electric green taxiing system
Presentation to Arts et Métiers – June 2013
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These Commodities, Technology or Software Were Exported From the United States in Accordance with the Export Administration Regulations. Diversion Contrary to U.S. Law Prohibited.
Introduce electric green taxiing system (EGTS) concept and Provide overview

- General Introduction to EGTS and Safran/Honeywell JV
- Technical Overview
- Benefits/Value
  - Operational benefits
  - Present Airline Value Model

Focus on ground operations

Summary

Informing on EGTS Program and Airline Benefits
electric green taxiing system
general introduction
Why an **electric green** taxiing system?

Current impact of global single aisle fleet in airport ground operations

- **Aircraft engines not optimized for ground operations**
  - Technology now available to offer a more efficient alternative

- **Fuel is now ~ 40% - 50% of Airlines’ costs**
  - Up to 6% of total fuel burnt on ground

- **One single EGTS aircraft equivalent to removing from European roads:**
  - ~ 400 Cars (Fuel + CO₂ emissions)

- **EGTS will save 50%**
  - ~ 1 Million+ cars

- **~3,000 EGTS single aisles**
  - ~ 13 Million tonnes CO₂
Basic Concept of the EGTS

- The **EGTS** will allow the aircraft to push-back and taxi under APU generated electrical power *without the main engines running*
  - APU generator powered motors allow aircraft to “taxi”
  - Motors housed in main landing gear wheels for maximized performance, traction and agility

- High value offering to Single Aisle Airline Customers with significant savings and “Green” Benefits, *reducing*:
  - Fuel Use
  - Airport Emissions
  - Need for Ground Tug
  - Other Direct Operation Costs

**Target Savings:** ~3% block fuel reduction depending on mission
A 50/50 JV combining the strength of two market leaders

- SAF-HON have established a JV for **electric green taxiing system** development
  - Provides an accelerated time to market for **electric green taxiing system**
  - Partnership includes joint system development, production, marketing and support
  - JV to provide a superior product and global customer support

- Partnership provides systems expertise and early availability of **electric green taxiing system**
  - Honeywell Avionics and APU system breadth
  - Safran landing gear systems breadth
  - Complementary capabilities in electric power products and systems integration
electric green taxiing system
technical overview
EGTS schematic architecture

Pilot and cockpit interface unit

EE bay

Green Taxiing control unit

Motor controller and power distribution

to APU and generator

Cargo bay

Wheel actuator with driver motor on main landing gear wheels

Pilot and cockpit interface unit

1. Pilot and cockpit interface unit
2. Motor controller and power distribution
3. Green Taxiing control unit

1. EGTS controller
2. Wiring
3. APU
4. Generator

EGTS schematic architecture

Interfaced Equipment

New Equipment

Upgraded Equipment

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SAFRAN  Messier-Bugatti-Dowty
Honeywell
Prototype Testing

WA Full perfo Testing

Dyna bench test

Equipped LG

EP system bench test

Full system integration on Airplane Testing started in March ‘13

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On-Aircraft testing began end of March on Safran A320 MSN 234
electric green taxiing system
Benefits / Value
EGTS: substantial **benefits** depending on operational profile

- **Net ~3% block fuel savings per average flight cycle** (750NM) when using EGTS

**EGTS Target Segment**

- **Short Haul**: (Average sector length <1000 NM)
- **Hub Congestion**: (Average Taxi Time > 20 min)
- **Annual Landings**: (Annual Utilization > 1500 landings)

**Target segment based on value drivers**
EGTS: benefits to airlines and environment

- **Benefits quantified:**
  - Reduced fuel burn and brake wear
  - Reduced ground tug operation
  - Reduced Foreign Object Debris damage (Estimate – Insight SRI)
  - Elimination of taxi out fuel contingency
  - Reduced emissions / carbon taxes

- **Benefits recognized but not quantified:**
  - Reduced noise in airport environment
  - Improved safety at apron: No engines running / no jet blast
  - Taxi to hangar / gate and stand positioning
  - Increased gate autonomy / Improved OTP
  - Reduced ground operations damage
  - Engine maintenance cost savings
  - Higher precision manoeuvring
  - Lower pilot workload vs. Single Engine Taxi

- **Additional costs quantified:**
  - Increased APU fuel burn
  - EGTS and additional APU Maintenance
  - Additional aircraft fuel burn due to EGTS Weight
Reducing fuel use and ground operations costs

Value model delivers over 50% savings compared to Dual Engine Taxi

Additional EGTS savings:
- Pushback costs
- Brake wear
- Carbon credit
- Foreign Object Damage
- ....

