TECHNOLOGY DEVELOPMENT AND SYSTEM INTEGRATION FOR A VEHICLE MILES TRAVELED BASED REVENUE COLLECTION SYSTEM PROTOTYPE

Local Database Documentation
Version 1.4

Subtask 5.1

Prepared for
Oregon Department of Transportation

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Introduction

The Microsoft Access 2002 SP-2 Local Database (Local DB) was designed and built by the OSU investigative team to store and manipulate fueling transactions data records for vehicles visiting the specific gas station where the Local DB is installed. The records stored will be vehicle miles traveled (VMT) data records for vehicles equipped with Odometer-based on-vehicle devices, and fuel tax data records for vehicles not equipped with on-vehicle devices. The Local DB is the persistent component of a five-tier application architecture, as depicted in Figure 1.

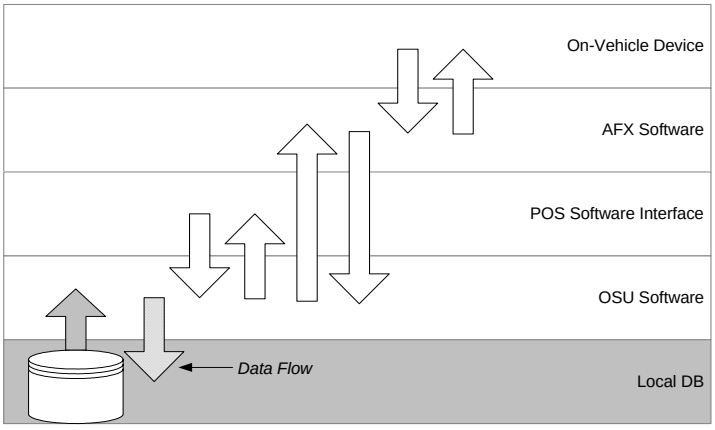


Figure 1. Local DB and Five-Tier model of Application for the Odometer-based Technology Configuration.

The Local DB has the following characteristics:

- *Maintains persistent storage of VMT data records*
  The tables TBL_TRANSACTIONS, TBL_VMT_TRANSACTIONS, and, TBL_TAX_TRANSACTIONS store useful information for enforcement purposes. Important fields in these tables are the vehicle identification number (VIN), the VMT-based or the fuel tax-based fee charged, the amount of fuel purchased, and a time stamp when the transaction was performed, along with other complementary fields.
- *Calculates VMT fee or fuel tax charged for each transaction*
  Based on whether or not the vehicle is equipped with an on-vehicle device, a VMT fee or the fuel tax is calculated by the OSU software and then stored in the corresponding table.
- *Allows a database administrator to maintain VMT fee information*
  Updated zone prices may be manually entered into the TBL_VMT_RATES table.
- *Generates a variety of reports*
  - *Individual vehicle transaction log report*
  - *Compliance and fee verification report*

Platform and Specifications

Microsoft Access 2002 was used as the platform to develop the Local DB. It is a normalized relational database that uses the standard query language (SQL) to issue queries, as defined by the ISO/IEC JTC1/SC32, WorkGroup 3, Database Languages committee (as per Technical Specification 5.5, Kim and Porter 2003).

For the purpose of demonstrating the prototype Odometer-based technology configuration, Microsoft Access was installed on an HP X2100 workstation running Windows XP.

Entity Relationship Diagram

An entity relationship (E-R) diagram is a tool used to describe the business needs or "rules" that a database is designed to support. An example of a business rule for the VMT-based revenue collection system is that a transaction initiated at a pump in the gas station could be of two kinds (specialization): a transaction with a VMT fee for those vehicles equipped with an on-vehicle device, or a transaction with fuel tax for those vehicles not equipped with an on-vehicle device or whose devices could not be read.

In order to model the business rules for the VMT based revenue collection system prototype, the data and functional requirements were mapped to a logical model represented by the E-R diagram depicted in Figure 2.

