

Appendix D – Examples of NBMD Use

Overview

This document presents a set of examples in use of the National Bridge Maintenance Database (NBMD) system developed under NCHRP project 14-15. The examples show what data are available, how to collect data from NBMD, and how to perform basic applications in counting and summarizing bridge maintenance activities.

NCHRP Project 14-15 and the NBMD system address basic evaluations of bridge maintenance programs, such as:

- What maintenance products and practices are in use?
- What intervals of (re)application are needed?
- What resources are expended? What costs are incurred?

Evaluations are conditioned by the context of use of maintenance. So there are further questions:

- Which bridges are maintained?
- What are their materials of construction?
- What protective systems are present?
- What service do these bridges see? What values of ADT?

The examples presented here focus on the collection and summary of data and, where appropriate, on the use of data in basic evaluations of maintenance actions.

NBMD Data System

The NBMD data system includes formats and contents for standard data files, XML schemas for bridge maintenance data, and software utilities for summary viewing of NBMD datasets and for creation of XML documents from NBMD data tables. XML documents can be imported to MS Access, and MS Access is used in examples here. MS Access supports simple collection of subsets of data, and export of subsets to Excel for computations.

NBMD is populated with bridge maintenance data collected from state DOTs in Alabama, Colorado and Ohio. Bridge inventory data are collected from the National Bridge Inventory System for all three states, and augmented by BMS data for bridges in Alabama and Colorado.

Downloads

(2009 note: The NBMD demonstration website deployed in 2007 is not longer active)

The examples presented here operate with a set of three MS Access databases available for download at the Examples page of the NBMD website (link inactive) The databases are called simply CU-Alabama, CU-Colorado and CU-Ohio. Examples, presented in this document, show the steps needed to obtain data from Access and to move data to Excel for further computations. Completed Excel workbooks are also available for download and use.

Examples and their associated Access and Excel files are one part of the NBMD demonstration materials that are available. Demonstration materials are listed below.

Requirements for PCs and host applications

The web portal is accessible using most web browsers that are java-enabled. The home page at the web portal has recommendations for security settings for browsers. This gets a bit detailed, but be sure to go through all steps to prepare your browser for NBMD use.

Zipped files are directly available in Windows Explorer for PCs running Windows XP or Windows Vista. Older operating systems, such as Windows 2000, may require installation of the most recent service packs, or installation of WinZip or other file compression software to view and extract zipped files. XML data files, the Organizer and the local version of the NBMD website are all available as zipped files.

XML files, in themselves, are text files. Interpretation of XML files into MS Access or MS Excel may require installation of the MSXML framework. Complete instructions are available in the Help facility at the web portal (<http://www.pdth.com/nchrp1415/usersmanual.pdf>.)

The MS Access databases, CU-Alabama, CU-Colorado and CU-Ohio that are used for the examples presented in this document require MS Access 2003 or later. Excel workbooks require MS Excel in any version from Office '97 forward.

14-15 Demonstration examples

Example Set

Ten examples are presented. The examples show how to collect data on maintenance actions, types, accomplishments, resource requirements and costs. Examples explore intervals for maintenance, relation of actions to bridge elements, and relation of actions to bridge inventory data. Procedures are similar among examples. Data sets are collected as Queries in MS Access, and exported to MS Excel for filtering and counting.

The ten examples are listed below. Most presented two or three closely related evaluations. Step-by-step procedures are provided for each example. The first few examples provided greater detail in Access and Excel use. Later examples presume familiarity with Access and Excel.

Examples are fully developed in the three Access databases CU-Alabama, CU-Colorado and CU-Ohio. Workbooks for each example are also available. These databases have data fields beyond the