As well as:
- Aircraft positioning
- On Time Performance
- ....

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Reducing airline and airport environmental footprint

- Reduced carbon and greenhouse gas emissions linked to aircraft ground operations

![Comparison of greenhouse gas emissions at airport level](image)

- Reduced noise in the airport environment

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Improving operational efficiency

- **Improved health, safety and efficiency for airport ground personnel**
  - No engines running in gate area
  - No jet blast
  - Personnel can get to work sooner after aircraft arrival at gate

- **Improved performance for airports... .... and passengers**
  - Reduced Turn Around Time at gate
  - Faster passenger disembarkation
  - Earlier luggage delivery

- **Increased aircraft autonomy**
  - Ability to “Pushback and Go”
  - No reliance on tug

Towards ultimately improving gate capacity via improved On Time Performance
Airlines will value **electric green taxiing system** differently depending on annual cycles & other operating parameters (i.e. $ benefits derives from the usage):

1. **Taxi time (In + Out)**
2. **Flight Cycles / year**
3. **Electric GTS Utilization**
4. **Flight Ranges**

<table>
<thead>
<tr>
<th>Taxi Time</th>
<th>$ savings</th>
<th>$$$ savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>10+5</td>
<td>15+10</td>
<td>20+10</td>
</tr>
<tr>
<td>Utilization</td>
<td>55%</td>
<td>65%</td>
</tr>
<tr>
<td>Flight cycles</td>
<td>1000</td>
<td>1800</td>
</tr>
<tr>
<td>Flight range</td>
<td>1500</td>
<td>600</td>
</tr>
<tr>
<td>$/USG</td>
<td>2$</td>
<td>3$</td>
</tr>
</tbody>
</table>

**Fuel & DOC Savings vs. EGTS Utilization for taxi out and in**

- **65%**: 145t, $239K
- **75%**: 165t, $261K
- **85%**: 185t, $283K

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electric green taxiing system
focus on ground operations
Designed to meet Airlines & Airports operational requirements

- Key system features:
  - ≈20 knots speed in 90 seconds (≈18 knots @ MTOW)
  - 10 knots speed in 20 seconds for active runway crossing
  - Breakaway torque @ 1.5% slope at MTOW
  - No degradation on current availability (dispatch; accessibility for line maintenance)

- Measured taxi profiles vs. predicted performance
Ground operations fuel burn segmentation

- **Pushback and Taxi Out**: different procedures, different fuel burns (ex 12 min PB & taxi out up to holding point)

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Fuel Burn (kg/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual Engine taxi</td>
<td>5.8</td>
</tr>
<tr>
<td>Single Engine taxi</td>
<td>7.42</td>
</tr>
<tr>
<td>Idle fuel burn</td>
<td>5</td>
</tr>
<tr>
<td>APU standard fuel burn</td>
<td>1.81</td>
</tr>
<tr>
<td>APU EGTS fuel burn</td>
<td>2.07</td>
</tr>
</tbody>
</table>

### Dual engine Pushback and Taxi Out: 133 kg fuel burn

1. **Pushback**: 3 min
2. **Eng 1 IDLE**: Start Eng 1
3. **Eng 1 Dual Eng taxi**: Eng 1 Dual Eng taxi
4. **APU ON**: APU ON
5. **APU cool down**: APU cool down
6. **TAXI OUT**: Holding
7. **12 min**: Holding

### Single engine Pushback and Taxi Out: 102 kg fuel burn

1. **Pushback**: 2 min
2. **Eng 1 Single Eng taxi**: Start Eng 1
3. **Eng 1 Dual Eng taxi**: Eng 1 Dual Eng taxi
4. **Eng 2 Dual Eng taxi**: Start Eng 2
5. **APU ON**: APU ON
6. **APU cool down**: APU cool down
7. **TAXI OUT**: Holding
8. **11 min**: Holding