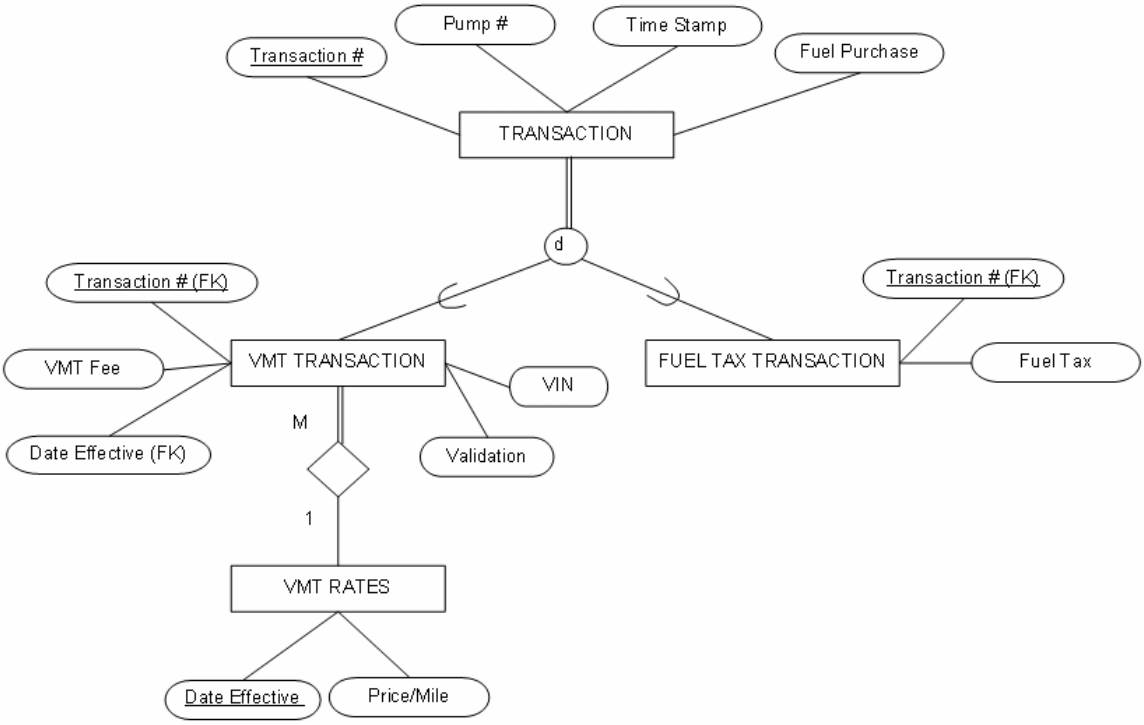


Figure 2. Entity Relationship Diagram for Local DB.

Other requirements for the VMT-based fee revenue system are that every transaction be saved in the database and have a record in the TBL_TRANSACTION table. This table stores the information that is common for all transactions, while the information that is specific for VMT transactions and fuel tax transactions is saved in the tables TBL_VMT_TRANSACTIONS and TBL_TAX_TRANSACTIONS, respectively.

Since the Odometer-based technology configuration charges a fee for miles traveled in only one geographical zone, every VMT transaction in the database is associated with just one VMT rate. This VMT rate represents the VMT rate that is effective on the date the transaction takes place. A given VMT rate can have multiple transactions associated with it. Note that not all the rates in the VMT_RATES table must have a transaction associated with them (partial participation), e.g., when a rate is kept in the database for planned future rate changes.

Physical Design

The logical design of the E-R Diagram depicted in Figure 2, translates by one-to-one correspondence into the four-table physical design depicted in Figure 3.

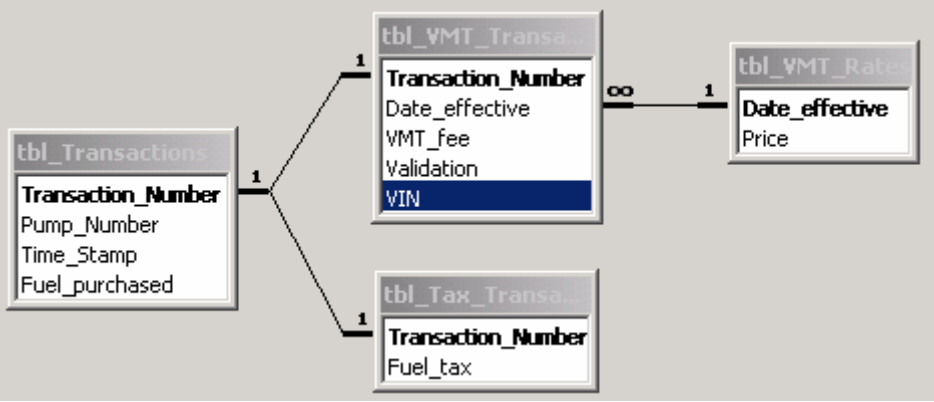


Figure 3. Physical Design of Local DB.

The physical structure of each table, including columns (attributes), characteristics and keys are further described below.

Table 1. Descriptions of Attributes in TBL_TRANSACTIONS Table.

