Eco-Efficiency in Aviation – Flying Off Course?

Dieter Scholz  
Hamburg University of Applied Sciences

Deutscher Luft- und Raumfahrtkongress 2012  
German Aerospace Congress 2012  
Berlin, Germany, 10.-12.09.2012
Eco-Efficiency in Aviation – Flying Off Course?

Contents

• Introduction

• Growth and Goals for Innovation

• Learning from History Looking into the Future

• Some Ideas (Air Travel Evaluator)

• Summary
Eco-Efficiency in Aviation – Flying Off Course?

Contents

• Introduction

• Growth and Goals for Innovation

• Learning from History Looking into the Future

• Some Ideas (Air Travel Evaluator)

• Summary
Introduction

Definition: **Eco-efficiency** (Ökoeffizienz)

*Eco-efficiency is based on the concept of creating more goods and services while using fewer resources and creating less waste and pollution.*


The term has become synonymous with a management philosophy geared towards **sustainability**.

The **eco-efficiency strategy** has the following characteristics:

- Technological **innovation** the main solution
- **Business** as the principal actor of transformation
- Trust in **markets** (if they are functioning well)
- “cradle-to-cradle” (essentially **waste free**) growth is conducive.

Definition: **Sustainability** (Nachhaltigkeit)

*A sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*


Since the 1980s sustainability has been used especially in the sense of human sustainability on planet earth.

Translation: **off course = vom Kurs abgewichen**
Introduction
**Airbus** develops *eco-efficient solutions at every stage of the aircraft life-cycle*:  
- Optimized *performance* by design  
- Dissemination of best environment practices within the *supply chain*  
- Greener *manufacturing* processes  
- Supporting efficient aircraft *operations*  
- *Recycling* and re-use at end-of-life

In addition, the company assumes a leading role in improving the overall air transport system by  
- contributing to the modernization of Air Traffic Management (*ATM*) and  
- promoting low-emission *alternative fuels*. 
Introduction
Introduction

some have a different view …
Eco-Efficiency in Aviation – Flying Off Course?

Contents

• Introduction

• **Growth and Goals for Innovation**

• Learning from History Looking into the Future

• Some Ideas (Air Travel Evaluator)

• Summary
Growth and Goals for Innovation


Jährliches Luftverkehrsaukommen, $10^{12}$ Passagier-Kilometer

1971-2005: 5,5%

1971-1979: 8,9%

1971-1979: 5,6%

1990-1997: 4,8%

1997-2000: 5,4%

2000-2005: 4,4%

Growth and Goals for Innovation

Fig.: Growth of Transport Capacity and Fuel Consumption at Lufthansa

Lufthansa: Balance – Das wichtigste zum Thema Nachhaltigkeit im Lufthansakonzert. 2011
Only a few people fly more than one time a year. So there is still a huge growth potential for aviation as less developed countries develop and the number of people on earth increases.

IATA: **Vision 2050.** Singapore, IATA, Report, 2011
Growth and Goals for Innovation

Fig.: Fuel efficiency improvements of long range transport aircraft

RAeS: *Greener by Design: Mitigating the Environmental Impact of Aviation: Opportunities and Priorities.*
Royal Aeronautical Society, Report, 2005
Growth and Goals for Innovation

Fuel efficiency improvements of transport aircraft

Growth and Goals for Innovation

ATAG Goals for the Reduction of Fuel Burn or CO2

Our climate targets:

1.5%
We will improve our fleet fuel efficiency by 1.5% per annum between now and 2020.

Stabilise
From 2020, net carbon emissions from aviation will be capped through carbon neutral growth.

50%
By 2050, net aviation carbon emissions will be half of what they were in 2005.
Growth and Goals for Innovation

An Old IATA Goal for the Reduction of Fuel Burn or CO2

IATA Calls for a Zero Emissions Future

VANCOUVER - The International Air Transport Association (IATA) issued four challenges to drive the air transport industry towards its vision of zero emissions.

“The environmental track record of the industry is good: over the last four decades we have reduced noise by 75%, eliminated soot and improved fuel efficiency by 70%. And the billions being invested in new aircraft will make our fleet 25% more fuel efficient by 2020. This will limit the growth of our carbon footprint from today’s 2% to 3% in 2050,” said Giovanni Bisignani, IATA Director General and CEO.

