**Maintenance Reserve Billing Project**

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**Contri­­­­butors**

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Contribution

This was a joint project and we contributed equally to each aspect of the project.

# Introduction

In this project we created a database for the management of Aircraft engine in an Engine Lease company. This will allow the user to add, update and retrieve data in database. This database is based on the relational model. The database management system also includes management and administrative functions, which use a command-line interface that allows the entry and executio­­­­­­n of language commands A database management system is the tool used to build the structure of the database and in operating on the data contained within it.

The Database is named engine\_management and consists of nine tables. Each table stores a specific set of data pertaining the customer, engine, the Operator and to events that occur during the leasing of an Aircraft Engine. The Engine Leasing database system is similar in principle to a library database system. The Engine, like a book has data specific to that engine. this information is stored in the ‘engine’ table. The Lessee details are kept in the ‘customer’ table, a Lessee is located and operates in a specific airspace, this information is stored in the ‘country’ table. Location of a Lessee (Engine operation) has an impact on billing, as the different operating environments has a multiplier due to the erosive effect of the environment in which they operate. The duration of the lease and operational details are kept in the ‘lease’ and operation’ and ‘engine\_usage’ tables. Different rates are applied to each lease, these depend on duration of lease and operating environment, information relating to these are stored in the ‘usage\_rate’ and ‘maintenance\_reserve\_billing’ tables.

Maintenance reserve is a form of billing where the customer contributes to the engine overhaul which takes place approximately every 15,000 cycles (engine take-off/landing) and is very expensive. For this reason, as part of engine leasing, the customer is asked to contribute to a fund to cover the maintenance

# Entity Relationship Diagram

Note: We have only included the primary key and foreign key information in this diagram to support an understanding of the relationships. Documentation on the table attributes and sample content are provided in the next section.



# Table Information

The ERD in the previous section provides information on the tables plus their primary (marked PK) and foreign (marked FKn). The following provides sample data for each table:

## Country

|  |  |  |  |
| --- | --- | --- | --- |
| country\_id | country\_name | harsh-environment | harsh\_environment\_loading |
| 1 | Ireland | 0 | NULL |
| 2 | United Kingdom | 0 | NULL |
| 3 | France | 0 | NULL |
| 4 | India | 1 | 0 |
| 5 | Egypt | 1 | 0 |

## Customer

|  |  |  |  |
| --- | --- | --- | --- |
| customer\_id | company\_name | address | country\_id |
| 1 | Aer Lingus | Dublin Airport, Dublin | 1 |
| 2 | Ryanair | Dublin Airport, Dublin | 1 |
| 3 | BA | Heathrow Airport, London | 2 |
| 4 | Air France | Charles De Gaul Airport, Paris | 3 |
| 5 | Jet Airways | Mumbai | 4 |
| 6 | Ejypt Air | Cairo | 5 |

## Engine

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| engine\_id | engine\_serial\_number | engine\_modle\_id | enrolement\_date | disposal\_date |
| 1 | 123456 | 1 | 01/01/2013 | NULL |
| 2 | 789103 | 2 | 01/01/2003 | 01/02/2017 |
| 3 | 606060 | 3 | 31/01/2013 | NULL |
| 4 | 101010 | 4 | 01/02/2010 | NULL |
| 5 | AF5092 | 5 | 01/01/2018 | NULL |
| 6 | AZ5092 | 6 | 01/02/2018 | NULL |
| 7 | 729101 | 2 | 01/01/2018 | NULL |

## Engine Model

|  |  |  |
| --- | --- | --- |
| engine\_model\_id | engine\_model | active |
| 1 | CFM56-5A | 1 |
| 2 | CFM56-5B | 1 |
| 3 | CFM56-5C | 1 |
| 4 | CFM56-7B | 1 |
| 5 | LEAP-1A | 1 |
| 6 | LEAP-1B | 1 |

## Engine Usage

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| engine\_usage\_id | operation\_id | year | month | cycles | billing\_generated |
| 1 | 1 | 2018 | 4 | 10 | 0 |
| 2 | 2 | 2018 | 4 | 15 | 0 |
| 3 | 3 | 2018 | 4 | 20 | 0 |
| 4 | 4 | 2018 | 4 | 25 | 0 |
| 5 | 5 | 2018 | 4 | 30 | 0 |