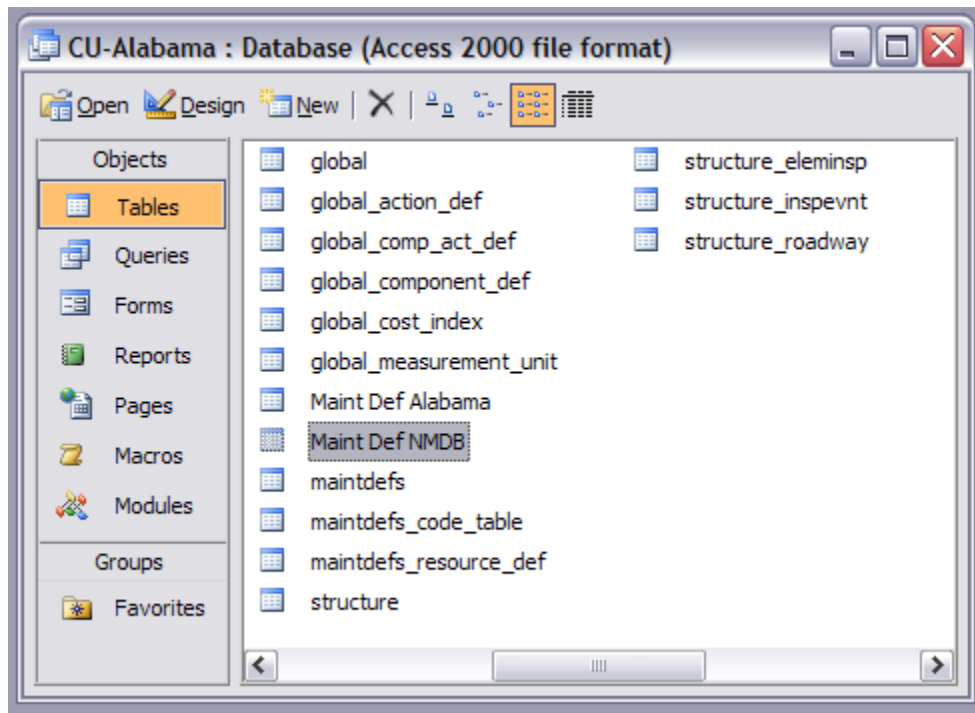
current NBMD XML schema, and these added data fields are essential to many of the tasks that are presented.

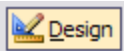
Example 1 - Maintenance Actions

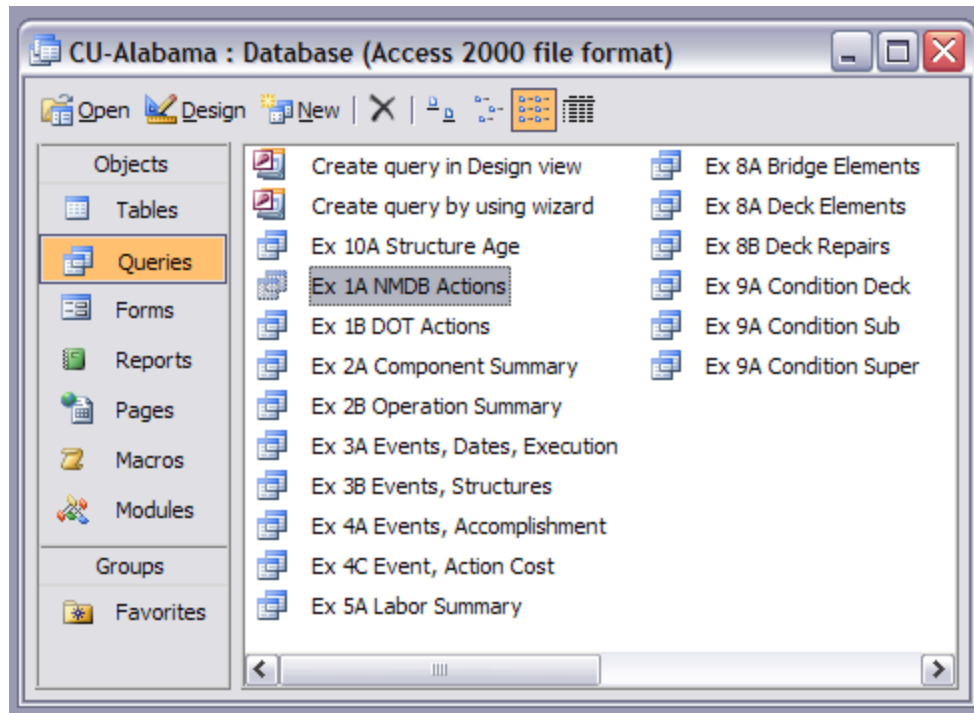
This example collects counts of maintenance actions, first using NBMD standard actions, and then again using DOT-native actions. Detailed step-by-step procedures are given for Alabama data. The same procedures are used for Colorado and Ohio data. Results for all three DOTs are summarized.

Ex 1A - Maintenance Actions Using NBMD Titles and Units

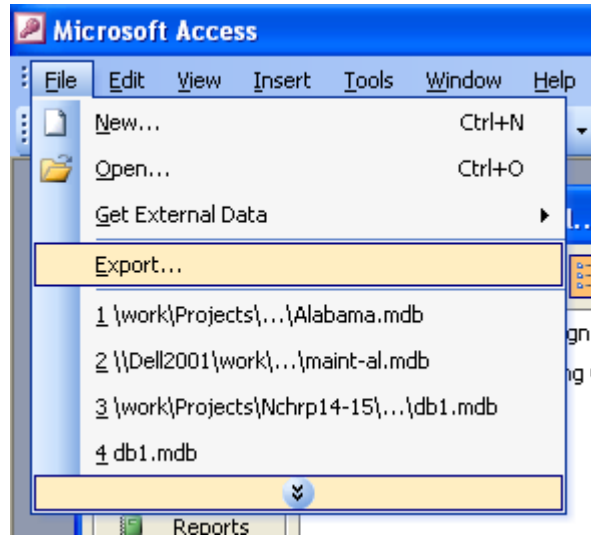
1. Open the MS Access database called CU-Alabama. Under Objects menu, select Tables. Find the table named Maint Def NBMD. Double click to open this table. The table's content is the catalog of standard maintenance actions, their codes, names, and default units of measurement.