“But a growing carbon footprint is no longer politically acceptable—for any industry. Climate change will limit our future unless we change our approach from technical to strategic. Air transport must aim to become an industry that does not pollute—zero emissions,” said Bisignani.
Growth and Goals for Innovation

A New IATA Goal for the Reduction of Fuel Burn or CO2

IATA Fuel Efficiency Goal

IATA airlines have adopted a voluntary fuel efficiency goal. This is to reduce fuel consumption and CO2 emissions (per revenue tonne kilometer) by at least 25% by 2020, compared to 2005 levels.

www.iata.org (12-09-10)
Growth and Goals for Innovation

Summary of Goals for the Reduction of Fuel Burn or CO2

<table>
<thead>
<tr>
<th>organization</th>
<th>goal</th>
<th>from</th>
<th>to</th>
<th>per year</th>
<th>level</th>
<th>source</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACARE</td>
<td>50.0%</td>
<td>2000</td>
<td>2020</td>
<td>2.05%</td>
<td>A/C</td>
<td>ACARE: Vision 2020, Luxembourg, EU, 2001 (deleted from www)</td>
</tr>
<tr>
<td>ACARE</td>
<td>75.0%</td>
<td>2000</td>
<td>2050</td>
<td>1.13%</td>
<td>A/C</td>
<td>ACARE: Flightpath 2050, Luxembourg, EU, 2011</td>
</tr>
<tr>
<td>ATAG</td>
<td>19.6%</td>
<td>2008</td>
<td>2020</td>
<td>1.50%</td>
<td>A/C</td>
<td>ATAG: Towards sustainable Aviation, Summit Declaration, Geneva, ATAG, 2012</td>
</tr>
<tr>
<td>ATAG/Airbus</td>
<td>0.0%</td>
<td>2020</td>
<td>---</td>
<td>---</td>
<td>fleet</td>
<td>ATAG: Towards sustainable Aviation, Summit Declaration, Geneva, ATAG, 2012</td>
</tr>
<tr>
<td>ATAG/Airbus</td>
<td>50.0%</td>
<td>2020</td>
<td>2050</td>
<td>1.36%</td>
<td>fleet</td>
<td>ATAG: Towards sustainable Aviation, Summit Declaration, Geneva, ATAG, 2012</td>
</tr>
<tr>
<td>IATA</td>
<td>build A/C zero emission</td>
<td>---</td>
<td>2062</td>
<td>---</td>
<td>---</td>
<td><a href="http://www.iata.org">www.iata.org</a> (2012-09-10)</td>
</tr>
<tr>
<td>IATA</td>
<td>25.0%</td>
<td>2005</td>
<td>2020</td>
<td>1.50%</td>
<td>fleet</td>
<td><a href="http://www.iata.org">www.iata.org</a> (2012-09-10)</td>
</tr>
<tr>
<td>historic data</td>
<td>70.0%</td>
<td>1960</td>
<td>2010</td>
<td>1.07%</td>
<td></td>
<td><a href="http://www.atag.org">www.atag.org</a> (2012-09-10)</td>
</tr>
</tbody>
</table>

- Goals are quite diverse
- Goals have been withdrawn over the years (ACARE, IATA)
- Some goals are not well defined
- Some goals may not be reached …
Growth and Goals for Innovation

Fuel Efficiency Improvements of Transport Aircraft Compared with ACARE Goals

![Graph showing fuel efficiency improvements over time, with a comparison to ACARE goals and research targets. The graph includes data points for different aircraft types and a focus on the Vision 2020 and Flightpath 2050 targets.]

Peeters et al., TAC Conference 2006

Index per pkm (Comet 4 = 100)


- IPCC
- Jets
- Piston
- A380
- A380 opt wing
- Powercurve
- Research target
- Flightpath 2050
Growth and Goals for Innovation

Working with Growth and Fuel Efficiency increases: Exponential Growth

Example

5.1 % Growth (p.a.)
3.6 % Efficiency Increase (p.a.)

Resulting in:
1.5 % Net Growth (p.a.)
Growth and Goals for Innovation

Comparing Lufthansa Achievements with ACARE/ATAG/IATA Goals

From 2009 to 2010 Lufthansa achieved 2.4% efficiency improvement on fuel burn. This is higher than goals by ACARE, ATAG and IATA setting 1% ... 2%. 

