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Aviation in Europe – Innovating for Growth

The 7th European Aeronautics Days



L O N D O N



20 – 23 OCTOBER 2015

RECREATE



Recreating the Air Transport Environment with Cruiser-Feeder Operations

Aerodays London - 2015
21 October 2015

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National Aerospace Centre (NLR)



FP7 RECREATE project



Cruiser-Feeder, an impression



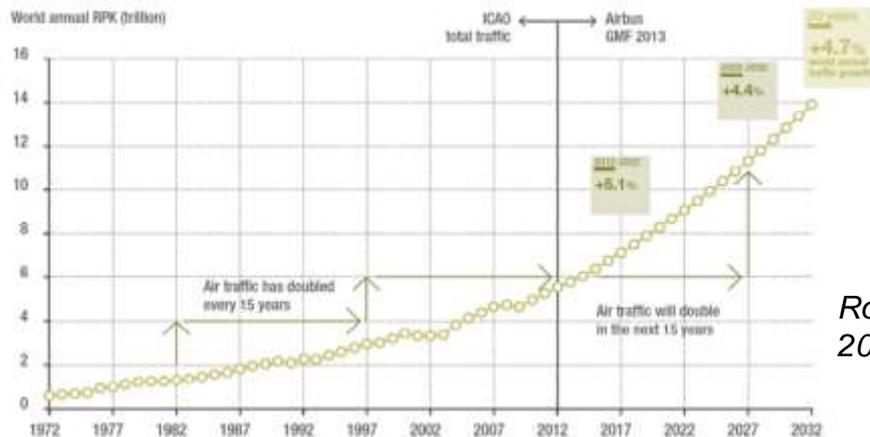
REsearch on a CRuiser Enabled Air Transport Environment

Why do we investigate new solutions?

- Predicted long term growth of world-wide air traffic.
- Equivalent growth in emissions not acceptable.
- Technological improvements only are not matching the traffic growth.



One day of air traffic -Wikipedia



Roadmap Aeronautics Manufacturing and Maintenance 2014-2020



The RECREATE project

Nine partners:

- NLR, The Netherlands
- DLR, Germany
- FOI, Sweden
- TU Munich, Germany
- TU Delft, The Netherlands
- Queen's University Belfast, UK
- ZHAW, Zurich, Switzerland
- Nangia Research Associates, UK
- NRG, Petten, The Netherlands



Funded in the 7th Framework Programme of the European Commission

Project time: August 2011 to January 2015



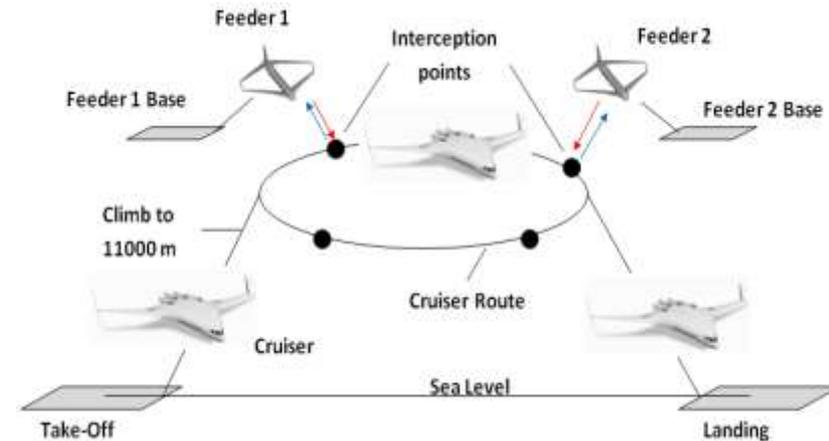
Perspective for solution based on Cruiser-Feeder operations

Cruiser-Feeder Concept I: Transfer of PAX, cargo, fuel:

- Offers a long-term solution.

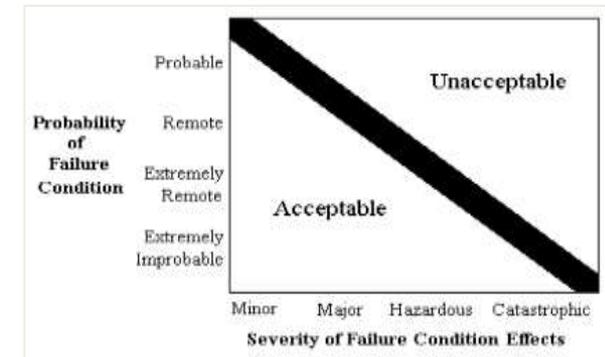
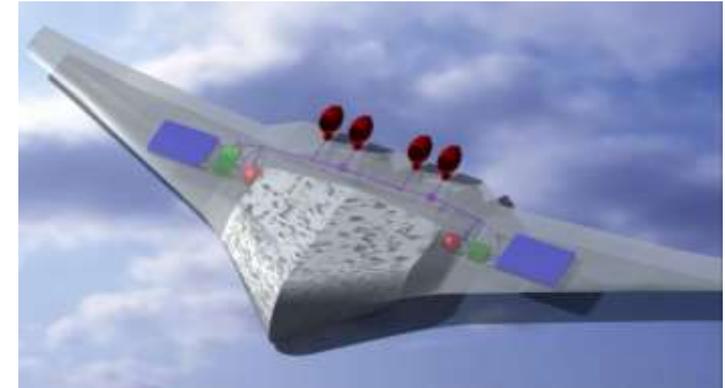
Research performed:

- Operations
- Airworthiness
- Benefits: fuel, environment, economical
- Aircraft design



Will Cruiser-Feeder Concept I work?

- No benefit for chemical propulsion.
- Fission-based nuclear propulsion:
 - Airworthiness cannot be shown
 - High weight penalties
 - Not accepted by society.
- Discovery of new nuclear physics required. Current research into energy sources:
 - E.g. condensed matter physics
Wisdom-Larsson theory
 - Compact Fusion Reactor proposed by Lockheed Martin.



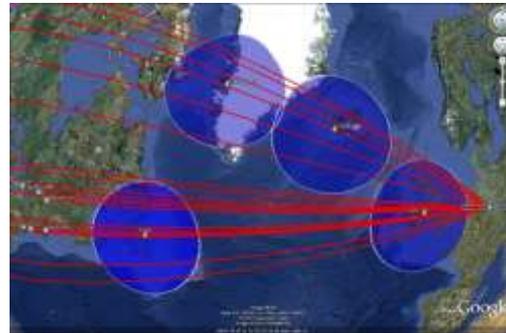
*Eric Schulzinger/
Lockheed Martin*



Perspective for solution based on Cruiser-Feeder operations

Cruiser-Feeder Concept II: Air-to-air refuelling (AAR)

- A short – to mid term solution.



Transatlantic scenario



Europe-Asia scenario

Research performed:

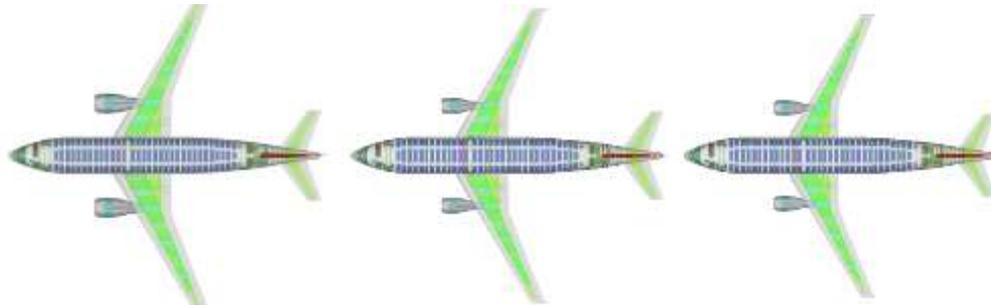
- Operations: traffic analysis, mission analysis
- Airworthiness
- Benefits: fuel, environment, economical
- Aircraft design: CFD, aeroelastic analysis
- Automated flight control system
- Flight simulation



What do the aircraft look like?

Dedicated cruiser aircraft:

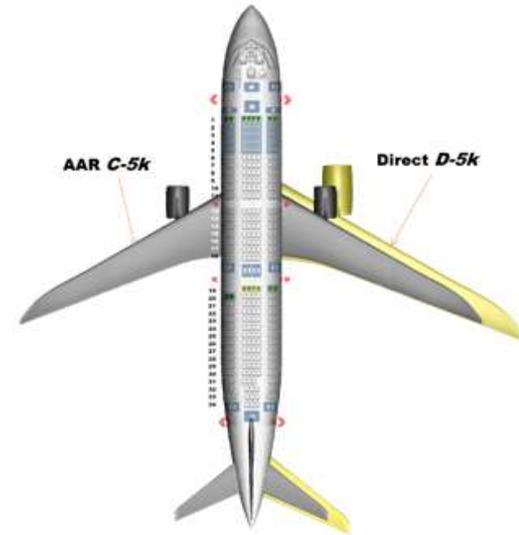
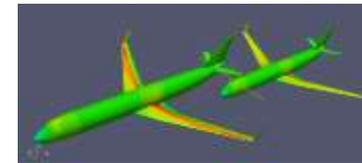
- Reduced **Operating Empty Weight**.
- Reduced **Wing area** at same fuselage volume.