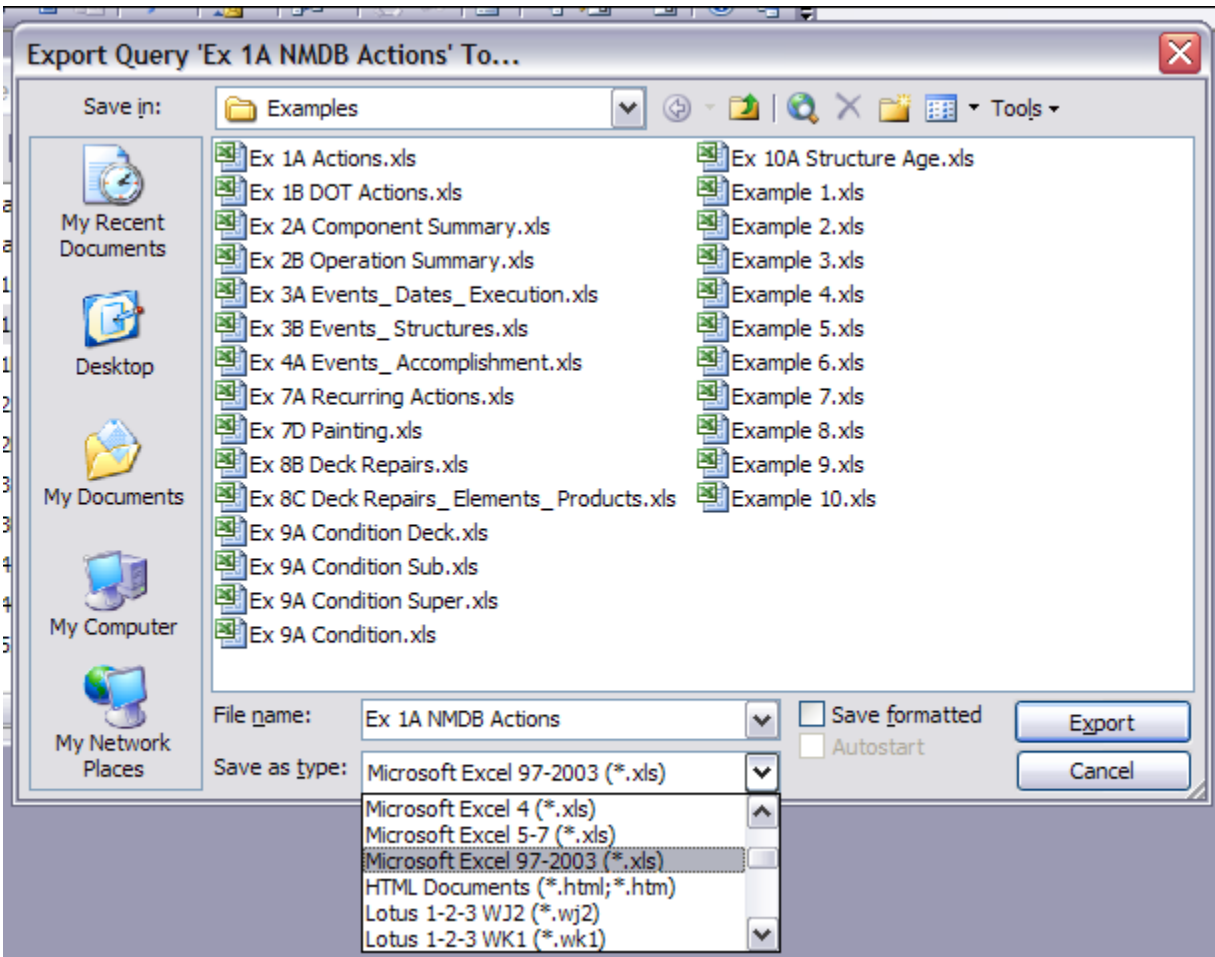
2. A Query is used to collect Alabama's maintenance actions, and a readable display of action names and units. Under Objects select Queries, and find Ex 1A NBMD Actions. The design view () for the query shows the data tables and data fields used to produce a list of maintenance actions.