## Lease

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| lease\_id | lease\_reference | engine\_id | customer\_id | start\_date | end\_date |
| 1 | L10001 | 2 | 1 | 01/01/2017 | NULL |
| 2 | L10002 | 3 | 2 | 01/01/2016 | 31/12/2016 |
| 3 | L10003 | 4 | 3 | 01/01/2017 | 01/01/2018 |
| 4 | L10004 | 5 | 4 | 01/02/2018 | NULL |
| 5 | L10005 | 7 | 5 | 01/01/2018 | NULL |

## Maintenance Reserve Billing

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| maintenance\_ reserve \_billing\_id | engine\_usage\_id | usage\_rate\_id | rate | harsh\_ environment | harsh\_ environment\_ loading | usage\_charge | harsh\_ environment\_ charge | billing\_ processed |
| 1 | 7 | 5 | 270 | 1 | 0.1 | 8100 | 810 | 0 |
| 2 | 6 | 5 | 270 | 1 | 0.15 | 8100 | 1215 | 0 |
| 3 | 4 | 3 | 260 | 0 | NULL | 5200 | 0 | 0 |
| 4 | 3 | 2 | 255 | 0 | NULL | 3825 | 0 | 0 |
| 5 | 2 | 1 | 250 | 0 | NULL | 2500 | 0 | 0 |

## Operation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| operation\_id | lease\_id | start\_date | end\_date | aircraft\_serial\_number |
| 1 | 1 | 01/01/2018 | 01/01/2016 | N904EE |
| 2 | 2 | 01/01/2018 | 01/01/2016 | N904XF |
| 3 | 3 | 01/01/2018 | 01/01/2016 | N904ZG |
| 4 | 4 | 01/01/2018 | 01/01/2016 | N904AH |
| 5 | 5 | 01/01/2018 | 01/01/2016 | N904KI |

## Usage rate

|  |  |  |  |
| --- | --- | --- | --- |
| usage\_rate\_id | from\_cycles | to\_cycles | rate |
| 1 | 1 | 10 | 250 |
| 2 | 11 | 15 | 255 |
| 3 | 16 | 20 | 260 |
| 4 | 21 | 15 | 265 |
| 5 | 26 | 30 | 270 |
| 6 | 31 | 999 | 275 |

## List of Foreign Key relationships for each table

The following Foreign key definitions have been defined in this system:

|  |  |  |  |
| --- | --- | --- | --- |
| Table | Column | Foreign Table | Foreign Key |
| customer | country\_id | country | country\_id |
| engine | engine\_model\_id | engine\_model | engine\_model\_id |
| lease | engine\_id | engine | engine\_id |
| customer\_id | customer | customer\_id |
| operation | lease\_id | lease | lease\_id |
| engine\_usage | operation\_id | operation | operation\_id |
| maintenance\_reserve\_billing | engine\_usage\_id | engine\_usage | engine\_usage\_id |
| usage\_rate\_id | usage\_rate | usage\_rate\_id |

# 3NF Proof

## Functional Dependencies

**Engine** (engine\_id, engine\_serial\_number, engine\_modle\_id, enrolement\_date, disposal\_date)={A,B,C,D,E}

engine\_id 🡪 engine\_serial\_number, engine\_modle\_id, enrolement\_date, disposal\_date

engine\_id 🡪 engine\_serial\_number, engine\_modle\_id,

A 🡪BC

engine\_id 🡪 enrolement\_date, disposal\_date

A🡪**,**D,E

With AB as the Key

R1(AB)

R2(BC)

R3(ABDE)

An attribute is prime if it is a member of any key.

X🡪A violates 3NF if and only if X is not a superkey, and A is not prime. In this case ‘A’ is superkey on the LHS of FD’s

**Engine Model** (engine\_model\_id, engine\_model, active) ={A, B, C}

engine\_model\_id🡪 engine\_model, active

A 🡪BC

R(ABC)

A=SuperKey

Relation in 3NF

**­­Country** (country\_id, country\_name, harsh-environment, harsh\_environment\_loading)={A, B, C, D}

country\_id 🡪 country\_name

A🡪 B

country\_id 🡪harsh-environment, harsh\_environment\_loading

A🡪CD

R1(AB)

R2(ACD)

A=SuperKey

Relation in 3NF

**Customer** (customer\_id, company\_name, address, country\_id) = {A, B, C, D}

customer\_id🡪 company\_name, address, country\_id

A 🡪 B, C, D

R1(ABCD)

A=SuperKey

Relation in 3NF

**Engine Usage** (engine\_usage\_id, operation\_id, year, month, cycles, billing\_generated) =   
{A, B, C, D, E}

engine\_usage\_id 🡪 year, month, cycles, billing\_generated

A 🡪 B, D, E

engine\_usage\_id 🡪 operation\_id

A 🡪 C

R1(ACDE)

