Airport Ground Support Equipment Inventory Data

In order to estimate the emissions benefit and costs of the off-road equipment rule, ARB staff must estimate the total population of affected equipment, its ages and characteristics, and how much it is used. ARB staff plan to use the ARB OFFROAD model as the primary tool to estimate off-road equipment population and emissions. However, we will update the model's assumptions where appropriate to more accurately reflect the fleet affected by the off-road equipment rule. ARB staff have evaluated other sources of off-road equipment inventory data including the following:

- United States Environmental Protection Agency (USEPA) NONROAD model – the USEPA's model of population and emissions from off-road equipment.
- 2005 ARB off-road equipment survey – The 2005 off-road equipment survey was conducted by ARB staff and included off-road equipment owned by both public and private entities.

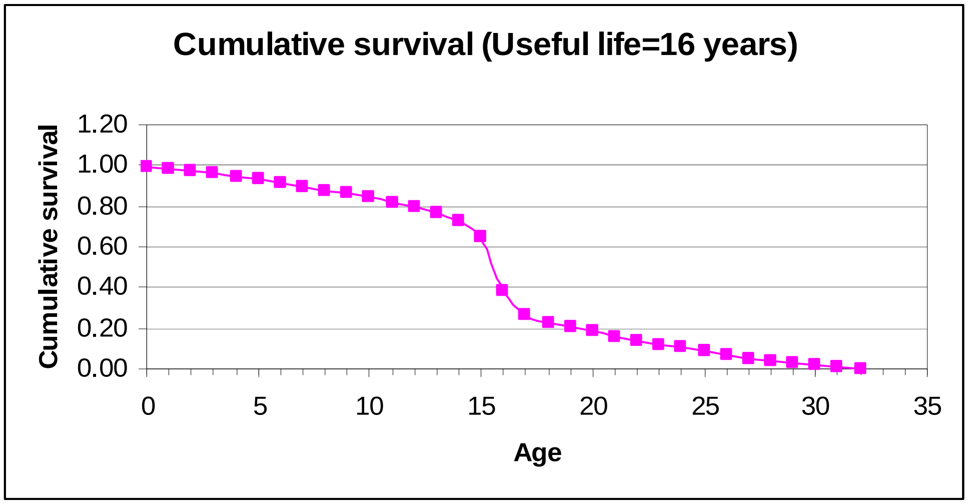
This discussion paper describes the equipment use, lifetime and population assumptions in the OFFROAD model for airport ground support equipment and compares them to comparable data from EPA NONROAD, and the 2005 off-road equipment surveys. ARB staff have prepared similar discussion papers for construction/mining equipment and industrial equipment. We would like to solicit any additional data or comments regarding the values presented in this paper.

Equipment Use and Lifetime

Understanding how equipment naturally ages and is replaced will be important for predicting the costs and benefits of the off-road rule. One way to comply with the rule will be to turn equipment over to cleaner equipment, so predicting the natural turnover that would occur in the absence of the rule will be critical.

ARB's OFFROAD model assumes that equipment enters the fleet, ages and is eventually scrapped. As equipment of a certain model year ages, each year some fraction of it is scrapped and some fraction of it survives. The cumulative survival at age x, S(x), is the fraction of equipment that survives to age x. By plotting survival versus age, the turnover of equipment can be represented by a survival curve. In the OFFROAD model, the survival curve is assumed to have a normal distribution of cumulative scrappage versus age. An example survival curve from the OFFROAD model is shown below in Figure G-1:

Figure G-1 – OFFROAD Model Cumulative Survival for Equipment of Useful Life 16 years



Eventually, all equipment of a certain model year will have been scrapped. When this occurs, cumulative survival equals 0. The survival curve for any given equipment type can be represented by one number, the useful life. The useful life, akin to a half-life, is the age at which the survival curve shows a point of inflection and is equivalent to when half of the units of a certain model year will have been scrapped. At the age of twice the useful life, all equipment will have been scrapped. The useful life for the survival curve shown in Figure G-1 is 16 years.

ARB's OFFROAD model estimates useful life based on the following equation:

Useful life (years) = Engine life at rated horsepower (hrs) / (Load factor x Annual Use (hours/year))

OFFROAD uses engine life at rated horsepower (hp) primarily from an analysis by Energy and Environmental Analysis, Inc. of Power Systems Research (PSR) on-highway engine life data, supplemented by interviews of engine manufacturers (EEA, September 2001). Load factor indicates the average proportion of rated horsepower used. OFFROAD uses load factors estimated by PSR based on surveys of equipment owners regarding how they use their equipment (ARB, 1999). OFFROAD uses estimates of annual use from a 1997 survey of ground support equipment (GSE) in the South Coast Air Basin done by the Air Transport Association (ATA).