Lufthansa: Balance – Das wichtigste zum Thema Nachhaltigkeit im Lufthansakonzert. 2011
Growth and Goals for Innovation

ACARE Goals Progress Evaluation (AGAPE) Public Summary

Whilst the AGAPE analysis has shown that significant progress has been achieved and is underway for all of the Goals, it also outlined that more efforts are required for the Goals to be fully reached at a uniform pace.

Furthermore, the transition from technology availability to technology uptake in product or system is influenced by many factors and amongst factors of a non-technological nature such as market expectations, new products or improvements being developed. Other factors …

Romain Muller: ACARE Goals Progress Evaluation. AeroSpace and Defence Industries Association of Europe, 2010

Not all ACARE goals from Vision 2020 will be met. This has no consequence, because the goal post has shifted to 2050 with the new Flight Path 2050. Therefore the Vision 2020 is no longer needed.
Making up for what is Missing: Introducing Compensation Schemes

There is no real reason to start with compensation in 2020. Compensation could as well start today. If the level of CO2 concentration in the atmosphere is not considered high enough jet, it may not warrant to start with compensation now.

www.iata.org (12-09-10)

IATA (and ATAG) want to achieve zero emission growth from 2020 onwards. This is only possible with carbon offset schemes.
Growth and Goals for Innovation

Carbon Offsets / Carbon Compensation

1.)

![Image of atmosfair emissions calculator](atmosfair-emissions-calculator.png)

Using *atmosfair* as an example.

www.atmosfair.de

Emission Calculation is sufficiently accurate.

2.) **Compensation rate**: 24 € for each t of CO2

Growth and Goals for Innovation

Some Comments on ETS and Carbon Compensation

Emission Trading Scheme (ETS)
• The EU charges with ETS for something they do not own! (It’s Gods nature!)
• But: ETS could also be called charge or tax.

Carbon compensation
• Only activities count that would otherwise not be done => activities in „third world countries“
• Activities do not ask for an economic equivalent contribution
• If they would, profit could be made => compensation costs were zero
• What happens to the “Diesel burners”? Still in use?
• Planting (new!) forests only works as long as land is available!
• My impression: Too much CO2 is compensated for too little activity (the wood stove).
• If you own an eco investment that makes a profit, it does not count.
• Compensation is compared to indulgences (Ablashandel) (R.E. Goodin)
• Compensation is morally problematic: “If you pay it’s ok”.
• Someone in Africa stops (flying) for you to continue.
• Big (IATA) compensation problematic: Who is so big as to compensate aviation (partially)?
• How many wood stove do you need to give to Africa to compensate for all aviation?
• But it could be cheaper to compensate (on the ground) than spend big money in the air.
Eco-Efficiency in Aviation – Flying Off Course?

Contents

• Introduction

• Growth and Goals for Innovation

• Learning from History Looking into the Future

• Some Ideas (Air Travel Evaluator)

• Summary
Learning from History Looking into the Future

Learning from History

1. Bust of the American whale oil industry. 1859, Edwin Drake struck oil at Titusville, Pennsylvania. In a few days, Drake extracted as many barrels of oil as a whaling ship could gather on a four-year voyage.

2. British excessive coal usage after the invention of the efficient steam engine by James Watt. William Jevson analyses the mechanism.
Learning from History Looking into the Future

**Jevsons Paradox:** Why Fuel Can Not Be Saved from Efficiency Increase

![Graph showing Jevons Paradox](de.wikipedia.org)

**William Jevson**
around 1885

[Source: W.S. Jevons: The Coal Question](de.wikipedia.org) (12-09-10)
Learning from History Looking into the Future

**Jevsons Paradox: Why Fuel Can Not Be Saved from Efficiency Increase**

Technological progress that increases the efficiency with which a resource is used tends to increase (rather than decrease) the rate of consumption of that resource.

Increased energy efficiency tends to increase energy consumption by two means:

1. Increased energy efficiency makes the use of energy relatively cheaper, thus encouraging increased use (the direct rebound effect).
2. Increased energy efficiency leads to increased economic growth, which pulls up energy use for the whole economy (indirect rebound effect).