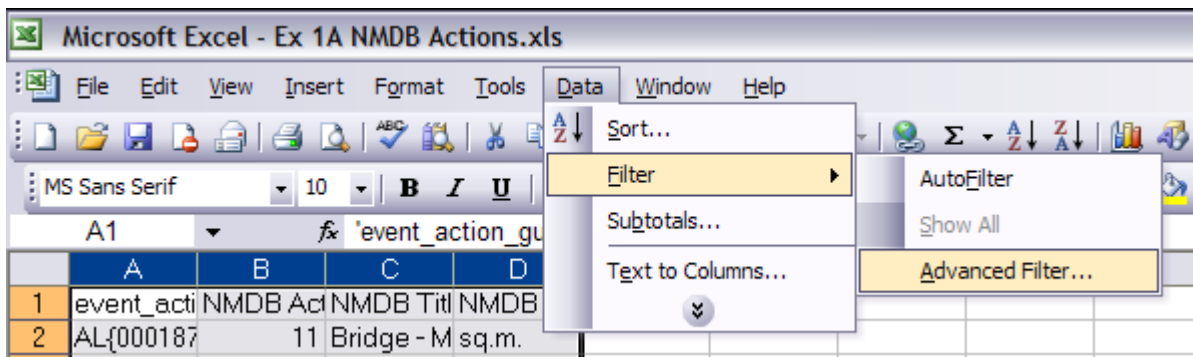
3. Double click to open the query. The listing contains four fields: event_action_guid, NBMD Action, NBMD Title and NBMD unit. 'guid' stands for Globally Unique ID. A separate ID is used for each combination of date, bridge and action. These are concatenated to make a guid. Since data from several DOTs may be combined, the state postal abbreviation is added to the guid. This form of guid is readable, and probably adequate for long-term storage and retrieval of US bridge maintenance data. Stronger, but unreadable, guids are deployed in the XML schema for NBMD.
4. Two or more records can have the same guid. This is because there is a one-to-one generation of action records from DOT records, and some maintenance actions are reported on two or more 'crew cards'. The outcome is that each maintenance action is uniquely identified, and more than one NBMD record can contain information that contributes to a single maintenance event.
5. The query (its content actually) is exported to Excel for data filtering and counting. While this query is highlighted, select File on the menu bar, and Export... on the drop-down menu.



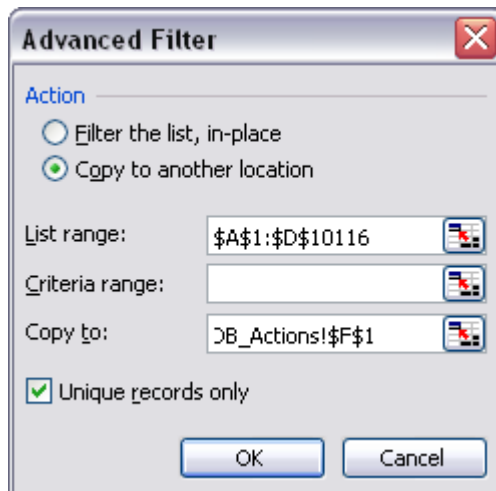
- 6. A file dialog box opens. Output file format and file name are selected by the user. Select an Excel (xls) output format. Any name and directory will do, but here the Examples directory, and the filename Ex 1A NBMD Actions are used.



7. Find the file Ex 1A NBMD Actions.xls in the Examples directory, and double-click to open it in Excel. The workbook has a single sheet with the name of the query. Columns in the sheet may be at standard width, making it difficult to read the cell entries. Widen the columns if you wish.
8. We use a data filter to collect unique occurrences of maintenance actions, and then a second filter to collect the separate actions. Here are the steps:
 - a. Select columns A thru D in the sheet.
 - b. On the menu bar, select Data and then Filter from the drop-down menu.