The USEPA NONROAD model uses the same methodology as described above. However, differences between USEPA's and ARB's methodology include the following:

- NONROAD caps maximum useful life at 25 years. Thus, the maximum age of equipment in NONROAD is 50 years. OFFROAD no longer caps maximum useful life.
- USEPA did a recent review of the EEA work that resulted in USEPA using longer engine lives at rated hp than are used in the OFFROAD model (USEPA, April

2004). For example, NONROAD now assumes that diesel engines over 300 hp last 7000 hours at full load versus OFFROAD's 6,000 hours.

- USEPA has done some recent work to refine load factor estimates, and NONROAD uses load factors obtained from engine testing over several transient cycles (USEPA, April 2004).
- NONROAD uses estimates of annual use from a 1998 database developed by PSR.

OFFROAD includes a more refined estimate of mobile airport GSE emissions than NONROAD, dividing the equipment into 16 equipment types. NONROAD on the other hand just has one equipment type, airport support equipment, for airport GSE.

As shown in Table G-1, annual use for OFFROAD GSE types range from 12 hours per year to nearly 3500 hours per year. Annual use for the NONROAD airport support equipment type is 732 hours per year. Table G-1 also includes the weighted average of annual use from ARB's 2005 off-road equipment survey. For each equipment type, the reported annual use from each survey response was weighted by the number of equipment of a certain type reported.

The annual uses reported in the survey were similar to OFFROAD's values (i.e., within 15%) for aircraft tractors, belt loaders, cargo loaders, forklifts, and lifts. The survey annual uses differ significantly from those in OFFROAD for the other equipment types, especially for cargo tractors and sweepers. The survey values may be used to update annual use in OFFROAD. Before making a final determination, however, we would like to solicit any additional data on annual use of diesel airport GSE.

Table G-1 – OFFROAD and 2005 Off-road Equipment Survey Annual Use (hrs/yr) for GSE

Equipment Type	ARB OFFROAD Annual Use (hrs/yr)	2005 Off-road Equipment Survey Average Annual Use (hrs/yr)	2005 Off-road Equipment Survey: # of Equipment with Annual Use Data	% difference = (Survey - OFFROAD)/ OFFROAD
A/C Tug Narrow Body*	606	625	*318*	3%
A/C Tug Wide Body	759	NA	*0*	NA
Baggage Tug	1624	1392	*361*	-14%
Belt Loader	1038	974	*152*	-6%
Bobtail	1867	683	*6*	-63%
Cargo Loader	902	906	*269*	0%
Cargo Tractor	101	1309	*42*	1196%

Equipment Type	ARB OFFROAD Annual Use (hrs/yr)	2005 Off-road Equipment Survey Average Annual Use (hrs/yr)	2005 Off-road Equipment Survey: # of Equipment with Annual Use Data	% difference = (Survey - OFFROAD)/ OFFROAD
Catering Truck	1600	370	*1*	-77%
Forklift	732	743	*42*	2%
Fuel Truck	3489	625	*10*	-82%
Hydrant Truck	224	623	*18*	178%
Lav Truck	1307	NA	*0*	NA
Lift	917	791	*56*	-14%
Other	1646	922	*87*	-44%
Service Truck	1931	505	*12*	-74%
Sweeper	12	289	*17*	2308%

* The ATA survey, which included combined GSE data for many major air carriers in California, did not include on-road equivalents such as service trucks. Also, ATA responders reported all their aircraft tugs as narrow body.

Table G-2 below shows the useful lives for airport GSE in the OFFROAD model and the average age when retired or sold reported in the 2005 off-road equipment survey. Useful lives range from 6 years to a maximum of 16 years in the OFFROAD model. NONROAD lifetimes for airport support equipment are consistent with OFFROAD and range from 6 years for the smallest equipment to 16 years for the largest. To determine the average age when retired for each equipment type, the reported age when retired from each survey response was weighted by the number of equipment of a certain type for which age when retired was reported. Average age when retired from the off-road equipment survey ranges from 9 to 19 years.

The survey average ages when retired are generally within 30% of those used in the OFFROAD model. However, the values differ significantly for aircraft tugs, lav trucks, and lifts. The ATA survey, which included combined GSE data for many major air carriers in California, did not report average age when retired or sold for each equipment type. However, ATA reported based on an analysis of the average of their equipment and an assumed ratio between average age and useful life that the median useful life of off-road diesel GSE was over 19 years. This is significantly longer than the useful lives included in the OFFROAD model for GSE. Before making a final determination, we would like to solicit any additional data on useful life of diesel airport GSE.

