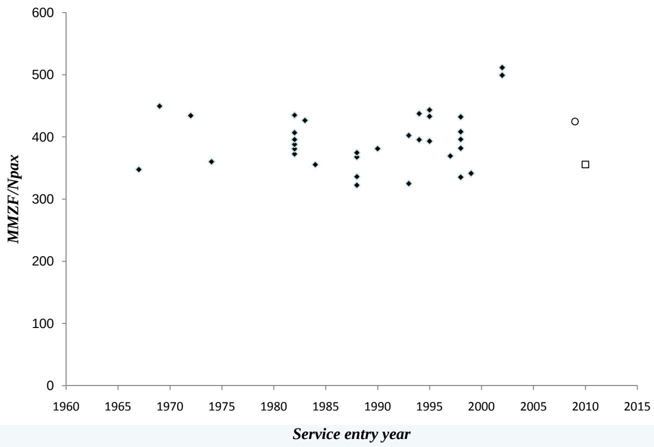

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