To ensure that efficiency enhancing technological improvements reduce fuel use, efficiency gains must be paired with government intervention that reduces demand (e.g., green taxes, a cap and trade program, or higher fuel taxes.)
Learning from History Looking into the Future

M. King Hubbert (1956): Peak Oil

Different assumptions for Peak Oil.


Net difference between annual world oil reserves additions and annual consumption.

Hirsch, R. L.: Peaking of World Oil Production – Impact, Mitigation and Risk Management. SAIC, 2005
Learning from History Looking into the Future

We will have not One but Three Issues!

- **E** => **CO2**: Burning Energy produces CO2
- **CO2** => **E**: Splitting CO2 with sunlight gives kerosine (some day): STL
- **E** => **W**: Sea water is converted to drinking water with help of energy
- **W** => **E**: Water is needed for BTL (exception: algae)
- **CO2** => **W**: global warming means melting of glaciers the drinking water storage
- **W** => **CO2**: melting of glaciers and polar caps means more global warming

**So what is of importance?**
1. water
2. energy
3. CO2

**What is needed?**
1. drinking water protection (from pollution)
2. reservoirs (saving water from melting glaciers)
3. wells
4. energy efficient salt water treatment plants
Learning from History Looking into the Future

Looking into the Future

• Past: climate models. Future: world models!
• Today things could be simulated much better than in the 70s (Dennis Meadows)

• Challenge all assumptions (like those from eco efficiency):
  • Technological innovation the main solution
  • Business as the principal actor of transformation
  • Trust in markets (if they are functioning well – no they are not)
  • (waste free) growth is conducive.

• We may need new guidance - maybe from a new buzz word?

Definition: Resilience (Widerstandsfähigkeit)
Resilience is the ability of an organization, resource, or structure to sustain the impact of an interruption, recover and resume its operations to continue to provide at least minimum services. One way to achieve resilience is by using redundancy.
Eco-Efficiency in Aviation – Flying Off Course?

Contents

• Introduction

• Growth and Goals for Innovation

• Learning from History Looking into the Future

• Some Ideas (Air Travel Evaluator)

• Summary
Some Ideas

Selecting Research Ideas

How to select and prioritize technologies / ideas with always limited financial resources?

• Time is running up - Get things done today!
• Consider possible "show stoppers" for ideas and eliminate these ideas first!
• Quantify potential savings first (and set them in relation to entry into service)!
• Is the (implementation) strategy sound?

... Get things done! This is what we could easily do:

• Get more openness in data and information sharing for aircraft and engine data [1]
• Reach general acceptance towards a metric for fuel efficiency of aircraft
• Provide on the Internet an “Air Travel Evaluator” (Avoid detours!)

Some Ideas

“Air Travel Evaluator”

Carbon compensation should only be a way with which to mitigate the damage of unavoidable emission release.

There is often no relationship between environmental impact (fuel burn) and ticket price. On the contrary, in many cases flight options with large detours would often be the cheapest travel option.

Atmosfair: *Airline Assessment Index* serves to differentiate between airlines.

Compensator’s online emission calculators give equivalent CO2 for each flight. No software support is given for the selection of the best flight. A flight evaluation tool the ‘Flight Evaluator’ is needed.
### Some Ideas

**“Air Travel Evaluator”**

<table>
<thead>
<tr>
<th>Airline</th>
<th>Stage 1 A/C</th>
<th>Via</th>
<th>Airport Code</th>
<th>Stage 2 A/C</th>
<th>GCR Distance (km)</th>
<th>Price (€)</th>
<th>m_F (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAP Portugal</td>
<td>A319</td>
<td>Lisbon</td>
<td>LIS</td>
<td>A319</td>
<td>2709</td>
<td>303</td>
<td>68.79</td>
</tr>
<tr>
<td>Aeroflot</td>
<td>A320</td>
<td>Moscow</td>
<td>SVO</td>
<td>A320</td>
<td>5181</td>
<td>453</td>
<td>143.09</td>
</tr>
<tr>
<td>Swiss Air</td>
<td>A319</td>
<td>Zurich</td>
<td>ZRH</td>
<td>A319</td>
<td>1931</td>
<td>516</td>
<td>47.62</td>
</tr>
<tr>
<td>Air Berlin</td>
<td>A320</td>
<td>Palma</td>
<td>PMI</td>
<td>A321</td>
<td>2203</td>
<td>517</td>
<td>53.81</td>
</tr>
<tr>
<td>Turkish Airlines</td>
<td>B737-800</td>
<td>Istanbul</td>
<td>IST</td>
<td>A321</td>
<td>4697</td>
<td>528</td>
<td>122.05</td>
</tr>
<tr>
<td>KLM</td>
<td>B737-800</td>
<td>Amsterdam</td>
<td>AMS</td>
<td>B737-800</td>
<td>1837</td>
<td>682</td>
<td>47.97</td>
</tr>
<tr>
<td>Lufthansa</td>
<td>B737-300</td>
<td>Direct</td>
<td>n/a</td>
<td>n/a</td>
<td>1778</td>
<td>717</td>
<td>47.17</td>
</tr>
</tbody>
</table>