TBL_TRANSACTIONS					
Key*	**Attribute**	**Data Type**	**Size**	**Null Values Permitted?**	**Attribute Definition**
PK	Transaction_Number	Text	50 characters	No	Transaction number
	Pump_Number	Text	50 characters	Yes	Pump number where transaction happens
	Time_stamp	Date/Time (General date)	8 bytes	Yes	Date of transaction (e.g., 12/28/2003)
	Fuel_purchased	Number (Double)	8 bytes	Yes	Amount of fuel purchased

* PK=Primary key

Note: The TBL_TAX_TRANSACTIONS table is a specialization of the TBL_TRANSACTIONS table.

Table 2. Descriptions of Attributes in TBL_TAX_TRANSACTIONS Table.

TBL_TAX_TRANSACTIONS					
Key*	**Attribute**	**Data Type**	**Size**	**Null Values Permitted?**	**Attribute Definition**
FK	Transaction_Number	Text	50 characters	No	Transaction number
	Fuel_tax	Currency	8 bytes	Yes	Fuel tax collected in transaction

*FK=Foreign key.

Note: The TBL_VMT_TRANSACTIONS table is a specialization of the TBL_TRANSACTIONS table.

Table 3. Descriptions of Attributes in TBL_VMT_TRANSACTIONS Table.

TBL_VMT_TRANSACTIONS					
Key*	**Attribute**	**Data Type**	**Size**	**Null Values Permitted?**	**Attribute Definition**
FK	Transaction_Number	Text	50 characters	No	Transaction number
FK	Date_Effective	Date/Time (Short date)	8 bytes	Yes	Date of transaction (e.g., 12/28/2003)
	VIN	Text	50 characters	Yes	Vehicle Identification Number
	VMT_Fee	Currency	8 bytes	Yes	VMT fee collected in transaction
	Validation	Yes/No	1 bit	Yes	Copy request validation

*FK=Foreign key.

Table 4. Descriptions of Attributes in TBL_VMT_RATES Table.

VMT_RATES					
Key*	**Attribute**	**Data Type**	**Size**	**Null Values Permitted?**	**Attribute Definition**
PK	Date_Effective	Date/Time (Short date)	8 bytes	No	Date effective of Price
	Price	Currency	8 bytes	Yes	Rate charged per mile

* PK=Primary key.

Application Design

Input

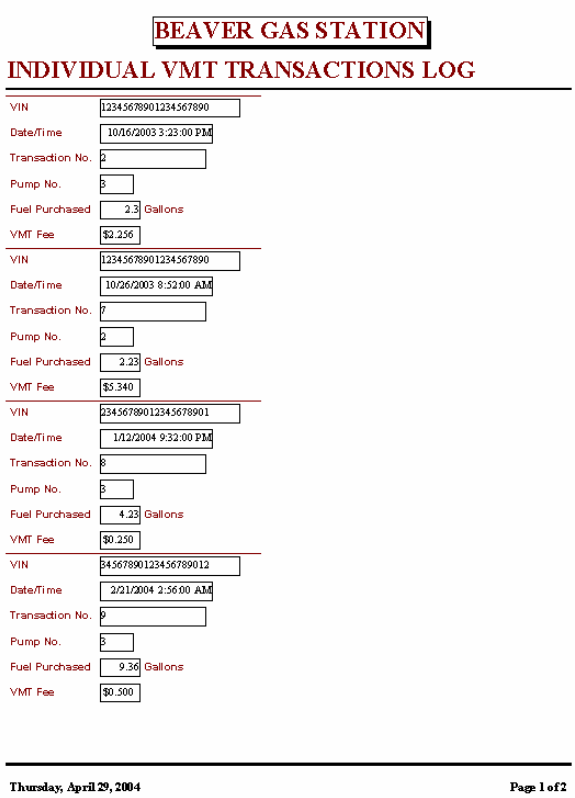
To reflect the addition or deletion of zones and changes in rates, the database administrator should update the information stored in the VMT_RATES table.

Reports

The Local DB is capable of generating the following reports:

1. INDIVIDUAL VMT TRANSACTIONS LOG report. This report provides a log of all the individual transactions that a gas station has processed in a given period of time. Figure 4 shows an example of this report.

INDIVIDUAL VMT TRANSACTIONS LOG
VIN Time Stamp Transaction Number Pump # Fuel Purchased Fee Calculated



BEAVER GAS STATION

INDIVIDUAL VMT TRANSACTIONS LOG

VIN	12345678901234567890
Date/Time	10/16/2003 3:23:00 PM
Transaction No.	2
Pump No.	3
Fuel Purchased	2.3 Gallons
VMT Fee	$2.256
VIN	12345678901234567890
Date/Time	10/26/2003 8:52:00 AM
Transaction No.	7
Pump No.	2
Fuel Purchased	2.23 Gallons
VMT Fee	$5.340
VIN	23456789012345678901
Date/Time	1/12/2004 9:32:00 PM
Transaction No.	8
Pump No.	5
Fuel Purchased	4.23 Gallons
VMT Fee	$0.250
VIN	34567890123456789012
Date/Time	2/21/2004 2:56:00 AM
Transaction No.	9
Pump No.	5
Fuel Purchased	9.36 Gallons
VMT Fee	$0.500

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Figure 4. Sample Individual VMT Transactions Log Report.

