



Reducing Aircraft Ground Emissions

presented by

Henry Fan

Centre for Infrastructure Systems

School of Civil and Environmental Engineering

26 May 2008



Presentation Outline

- Types of airport pollutants
- Sources of airport pollutant emissions
- Potential measures to control aircraft ground emissions
 - Operating fewer engines while taxiing
 - Use of GPU instead of APU
 - Extended towing of aircraft instead of taxiing
- Case study (Singapore Changi Airport)
- Conclusions and recommendations



Types of Airport Pollutants

- Volatile Organic Compounds, VOC / HC
- Carbon monoxide, CO (incomplete fuel burn) and Carbon dioxide, CO₂ (complete combustion)
- Oxides of Nitrogen, NO_x
- Sulfur dioxide, SO₂
- Particulate matter, PM

These can cause harm to human beings, plants and animals, damage ozone layer, and reduce visibility at an airport.



Sources of Pollutant Emissions

- Aircraft engine exhaust (including fuel venting)
 - approach, landing, taxi/idle, takeoff, climb-out
 - terminal/apron area (auxiliary power unit)
 - Maintenance (engine run-up)
- Fueling system & storage tanks: accidental spillage, HC vapour
- Ground service equipment
- Airport construction activities
- Vehicular traffic in and out of airport



Measures to Reduce Aircraft Pollutant Emissions

- Improve airframe and engine design
- Better flight planning and air traffic control procedures to increase flight operation efficiency
- Increase airfield capacity to reduce congestion
- Modify aircraft ground operations



Taxi with Fewer Operating Engines

- Taxiing requires very low thrust (idle thrust), hence one or more engines may be shut down to reduce fuel consumption during taxi-in and/or taxi-out
- Engine(s) in use would operate at higher power setting to compensate for power loss (more efficient fuel-burn with little increase in fuel consumption)
- May cause delay to departures (engine warm-up before takeoff; engine fail to start)
- May need additional fire-fighting equipment



Use GPU/PCA Instead of APU

- APU provides electric power supply and conditioned air when an aircraft is parked at the apron with its main engines shut down
- In place of APU, GPU (115/220V, 400 Hz) can be used to provide electric power and PCA (pre-conditioned air) system used to provide temperature-controlled air
- Cost of GPU/PCA can be justified by reduced fuel consumption and maintenance costs of APU



Extended Aircraft Towing

- Regular extended towing of loaded aircraft between runways and terminal apron areas
- Safety Concerns
 - Stress imposed on nose-gear
 - Control of aircraft (tractor driver v pilot)
 - Fire protection
- Operational and Cost Concerns
 - Increased controller workload, low tractor speed
 - Large staging area for engine warm-up
 - Additional equipment and manpower needed
 - May need additional roadway(s) for tractors



Changi Airport Information*

- Operating runways: 2 (02L/20R and 02R/20L)
- Operating terminals: 3 (Terminal 1, Terminal 2, Budget Terminal)
- Commercial passenger aircraft movements: 214,224
- Aircraft parking positions: 109 at T1 and T2 (67 contact gates, 42 remote positions)
- Observed average taxi speeds: arrivals – 25 knots; departures – 12 knots

* *Information for 2006*



SCA Case Study

- Fleet mix extracted from SCA website
- Engine type and APU obtained from manufacturers
- Engine fuel consumption and emission rates obtained from data published by US EPA

Aircraft Model	Fleet Mix (%)	Average Fuel Rate (kg/h)	Emission Rate (kg / tonne of fuel)		
			HC	CO	NO _x
A320	14.92	820.8	1.85	28.93	3.46
A330-300	6.60	1756.8	1.58	12.02	3.87
B747-400	13.10	3304.8	6.39	28.33	4.13
B777-300	11.55	2221.2	16.47	31.49	3.59
B777-200	16.78	2145.6	15.95	30.35	3.44

Baseline* Fuel & Emission Levels (SCA)

	Fuel Consumed (tonnes)	Emission Amounts (tonnes)		
		HC	CO	NO _x
Aircraft -- taxi/idle	32,498.8	282.8	920.3	123.6
Aircraft -- pushback	7,812.4	55.9	222.9	29.2
<i>Subtotal</i>	40,311.2	338.7	1,143.2	152.8
APU	18,604.1	6.7	59.5	105.1
Total	58,915.3	345.4	1,202.7	257.9

* Based on 2006 aircraft operation levels.



Fuel & Emission Levels (Various Cases)

Study Cases	Fuel Consumed (tonnes)	Emission Amounts (tonnes)		
		HC	CO	NO _x
<i>Taxi with fewer operating engines (use APU during parking)</i>				
-- taxi on one engine	35,893.1	154.9	546.1	169.9
-- with one engine off	41,626.4	197.1	716.2	193.1
<i>Taxi with fewer operating engines (use GPU/PCA during parking)</i>				
-- taxi on one engine	17,288.9	148.2	486.6	64.8
-- with one engine off	23,022.2	190.4	656.7	88.0
<i>Extended aircraft towing</i>				
-- with APU	42,582.8	179.0	671.2	212.0
-- with GPU/PCA	23,978.7	172.3	611.6	106.9

Estimated Emission Reductions (SCA)

Control Measure	Fuel Savings (tonnes)	Emission Amounts (tonnes)		
		HC	CO	NO _x
<i>Taxi with fewer operating engines & use APU during parking</i>				
-- taxi on one engine	23,022.2	190.4	656.7	88.0
-- with one engine off	17,288.9	148.2	486.6	64.8
<i>Taxi with fewer operating engines & use GPU/PCA during parking</i>				
-- taxi on one engine	41,626.4	197.1	716.2	193.1
-- with one engine off	35,893.1	154.9	546.1	169.9
<i>Use GPU/PCA</i>	18,604.1	6.7	59.5	105.1
<i>Extended aircraft towing</i>				
-- use APU	16,332.5	166.4	531.6	45.9
-- use GPU/PCA	34,936.6	173.1	591.2	151.0



Conclusions

- Significant reductions in fuel consumption and pollutant emissions can be achieved with the three ground operation strategies studied
- Operating fewer engines during taxiing can save 17,300 to 23,000 tonnes of fuel, leading to reductions of 148 to 190 tonnes of HC, 486 to 656 tonnes of CO, and 65 to 88 tonnes of NO_x emissions
- Use of GPU/PCA instead of APU during parking would save 18,600 tonnes of fuel and reduce CO and NO_x emissions by 59 and 105 tonnes



Conclusions (cont.)

- Use of GPU/PCA plus fewer operating engines result in reductions of 35,900 to 41,600 tonnes of fuel, 155 to 197 tonnes of HC, 546 to 716 tonnes of CO, and 170 to 193 tonnes of NO_x emissions
- Extended aircraft towing can save 16,300 tonnes of fuel, resulting in reductions of 166 tonnes of HC, 531 tonnes of CO, and 46 tonnes of NO_x emissions
- Use of GPU/PCA plus extended towing would save 34,900 tonnes of fuel and reduce HC, CO and NO_x emissions by 173, 591 and 151 tonnes



Recommendations

- Operating fewer engines during taxiing and replacing APU with GPU/PCA are feasible measures that could be implemented readily with no apparent concerns.
- Though substantial reductions in fuel use and emissions could be achieved with extended aircraft towing, there are safety, operational and cost concerns that need to be addressed. A pilot program to demonstrate how these issues could be resolved would be useful.





Thank You