*per pax*
Some Ideas

“Air Travel Evaluator”
Some Ideas

“Air Travel Evaluator”

![Graph showing the spread of ticket price vs. trip time for flights between Madrid (MAD) and Hamburg (HAM). The graph includes data points for Lufthansa, KLM, Swiss Airutha Air Berlin, Turkish Airlines, Aeroflot, and Tap Portugal. The x-axis represents trip time in hours, ranging from 0 to 14, and the y-axis represents ticket price in euros, ranging from 0 to 800. The graph includes colored lines indicating different cost rates per hour: 150 €/h, 100 €/h, 50 €/h, 25 €/h, and 10 €/h.]
Some Ideas

“Air Travel Evaluator”

![Diagram showing fuel consumption vs. ticket price for flights between Madrid (MAD) and Hamburg (HAM). The graph compares different airlines with varying fuel consumption rates per passenger.]
Some Ideas

“Air Travel Evaluator”

![Graph showing fuel consumption vs. trip time for flights from Madrid (MAD) to Hamburg (HAM). The graph compares different airlines with varying fuel consumption rates per passenger per hour.](image)
Some Ideas

“Air Travel Evaluator”

\[
X_p = 1 - \frac{P_x - P_{Min}}{P_{Max} - P_{Min}}
\]

\[
X_t = 1 - \frac{t_x - t_{Min}}{t_{Max} - t_{Min}}
\]

\[
X_{m_F} = 1 - \frac{m_{F,x} - m_{F,Min}}{m_{F,Max} - m_{F,Min}}
\]
Some Ideas

“Air Travel Evaluator”

<table>
<thead>
<tr>
<th></th>
<th>$X_p$</th>
<th></th>
<th>$X_l$</th>
<th></th>
<th>$X_{mf}$</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TAP Portugal</td>
<td>100</td>
<td>A</td>
<td>Lufthansa</td>
<td>100</td>
<td>A</td>
<td>Lufthansa</td>
</tr>
<tr>
<td>Aeroflot</td>
<td>64</td>
<td>D</td>
<td>Swiss Air</td>
<td>83</td>
<td>B</td>
<td>Swiss Air</td>
</tr>
<tr>
<td>Swiss Air</td>
<td>49</td>
<td>E</td>
<td>KLM</td>
<td>80</td>
<td>B</td>
<td>KLM</td>
</tr>
<tr>
<td>Air Berlin</td>
<td>48</td>
<td>E</td>
<td>Air Berlin</td>
<td>73</td>
<td>C</td>
<td>Air Berlin</td>
</tr>
<tr>
<td>Turkish Airlines</td>
<td>46</td>
<td>E</td>
<td>TAP Portugal</td>
<td>48</td>
<td>E</td>
<td>TAP Portugal</td>
</tr>
<tr>
<td>KLM</td>
<td>8</td>
<td>G</td>
<td>Turkish Airlines</td>
<td>2</td>
<td>G</td>
<td>Turkish Airlines</td>
</tr>
<tr>
<td>Lufthansa</td>
<td>0</td>
<td>G</td>
<td>Aeroflot</td>
<td>0</td>
<td>G</td>
<td>Aeroflot</td>
</tr>
</tbody>
</table>

4 EU Directive 2006/32/EC is applicable to ‘Energy End-use Efficiency and Energy Services’. To ensure complete suitability, the introduction of an aviation specific directive would be advised.
Some Ideas