reference
 $\Delta m_f = 0\%$

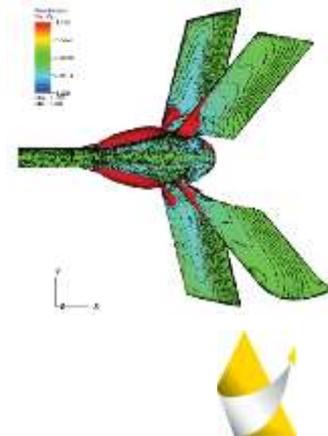
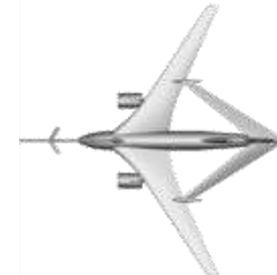
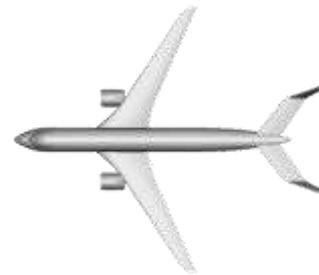
one refuel
 $\Delta m_f = 20.6\%$

two refuels
 $\Delta m_f = 24.9\%$



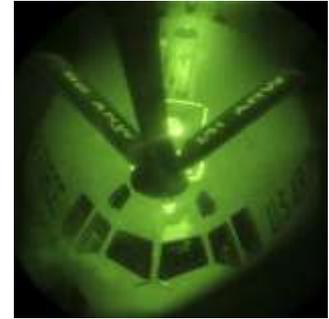
Dedicated tanker aircraft:

- Reduced fuselage;
- Adapted tail configuration;
- Adapted boom layout.

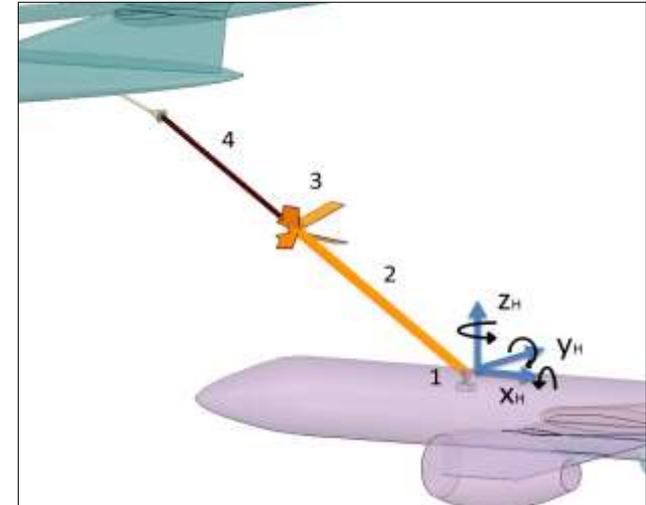


Is it safe?

- AAR in regular use by military for decennia;
 - Different requirements for safety and reliability.
- Unconventional configuration has essential benefits:
 - Safety;
 - Passenger comfort;
 - Thrust requirement for cruiser;
 - Pilot training requirements.
- Critical point: aeroelastic stability
 - Feasible design space found



USAF



Inverted tanker position

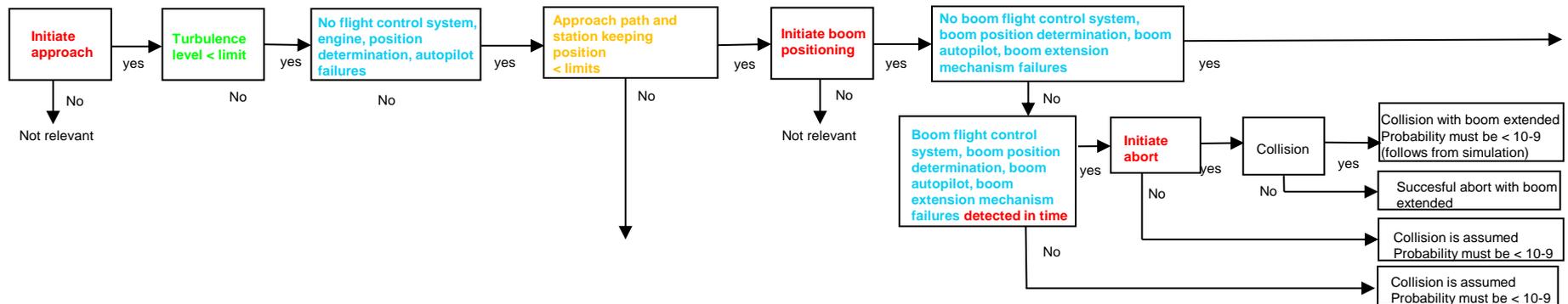


Will it ever be airworthy?