Table G-2 – Useful Life Estimates for Airport GSE (years) in OFFROAD model and 2005 Survey*

Equipment Type	**ARB OFFROAD Useful Life (years)**	**2005 Off-road Equipment Survey Average Age When Retired (years)**	**2005 Off-road Equipment Survey: # of Equipment with Age Retired Data**	**% difference = (Survey - OFFROAD)/ OFFROAD**
A/C Tug Narrow Body	11	19	70	43%
A/C Tug Wide Body	15	14	7	-5%
Baggage Tug	14	14	319	2%
Belt Loader	12	14	122	14%
Bobtail	16	NA	0	NA
Cargo Loader	13	18	65	27%
Cargo Tractor	16	15	19	-5%
Catering Truck	11	10	1	-10%
Forklift	16	15	20	-5%
Fuel Truck	16	16	7	0%
Hydrant Truck	16	17	3	4%
Lav Truck	16	9	3	-78%
Lift	6	17	9	64%
Other	16	15	62	-9%
Service Truck	16	14	9	-12%
Sweeper	12	16	2	25%

*The ATA survey, which included combined GSE data for many major air carriers in California, did not report average age when retired or sold for each equipment type. However, the ATA survey stated that the median useful life of off-road diesel GSE was over 19 years.

Tier Distribution

Table G-3 and Figure G-2 show the distribution of airport GSE among the various emission standard tiers as modeled in ARB's OFFROAD model for the year 2005. The fleet in 2005 is split among Tier 0 (i.e. uncontrolled), Tier 1, and Tier 2 equipment, with the majority of equipment assumed to be Tier 1. We would like to solicit input from fleet owners on whether this tier distribution appears reasonable and consistent with their fleets.

Table G-3: 2005 OFFROAD Percent Population by Emission Standard Tier for GSE

Tier	Model Years[1]	Age of Equipment in Tier in 2005 (years)[1]	OFFROAD Percent
0	Up to 1999	>=6	32%
1	1996-2005	0-9	46%
2	2001+	0-4	22%

[1] – The effective dates of each emission standard tier vary by maximum horsepower. The off-road compression ignition engine standards are in Title 13, California Code of Regulations, Section 2423.