“Air Travel Evaluator”
Some Ideas

\[ P_{\text{eff}} = P + L(t_x - t_{\text{Min}}) + C(m_{F,Pax,x} - m_{F,Pax,\text{Min}}) \]

\[ X_{p_{\text{eff}}} = 1 - \frac{P_{\text{eff},x}}{P_{\text{eff},\text{Max}}} \]

To provide illustration of the system, predefined rates for \( L \) and \( C \) of 6 €/h leisure, 20 €/h business, and 0 €/tCO\(_2\) indifferent, 25 €/tCO\(_2\) green, respectively, are used in the analysis.
Some Ideas

“Air Travel Evaluator”

<table>
<thead>
<tr>
<th>Airline</th>
<th>Green Ranking</th>
<th>Indifferent Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAP Portugal</td>
<td>100 A</td>
<td>TAP Portugal 100 A</td>
</tr>
<tr>
<td>Swiss Air</td>
<td>58 E</td>
<td>Aeroflot 54 D</td>
</tr>
<tr>
<td>Air Berlin</td>
<td>52 E</td>
<td>Swiss Air 50 E</td>
</tr>
<tr>
<td>Aeroflot</td>
<td>9 E</td>
<td>Air Berlin 48 E</td>
</tr>
<tr>
<td>KLM</td>
<td>6 F</td>
<td>Turkish Airlines 35 E</td>
</tr>
<tr>
<td>Lufthansa</td>
<td>4 G</td>
<td>KLM 6 G</td>
</tr>
<tr>
<td>Turkish Airlines</td>
<td>0 G</td>
<td>Lufthansa 0 G</td>
</tr>
</tbody>
</table>
Some Ideas

“Air Travel Evaluator”

<table>
<thead>
<tr>
<th>Airline</th>
<th>Green Ranking</th>
<th>Indifferent Airline</th>
<th>Indifferent Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAP Portugal</td>
<td>100, A</td>
<td>TAP Portugal</td>
<td>100, A</td>
</tr>
<tr>
<td>Swiss Air</td>
<td>75, D</td>
<td>Swiss Air</td>
<td>54, D</td>
</tr>
<tr>
<td>Air Berlin</td>
<td>67, E</td>
<td>Air Berlin</td>
<td>48, E</td>
</tr>
<tr>
<td>Lufthansa</td>
<td>35, F</td>
<td>Aeroflot</td>
<td>25, F</td>
</tr>
<tr>
<td>KLM</td>
<td>33, F</td>
<td>Turkish Airlines</td>
<td>3, G</td>
</tr>
<tr>
<td>Aeroflot</td>
<td>7, G</td>
<td>Lufthansa</td>
<td>1, G</td>
</tr>
<tr>
<td>Turkish Airlines</td>
<td>0, G</td>
<td>KLM</td>
<td>0, G</td>
</tr>
</tbody>
</table>
Some Ideas

“Air Travel Evaluator”

Tools for Political Influence

- Fiscal Policy
  - Charges
  - Subsidies
  - Capital Investments

- Administrative Policy
  - Traffic Regulations
  - Administrative Regulations
  - Technical Regulations
  - Personnel Certification

- Regulatory Policy
  - Market Authorisation
  - Capacity Control
  - Price Regulation
  - Monopoly Prevention, Code-share & Co-operation
Eco-Efficiency in Aviation – Flying Off Course?

Contents

• Introduction

• Growth and Goals for Innovation

• Learning from History Looking into the Future

• Some Ideas (Air Travel Evaluator)

• Summary
Eco-Efficiency in Aviation – Flying Off Course?

My very personal Summary and Outlook

• **The aircraft is mature**, whatever will come, will not change the game

• With ever more people on this planet, life will get more difficult
• Primary concern in the future is **water**, if water runs out, a war can start in days

• Fossil fuels will come to an end – probably later than we now believe
• Something totally different will be coming after this energy aera – we need to work on it
• The change will not be smooth so we need **resilience**

• We spend our resources on too many things that do not matter in the big picture
• We could be advancing at a faster pace if we **get focused on what really matters**
Eco-Efficiency in Aviation – Flying Off Course?

Contact

info@ProfScholz.de

http://www.ProfScholz.de