R2(AB)

A=SuperKey

Relation in 3NF

**Lease** (lease\_id, lease\_reference, engine\_id, customer\_id, start\_date, end\_date) = {A, B, C, D, E, F}

lease\_id🡪lease\_reference

A 🡪B

lease\_id, 🡪 engine\_id

A 🡪C

lease\_reference 🡪 customer\_id, start\_date, end\_date

A 🡪 D, E, F

R1(AB)

R2(AC)

R3(DEF)

A=SuperKey

Relation in 3NF

**Operation** (operation\_id, lease\_id, start\_date, end\_date, aircraft\_serial\_number) = {A, B, C, D, E}

operation\_id🡪lease\_id

A 🡪 B

operation\_id🡪 start\_date, end\_date, aircraft\_serial\_number

A 🡪 C, D, E

R1(AB)

R2(CDE)

A=SuperKey

Relation in 3NF

**Usage rate** (usage\_rate\_id, from\_cycles, to\_cycles, rate) = {A, B, C, D}

usage\_rate\_id, 🡪 from\_cycles, to\_cycles

A🡪 B, C, D

R1(A, B, C, D)

A=SuperKey

Relation in 3NF

**Maintenance Reserve Billing** (maintenance\_reserve\_billing\_id, engine\_usage\_id, usage\_rate\_id, rate, harsh\_ environment, harsh\_ environment\_ loading, usage\_charge,   
harsh\_ environment\_ charge, billing\_ processed) = {A, B, C, D, E, F, G, H, I, J}

maintenance\_reserve\_billing\_id🡪engine\_usage\_id,

A🡪B

maintenance\_reserve\_billing\_id ,engine\_usage\_id, 🡪 usage\_rate\_id, rate

A🡪C, D

Maintenance Reserve Billing(harsh\_ environment, harsh\_ environment\_ loading, usage\_charge, harsh\_ environment\_ charge)

A 🡪 E, F, G, H

maintenance\_reserve\_billing\_id 🡪 billing\_ processed

A 🡪J

R1(AB)

R1(ACD)

R3(AEFGH)

R4(AJ)

A=SuperKey

Relation in 3NF

# Design Justifications

## Views

Three views have been created in this database to allow users to view the data in a useful way:

* Company Annual Usage  
  This view gives totals for engine cycles, usage charges, and harsh environment charges for each year they have leased an engine.
* Engine Model Cycles  
  This view gives the average cycles for each engine model and supports planning for future utilisation and maintenance schedules
* Current Engine Location  
  This view gives the location of each engine that is currently being managed by the company along with the customer it is with

## Indexes

This database will not store large volumes of data so indexing is not vital to its operation, having said that we have implemented several key indexes that we feel will assist to performance:

* Engine Table  
  We have added an index for the engine serial number as this is the identifier most often used by our users to find information across the system
* Lease  
  We have also added an index for the Lease Reference as again this is most often used by users when retrieving information

## Triggers/Stored Procedures

The following triggers have been created in this system:

* Before Engine Insert  
  engines can be enrolled onto the system and disposed several times as they are bought, sold and leased in. This trigger prevents overlapping date ranges for the enrolment/disposal dates so that mistakes are prevented when adding engines
* Before Engine Update   
  This trigger also prevents overlapping periods when a user makes changes to the enrolment/disposal date ranges

The following Stored Procedures have been created in the system:

* Generate Maintenance Reserve Billing  
  Monthly, users enter the amount of cycles (take off/landing cycles) an engine has performed in a month. To support the invoicing module, this stored procedure completes the following
  + asks the user for a year/month to process
  + Finds all unprocessed entries in that period in the engine\_usage table
  + Gets a matching rate for the entry and calculates the charges to be applied to the customer
  + Adds a new entry to the maintenance\_reserve\_billing table with the charge details to be applied to the customer
* Check Maintenance Reserve Billing  
  This stored procedure is designed to be run after the generate maintenance reserve billing stored procedure and it presents a list showing entries with the following issues
  + Rows from the engine\_usage table that have not been successfully processed for billing (“Billing Not Generated”)
  + Rows from the maintenance\_reserve\_billing that have not been processed by the invoicing system (Note the invoicing system is out of scope for this module)

# Test plan

We have designed a test plan for this system to validate the following:

* Inserting engines with overlapping date ranges results in an error
* Adding an engine without an active engine model results in an error
* Execution of the generate billing entries stored procedure for April 2018
* Execution of the check maintenance reserve billing stored procedure for March and April 2018