### EGTS Pushback and Taxi Out: 56 kg fuel burn

1. **Pushback**: 1 min
2. **Eng 1 IDLE**: Start Eng 1
3. **Eng 1 Dual Eng taxi**: Eng 1 Dual Eng taxi
4. **Eng 2 Dual Eng taxi**: Start Eng 2
5. **APU ON**: APU ON
6. **APU cool down**: APU cool down
7. **TAXI OUT**: Holding
8. **10 min**: Holding

- **>50% fuel burn reduction & 2 min time savings with EGTS vs. Dual Engine taxi**
### Ground operations fuel burn segmentation

- **Taxi In**: different procedures, different fuel burns (ex 7 min Taxi In from end of landing roll, Idle Reverse)

<table>
<thead>
<tr>
<th>Time</th>
<th>Fuel Burn</th>
<th>Procedure</th>
<th>Engines</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 min</td>
<td>85 kg</td>
<td>Dual Eng taxi</td>
<td>Eng 1 Dual Eng taxi, Eng 2 Dual Eng taxi</td>
</tr>
<tr>
<td>5 min</td>
<td>71 kg</td>
<td>Single Eng taxi</td>
<td>Eng 1 Single Eng taxi</td>
</tr>
<tr>
<td>7 min</td>
<td>36 kg</td>
<td>EGTS pushback and taxiing</td>
<td></td>
</tr>
</tbody>
</table>

#### Time saving to be assessed

- Dual Engine taxi fuel burn: 5.8 kg/min
- Single Engine taxi fuel burn: 7.42 kg/min
- Idle fuel burn: 5 kg/min
- APU standard fuel burn: 1.81 kg/min
- APU EGTS fuel burn: 2.07 kg/min

>55% fuel burn reduction with EGTS compared with Dual Engine taxi
electric green taxiing system

conclusion
Strong VOC Interest From Airlines

Airlines

- Highly interested due to fuel burn and “Green” benefits
  - “EGTS has big impact on fuel savings and we are very much focused on that”
  - “Green issues are becoming more and more important for us.”
- Completely driven by cost reduction and agrees that system provides significant savings
  - “…if Flt Ops, Ground Ops & Engineering happy, would likely order EGTS”
- “Green taxi will happen” “We are focused on reducing taxi fuel consumption”
- Focused on reducing fuel burn and evaluating ways to achieve more efficient taxi ops
  - “…would order if investment criteria met and comfortable with risk”
- Interested in concept and want to understand value proposition
  - “Very interesting…like the concept…a real benefit is increased flexibility on pushback”
- N European airline: Even with short taxi times, interested in EGTS due to “Green” and other benefits
- Interested in EGTS as it aligns with focus on fuel reduction.
  - “We are focused on fuel reduction and are currently assessing a number of fuel saving measures with less or much less benefit than what EGTS would provide.”
- Head of NA Airline Fuel Efficiency Group, with long sectors resulting in ~1.5% fuel savings
  - “…this system is very exciting and has a very good future ahead of it….philosophy is sound….it is the way of the future!”
Strong VOC Interest From Airports

- North American and European airports
  - Highly interested due to Green and other benefits
    ".. lower emissions is a real benefit"
    "...we see a benefit from the environmental impact – lower noise and emissions."
    "...we hope EGTS will put our tug business out of business!"
  - Willing to work with airlines to change ground operations procedures
    "...we’ll do what we need to do to accommodate electric green taxiing system."
  - Believe that aircraft with EGTS could pay lower landing and other fees
    "Differentiation fees for EGTS vs. non-EGTS may be possible. Airport community could be driven to accept this change, globally."
electric green taxiing system: summary and way forward

- **Main benefits**
  - Increased fuel efficiency
  - Operational benefits
  - Environmental benefits
  - Operating cost savings

- **Honeywell and Safran: A powerful partnership bringing a mature EGTS to market**

**A green and innovative concept**

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