2. INDIVIDUAL VEHICLE TRANSACTION LOG report. This report provides a transaction log for each vehicle. Figure 5 shows an example of this report.

INDIVIDUAL VEHICLE TRANSACTION LOG
VIN Time Stamp Transaction Number Fuel Purchased VMT Fee

BEAVER GAS STATION

INDIVIDUAL VEHICLE TRANSACTION LOG

VIN 12345678901234567890

Time Stamp	Transaction Number	Fuel Purchased	VMT Fee
10/16/2003 3:23:00 PM	2	2.3	$2.256
10/26/2003 8:52:00 AM	7	2.23	$5.340
Summary for 'VIN = 12345678901234567890 (2 detail records)			
Sum		4.53	$7.596

VIN 23456789012345678901

Time Stamp	Transaction Number	Fuel Purchased	VMT Fee
1/12/2004 9:32:00 PM	8	4.23	$0.250
4/1/2004 2:56:00 PM	4	5.69	$3.250
Summary for 'VIN = 23456789012345678901 (2 detail records)			
Sum		9.92	$3.500

VIN 34567890123456789012

Time Stamp	Transaction Number	Fuel Purchased	VMT Fee
2/21/2004 2:56:00 AM	9	9.36	$0.500
6/6/2004 12:01:00 AM	6	9.46	$4.500
Summary for 'VIN = 34567890123456789012 (2 detail records)			
Sum		18.82	$5.000
Grand Total		**33.27**	**$16.096**

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Figure 5. Sample Individual Vehicle Transaction Log Report.

3. COLLECTED VMT FEE VS COLLECTED FUEL TAX report. This report provides a summary of the amount of VMT fee and fuel tax collected in a given month, as well as the amount of fuel sold in each month. Figure 6 shows an example of this report.

COLLECTED VMT FEE VS COLLECTED FUEL TAX
VMT Fee Month VMT Fee Fuel Fuel Tax Month Fuel Tax Fuel

BEAVER GAS STATION

COLLECTED VMT FEE vs COLLECTED FUEL TAX

VMT FEE			FUEL TAX		
Month	VMT Fee	Fuel	Month	Fuel Tax	Fuel
			December 2004	$1.75	21.22
April 2004	$3.25	5.69			
February 2004	$0.50	9.36	February 2004	$0.50	4.66
January 2004	$0.25	4.23			
June 2004	$4.50	9.46			
October 2003	$7.60	4.53			

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Figure 6. Sample Collected VMT Fee vs Collected Fuel Tax Report.

Graphical User Interface

The main switchboard of the graphical user interface (GUI) of the local database is shown in Figure 7.

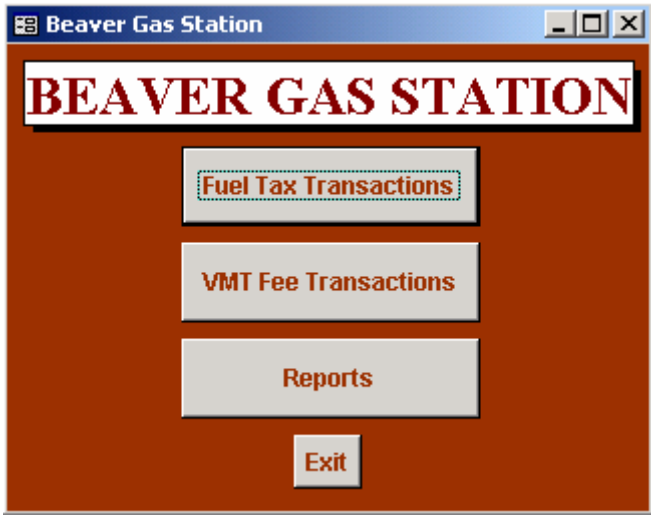

Figure 7. Main Switchboard for the Local DB GUI

The form that presents the transactions that have a VMT fee is depicted in Figure 8.