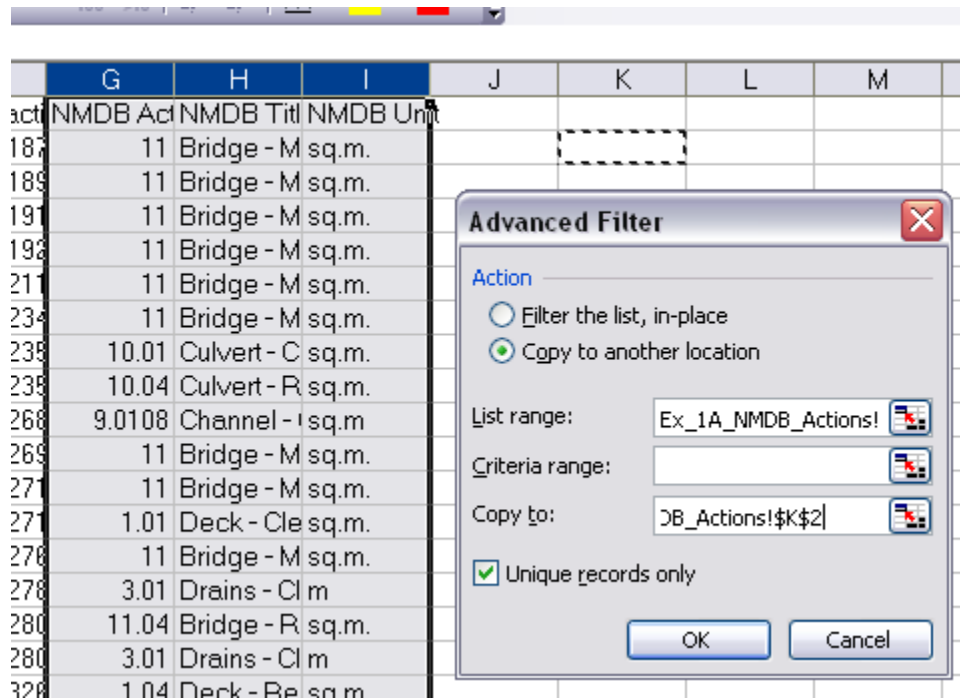


- c. Click on Advanced Filter. A new dialog appears. Select Copy to another location (use column F). Check the box for Unique records only.



- d. Hit OK. Columns F to I now contain a single record for each unique event_action_guid. Duplicates are eliminated. There are now 8516 maintenance actions in this list.

- e. A second filter is used to identify the different types of maintenance actions. Select columns F through I. Use an advanced filter, select Copy to another location. Use column K. Select Unique records only. Click OK.



- f. Columns K to M now contain 25 actions; all of the unique actions in the Alabama data. The results are shown below.

NBMD Action	Production Unit
Deck - Clean / Clear	sq.m.
Deck - Repair	sq.m.
Joints - Repair	m
Joints - Repair - Re-attach / Re-anchor	m
Drains - Clean / Clear	m
Railings - Repair	m
Bearings - Maintenance	each
Bearings - Repair	each
Superstructure - Repair	sq.m.
Substructure - Clean / Clear	sq.m.
Substructure - Repair	sq.m.
Approach/ Embankment - Clean / Clear - Vegetation / Trees	sq.m
Approach/ Embankment - Coat / Paint - Chemical treatments	sq.m
Channel - Clean / Clear - Debris / Drift	sq.m
Channel - Repair - Re-attach / Re-anchor	sq.m
Culvert - Clean / Clear	sq.m.
Culvert - Repair	sq.m.
Bridge - Maintenance -	sq.m.

Bridge - Reset - Consumable	each
Bridge - Coat / Paint - Paint	sq.m
Bridge - Coat / Paint - Spot paint	sq.m
Bridge - Repair	sq.m.
Movable Bridge - Maintenance -	sq.m.
Non Maintenance	
Non Bridge	

- g. Use a COUNTIF() function to count the number of events for each maintenance action. COUNTIF() takes two arguments: COUNTIF(range, criterion) where range is a data set, and criterion is a search string. COUNTIF() returns the number of occurrences of the *criterion* in the range. The results are shown below:

NBMD Action	Unit	Count
Deck - Clean / Clear	sq.m.	1520
Deck - Repair	sq.m.	188
Joints - Repair	m	118
Joints - Repair - Re-attach / Re-anchor	m	98
Drains - Clean / Clear	m	136
Railings - Repair	m	174
Bearings - Maintenance	each	28
Bearings - Repair	each	33
Superstructure - Repair	sq.m.	224
Substructure - Clean / Clear	sq.m.	109
Substructure - Repair	sq.m.	309
Approach/ Embankment - Clean / Clear - Vegetation / Trees	sq.m	387
Approach/ Embankment - Coat / Paint - Chemical treatments	sq.m	20
Channel - Clean / Clear - Debris / Drift	sq.m	289
Channel - Repair - Re-attach / Re-anchor	sq.m	278
Culvert - Clean / Clear	sq.m.	190
Culvert - Repair	sq.m.	44
Bridge - Maintenance -	sq.m.	2515
Bridge - Reset - Consumable	each	61
Bridge - Coat / Paint - Paint	sq.m	257
Bridge - Coat / Paint - Spot paint	sq.m	11
Bridge - Repair	sq.m.	221
Movable Bridge - Maintenance -	sq.m.	259
Non Maintenance		30
Non Bridge		1017

- h. Counts of actions range from 11 for spot painting to more than 2500 for non-specific bridge maintenance. The complete example is available in Example1.xls