Figure G-2: 2005 OFFROAD Percent Population by Emission Standard Tier for GSE

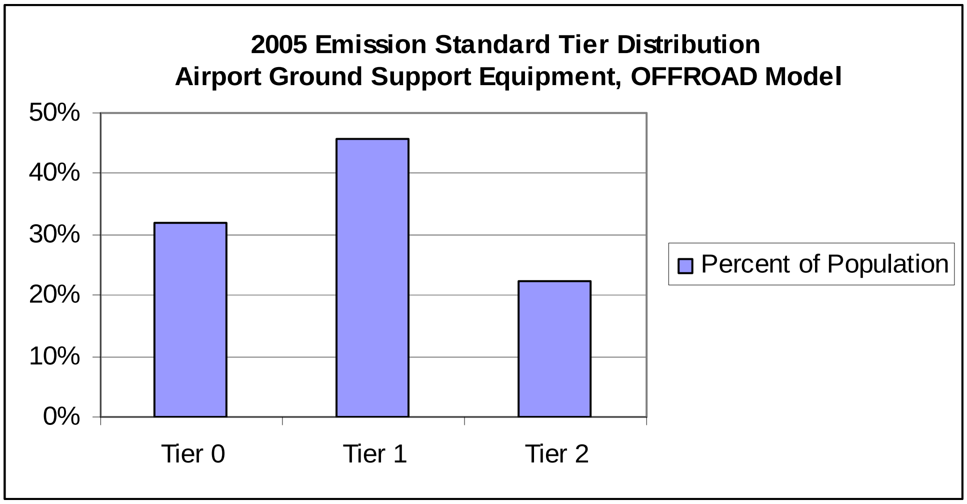


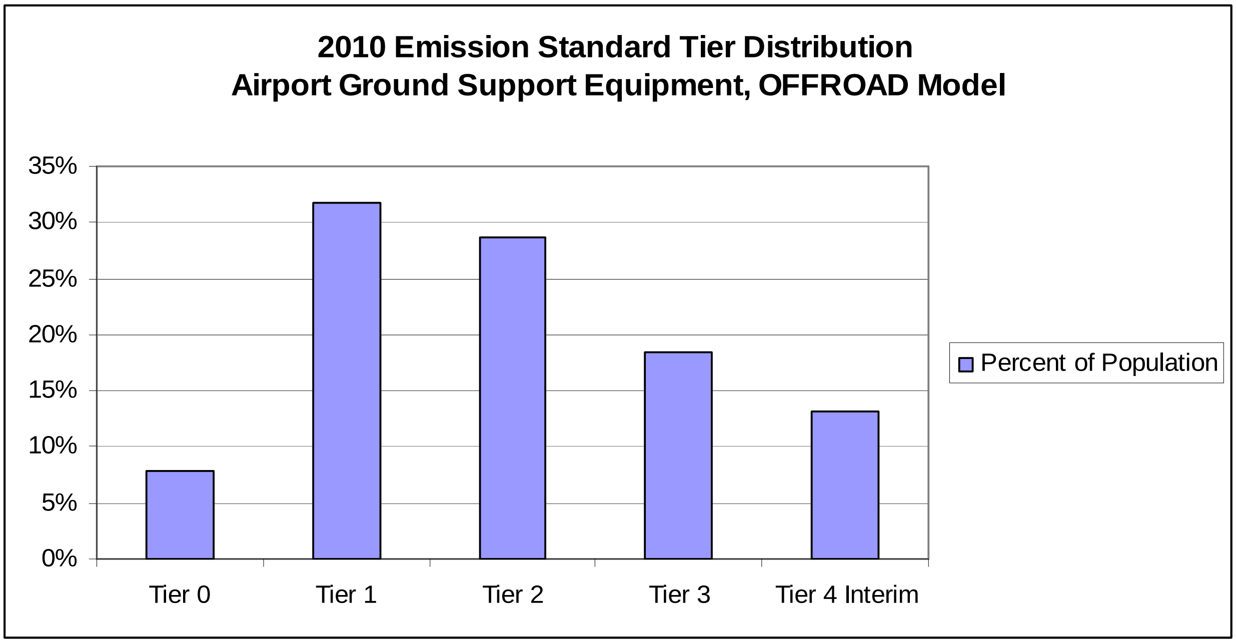
Table G-4 and Figure G-3 show the distribution of airport GSE among the various emission standard tiers as modeled in ARB's OFFROAD model for the year 2010. In 2010, the population is split among equipment meeting Tier 0, Tier 1, Tier 2, Tier 3, and Tier 4 interim standards. The majority of equipment is Tier 1 or 2.

Table G-4 - 2010 OFFROAD Population by Emission Standard Tier for GSE

Tier	Model Years[1]	OFFROAD Population	OFFROAD Percent
Tier 0	Up to 1999	124	8%
Tier 1	1996-2005	498	32%
Tier 2	2001-2007	452	29%
Tier 3	2006-2011	290	18%
Tier 4 Interim	2008+	208	13%

[1] – The effective dates of each emission standard tier vary by maximum horsepower. The off-road compression ignition engine standards are in Title 13, California Code of Regulations, Section 2423.

Figure G-3 - 2010 OFFROAD Percent Population by Emission Standard Tier for GSE



Equipment Population

OFFROAD equipment populations for airport GSE are based on a 1997 survey of GSE in the South Coast Air Basin done by the Air Transport Association (ARB, 1999). OFFROAD uses a base year of 2000 and then forecasts or backcasts populations from that year.

Table G-5 shows equipment population by equipment type from the OFFROAD model for calendar year 2005 and from ARB's 2005 off-road equipment survey. Equipment types are ranked from highest population to lowest, according to the populations in the OFFROAD model.

We received a strong response to the 2005 survey from operators of airport GSE. Overall, operators of GSE reported equipment summing to over 90% of the total statewide GSE population in the OFFROAD model. For some equipment types (highlighted in Table G-5), the equipment populations reported in the survey exceed those in the OFFROAD model for the whole state. For these highlighted equipment types, we propose updating the populations based on the survey. For aircraft tractors, many airlines reported all their aircraft tractors as narrow body, rather than distinguishing between narrow- and wide-body. The total population of narrow- and wide-body aircraft tractors reported in the survey, 331, was greater than the total population in the OFFROAD model, 317. Staff proposes maintaining the split between narrow- and wide-body tractors, but updating the populations of narrow- and wide-body tractors such that the total matches the total reported in the survey for narrow- plus wide-body tractors.

Table G-5 – Estimates of 2005 California Population of Airport GSE by Equipment Type – ARB OFFROAD model and ARB 2005 Off-road Equipment Survey*

Equipment	OFFROAD Population	Survey Population
Baggage Tug	538	404
Cargo Loader	317	287
Belt Loader	260	174
A/C Tug Narrow Body	254	325
A/C Tug Wide Body	63	6
Other	54	103
Service Truck	37	21
Forklift	29	43
Fuel Truck	24	20
Lift	21	58
Bobtail	19	10
Hydrant Truck	12	18
Catering Truck	9	2
Cargo Tractor	6	49
Lav Truck	6	3
Sweeper	3	26
Total	1652	1549

* The ATA survey, which included combined GSE data for many major air carriers in California, did not include on-road equivalents such as service trucks. Also, ATA responders reported all their aircraft tugs as narrow body.

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EEA, September 2001. Documentation of Diesel Engine Life Values Used in the ARB Off-Highway Model, Prepared for Office of Mobile Sources, Environmental Protection Agency, EPA Purchase Order 1A-0462-NASX, by Energy and Environmental Analysis, Inc., September 2001.

USEPA, April 2004. Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling, USEPA, EPA420-P-04-005, April 2004.

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