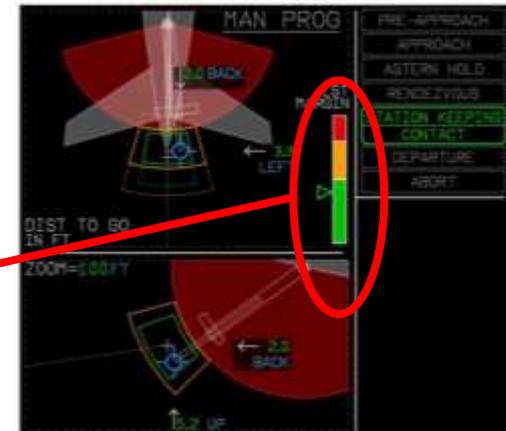
Concept II (AAR): System Safety Assessment:

- Full evaluation of CS-25, MIL-HDBK 516B, ..
- EASA All Weather Operations (CS-AWO) and Acceptable Means of Compliance (AMC);
- Simulations for System Safety Model showed compliance up to **medium turbulence** and **one engine out failure**;
- **Only automated**, no safety-showstoppers.



What do the pilots think of it?

- Research simulators GRACE (NLR) and GECO (DLR) in coupled real time experiments.
- 12 days of flight simulator experiments.
- 20 crews of commercial airline pilots.
- Almost all pilots felt it to be **safely implementable**, with little extra training.



Safety margin estimator

Relative position indicators

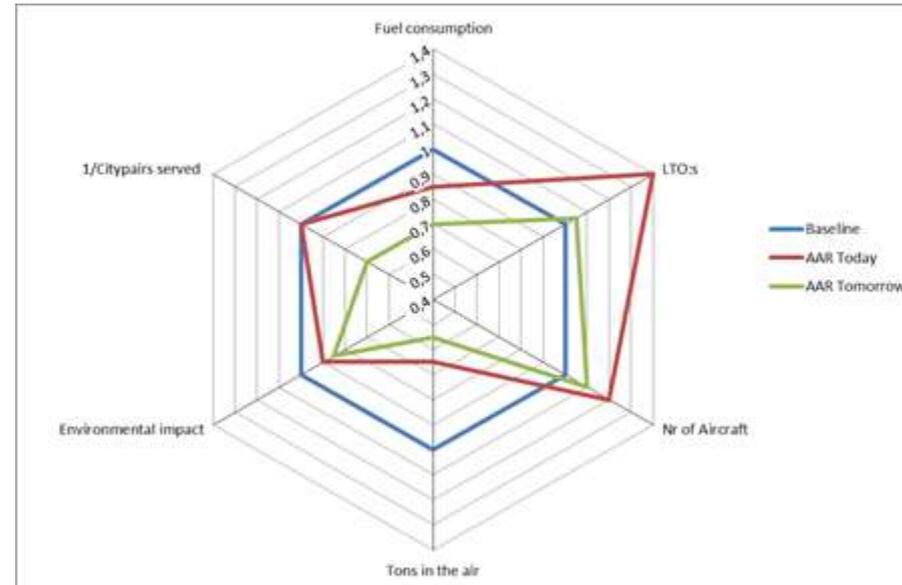


Civil Air-to-Air Refuelling, an impression



What is the significance for the aerospace business?

Fuel reduction with AAR – Reference Mission	
Cruiser only	21%
Efficient tanker	-5%
Realistic tanker	-12%
Bottom-up analysis:	9% - 16%
Top down analysis:	23%



- Overall economic benefit possible.
- More **point-to-point** instead of **hub-spoke** connections.
- Newly designed aircraft required.
- AAR is enabler for more advanced cruiser-feeder concepts.



Conclusions

- Civil AAR is a **feasible** concept:
 - Airworthy design is possible, certification approach similar to auto land systems;
 - Fuel reduction and economic benefits have been shown by traffic simulations, economic modelling and preliminary a/c design.
 - Unconventional, inverted refuelling boom configuration is preferable.
- For RECREATE concept 1 (nuclear cruiser) airworthiness is **not within reach** without advanced technology.
- Impact on aircraft design and on relocation of air traffic has been evaluated: shift to more point-to-point traffic.



Outlook

Future research should include:

- Comprehensive business cases for air transport organisations, aircraft fuel providers and other stakeholders.
- Regarding airworthiness; development of a roadmap for civil certification regulations in consultation with certifying authorities is envisaged.
- Technical research: focus on the design of automated flight control systems and on the airworthiness of the forward swept boom configuration, including ground and flight test demonstrations.





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Thank you for your attention.



The 42-month RECREATE project research receives funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 284741.
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