Ex 1B - DOT Titles and Units for Maintenance Actions

1. Alabama DOT has its own names and units for maintenance actions. The CU-Alabama database keeps this information. A summary of Alabama actions, in Alabama's nomenclature, can be obtained with a query.
2. Open the CU-Alabama database in MS Access. Under Tables, find Maint Def Alabama. Double click on the table. The set of Alabama DOT 'B' codes that identify maintenance actions are mapped to NBMD standard components, operations and activities.
3. A list and count of Alabama maintenance actions is obtained. The steps are similar to those in Example 1A, and the process is taken all the way from query to counting in Excel. The query is Ex 1B DOT Actions. The output can be found as sheet Ex 1B Alabama in the Excel workbook Example 1.xls. The results are shown below.

DOT Action	DOT name	Unit	Count
B01	Deck Cleaning	hours	1520
B05	Minor Deck Repair - Steel	sq feet	3
B06	Minor Deck Repair - Concrete	sq feet	40
B07	Minor Deck Repair Timber	sq feet	60
B08	Major Deck Repair - Steel	sq feet	10
B09	Major Deck Repair - Concrete	sq feet	29
B10	Major Deck Repair - Timber	sq feet	38
B13	Minor Superstructure Repair Timber	hours	13
B03	Joint Repair - Open	feet	100
B04	Joint Repair - Sealed	feet	18
B45	Joint Sealing- Installation	feet	98
B41	Drain/Joint Cleaning	hours	136
B02	Curb/Rail/Fence Repair	feet	174
B44	Minor Bearing Devices and Assemblies - Maintenance / Repair	hours	28
B43	Major Bearing Devices and Assemblies - Installation / Maintenance / Repair	hours	33
B11	Minor Superstructure Member Repair - Steel	hours	52
B12	Minor Superstructure Member Repair - Concrete	hours	51
B14	Major Superstructure Member Repair - Steel	hours	23
B15	Major Superstructure Member Repair - Concrete	hours	88
B16	Major Superstructure Member Repair - Timber	hours	16
B42	Bent Cap / Beams and Beam Sear	hours	109
B17	Minor Substructure Member Repair - Steel	hours	101
B18	Minor Substructure Member Repair - Concrete	hours	42
B19	Minor Substructure Repair Timber	hours	42
B20	Major Substructure Member Repair - Steel	hours	35
B21	Major Substructure Member Repair - Concrete	hours	56
B22	Major Substructure Member Repair - Timber	hours	34
B46	Vegetation Control	hours	387
B47	Beaver Control	hours	20

DOT Action	DOT name	Unit	Count
B29	Drift Removal	hours	289
B30	Slope and Shore Protection Repair	hours	278
B26	Bridge Culvert Cleaning	hours	190
B27	Bridge Culvert Repair	hours	44
B37	Bridge Inspection	hours	2450
B40	Construction Materials Testing	hours	1
B99	Bridge Maintenance Overhead	hours	293
B28	Light and Navigation-Light Repair	hours	61
B24	Bridge Painting - Partial	sq feet	48
B25	Bridge Painting - Complete	sq feet	213
B23	Bridge Painting - Spot	sq feet	11
B31	Accident Repair	hours	169
B32	Vandalism Repair	hours	52
B33	Moveable Span Maintenance	hours	11
B34	Moveable Span Operations	hours	259
B39	Construction Engineering and Inspection	hours	30
B35	Tunnel Maintenance	hours	6
B36	Tunnel Operations	hours	3
B38	Other Structure Maintenance	hours	1008

The listing in this form is useful in seeking additional information on Alabama's maintenance programs, and to be able to direct the search in Alabama's own terms, and within Alabama sources. (see Alabama 'B' codes, available at CU's NBMD home page)

There are 47 Alabama actions. Alabama's units for actions differ from NBMD units. For a few actions, the Alabama units of feet or square feet can be converted to the metric units that are standard for NBMD. For actions measured in labor hours, no conversion is possible.

Ex 1A & 1B - Colorado & Ohio Results

Lists and counts of NBMD maintenance actions for Colorado and for Ohio are collected by operations similar to those described for Alabama. Colorado data spans five years. Ohio is a single year. Queries are found in the databases CU-Colorado and CU-Ohio. Complete results are in Example 1.xls

Colorado Results

Colorado NBMD actions:

NBMD Title	Unit	Count
Deck - Coat / Paint - Spot paint	sq.m	2
Deck - Coat / Paint - Seal cracks	m	274
Deck - Repair	sq.m.	1516
Joints - Maintenance	m	1112
Joints - Replace	m	2
Joints - Replace - Complete	m	1