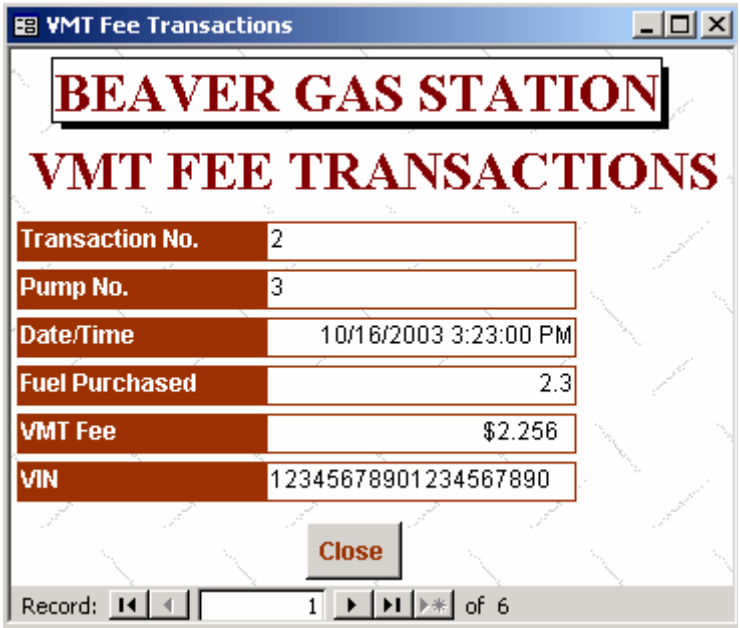

Figure 8. Form for VMT Fee Transactions

The form that presents the transactions that have fuel tax is depicted in Figure 9.

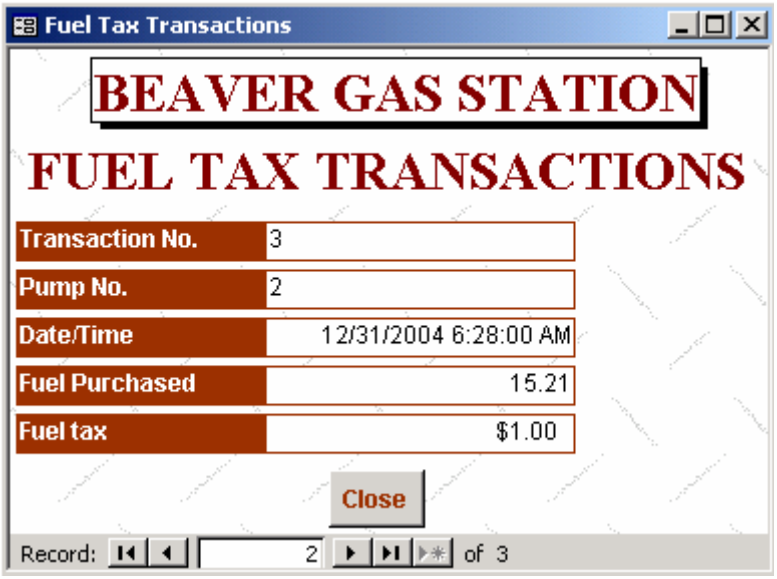

Figure 9. Form for Fuel Tax Transactions

The form that allows a user to generate the different transaction reports is presented in Figure 10.

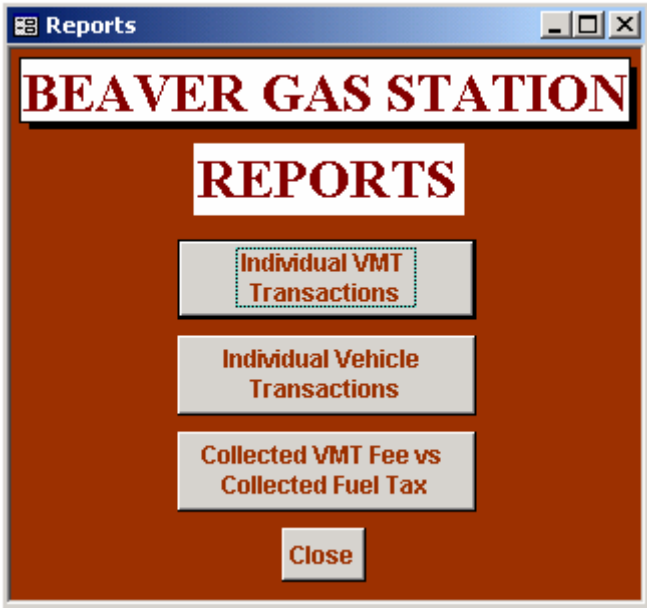

Figure 10. Form that Leads to Reports

References

Kim, DS and JD Porter (2003). *Project Work Plan for Technology Development and System Integration for A Vehicle Miles Traveled Based Revenue Collection System Prototype*. Oregon State University.