Joints - Replace - Span	m	4
Railings - Maintenance	m	4
Railings - Reset	m	7
Railings - Repair	m	1290
Bearings - Maintenance	each	187
Superstructure - Maintenance	sq.m.	1022
Substructure - Maintenance	sq.m.	1061
Approach/ Embankment - Clean / Clear - Vegetation / Trees	sq.m	58
Approach/ Embankment - Coat / Paint - Chemical treatments	sq.m	3
Approach/ Embankment - Repair	sq.m.	9
Approach/ Embankment - Repair - Patch	sq.m	863
Approach/ Embankment - Replace	sq.m.	7
Channel - Clean / Clear - Debris / Drift	sq.m	7
Culvert - Clean / Clear	sq.m.	67
Bridge - Maintenance -	sq.m.	9858
Bridge - Clean / Clear	sq.m.	10379
Bridge - Clean / Clear - Sweep	sq.m	202
Bridge - Clean / Clear - Debris / Drift	sq.m	16
Bridge - Reset	each	16
Bridge - Reset - Consumable	each	1
Bridge - Reset - Reposition	each	6
Bridge - Coat / Paint - Paint	sq.m	1519
Bridge - Coat / Paint - Seal cracks	sq.m	17
Bridge - Repair - Patch	sq.m	108
Bridge - Repair - Dredge / Grade	sq.m	3
Non Maintenance		171
Non Bridge		23

Colorado actions expressed in Colorado DOT codes, names and units.

DOT Action	DOT name	Unit	Count
310.00	Pave marking hand	sq yard	2
353.08	Pavement crack sealing.	sq yard	7
353.10	Crack/joint seal rig brdg deck	gallon	100
353.40	Crack seal flex bridge deck	gallon	169
353.00	Bridge deck repair/ etc.	sq yard	1349
353.20	Rotomil flex pave bridge deck	sq yard	176
353.30	Rotomil flex pave bridge deck	sq yard	25
364.00	Expansion joints	feet	1106
364.08	Expansion joint	feet	5
364.09	Expansion joint	feet	6
216.00	Fence / gate maintenance	feet	3
217.00	Soundbarrier maintenance	feet	1
307.00	Con guard rail mtn	feet	7
306.00	Guard rail repair	feet	131
356.00	Bridge rail repair	feet	1143

DOT Action	DOT name	Unit	Count
356.08	Bridge rail repair	feet	17
357.00	Bearings/ maintenance	each	187
354.00	Superstructure maintenance	each	1021
354.08	Bridge structure maintenance	each	1
358.00	Substructure maintenance	each	1053
358.08	Substructure maintenance	each	8
252.00	Veg ctrl mach mow	mile	11
254.00	Hand mowing	hour	41
260.00	Tree plant+trim	each	7
256.00	Herb-pest applicat	acre	2
258.00	Veg control irrig	hour	1
164.00	Base stab & repair	cu yard	1
210.00	Slope repair	cu yard	6
360.08	App slab/slope rpr	each	2
360.00	Approach slabs and slope protection repair	each	863
162.00	Restore shoulder	feet	2
163.00	Restore shoulder	feet	5
206.00	Mtc/ditc/streambed	feet	7
202.00	Clean drain struct	each	67
302.00	Single post signs	each	32
304.00	Del posts mtnce	each	37
326.00	Mast inter maintenance	each	1
351.00	Bridge/structural visual inspection/monitoring	each	9789
352.00	Cleaning or washing	each	10379
220.00	Sweeping machine	mile	112
222.00	Sweeping hand	hour	92
207.00	Salt/sand cleanup	ton	3
218.00	Litter trash clean	cu yard	13
316.00	Attenuator maint	each	8
320.00	Elect wire refurb	hour	8
312.00	Roadway sign lighting	each	1
355.00	Bridge painting	gallon	1519
156.00	Crack-joint seal	gallon	11
156.08	Crack-joint seal	gallon	1
156.09	Crk sl flex pvt hnd prev mtc	gallon	5
152.00	Patching/minor rep	sq yard	71
152.08	Patching-minor rep	sq yard	1
152.10	Rigid pavement patch/minor rep	sq yard	3
154.00	Patching-machine	ton	30
154.08	Patching-machine	ton	1
152.20	Rotomilling flexible pavements	sq yard	2
152.30	Rotomilling rigid pavements	sq yard	1
102.00	Plan + schedule	hour	48
103.00	Training/meetings	hour	3
104.00	Leave	hour	24

DOT Action	DOT name	Unit	Count
329.00	Courtesy patrol		5
402.00	Snow removal+sand	mile	24
403.00	Ice ctr drain-hand	hour	25
406.00	Sn/removal/sp eq.	hour	6
454.00	Stockpile/ hauling	ton	2
460.00	Building+grounds	hour	7
502.00	Tunnel operations	hour	27
458.00	Equipment maintenance	hour	2
504.00	Tunnel washing	sq yard	8
506.10	Tunnel traff contl	hour	1
512.00	Tunnel structural	hour	8

Ohio Results

Ohio DOT results for NBMD actions are

NBMD Title	Unit	Count
Deck - Coat / Paint - Seal surface	sq.m	61
Deck - Repair	sq.m.	588
Joints - Repair	m	113
Drains - Modify - Strength / Capacity	m	5
Railings - Repair	m	28
Superstructure - Repair	sq.m.	142
Substructure - Coat / Paint - Seal surface	sq.m	7
Substructure - Repair	sq.m.	139
Channel - Modify - Protection	sq.m	27
Bridge - Clean / Clear	sq.m.	2125
Bridge - Coat / Paint - Paint	sq.m	5
Bridge - Modify	sq.m.	50

Ohio DOT results in Ohio actions and units are

DOT Action	DOT name	Unit	Count
6161	Sealing Bridge Decks/Gutters/Curbs/Railing	sq feet	61
6153	Bridge Deck Repair	sq feet	588
6154	Bridge Joint Repair	feet	113
6165	Extending Bridge Scuppers	each	5
6157	Bridge Railing Repair	feet	28
6156	Superstructure Repair	hours	142
6162	Seal Bridge Abutments/Seats/Backwalls/Piers	sq feet	7
6155	Substructure Repair	hours	139
6160	Add Channel Protection for Bridges	ton	27
6151	Bridge Cleaning	each	2125
6163	Removal of Loose Bridge Concrete Spalls	sq feet	241
6152	Bridge Painting	sq feet	5
6351	Bridge Betterment	each	50

Example 2 - Using the NBMD Catalog

The NBMD catalog for maintenance actions has three levels: bridge component, maintenance operation and work activity. The first two levels, component and operation, are useful for summary and comparison of activities among DOTs.

Ex 2A - Summary of Maintenance Actions by Bridge Component

Actions at Alabama, Colorado and Ohio are grouped by component, summarized (using an Excel COUNTIF() function) and compared. Detailed steps are provided for Alabama data. Results for Colorado and Ohio are obtained by similar steps.

1. Open the CU-Alabama database in MS Access. Under Objects select Queries, then select Ex 2A Component Summary. This query collects actions for each bridge component. Notice that the query begins with the NBMD catalog. We'll get a list of all components along with any maintenance actions performed for that catalog.
2. Export the query to Excel, apply an advanced data filter to collect unique event-action_guids and then unique components. At the second filter, COUNTIF() functions obtain counts of actions for each component. These steps are shown in the Excel workbook Example 2.xls
3. Similar query, export, filtering and counting are performed for Colorado and Ohio. Both of Colorado and Ohio databases include an Ex 2A query. After export and work in Excel, the results are:

NBMD Component	Number of Actions		
	Alabama	Colorado	Ohio
Deck	1708	1792	649
Joints	216	1119	113
Drains	136	0	0
Railings	174	1301	28
Bearings	61	187	0
Superstructure	224	1022	142
Substructure	418	1061	146
Approach / Embankment	407	940	0
Channel	567	7	27
Culvert	234	67	0
Bridge	3065	22125	2180
Movable Bridge	259	0	0
non Maintenance	30	171	0
non Bridge	1017	23	0

2B - Summary by Maintenance Operation

Similar queries are used to collect maintenance actions by operation.

1. Open the CU-Alabama Access database. Under Objects select Queries, then select Ex 2B Operation Summary. This query collects actions by their maintenance operation. We'll get a list of all operations performed.
2. Export the query to Excel. First, a data filter is applied to collect unique event_action_guids. Then a second filter is applied to get a list of maintenance operations. Then COUNTIF() functions obtain counts of occurrences of each operation. These steps are completed in the Excel workbook Example 2.xls
3. The CU-Colorado and CU-Ohio databases each contain an Ex 2B query. For each, data are exported to Excel, then filtered and counted. Results are summarized below.

NBMD Operation	Number of Actions		
	Alabama	Colorado	Ohio
Maintenance	2802	13244	
non Bridge	1017	23	
non Maintenance	30	171	
Clean / Clear	2631	10729	2125
Reset	61	30	
Coat / Paint	288	1815	73
Repair	1687	3789	1010
Replace		14	
Modify			82

Example 3 - Events, Dates, and Execution

Dates, actions and executions of events are summarized. Again, the detailed procedure is provided for Alabama data, and results for all three DOTs are shown.

Each maintenance event can include more than one maintenance action. Events identify execution of actions at specific structures and on specific dates. Our first work retrieves the number of events, number of structures involved, range of dates and mode of execution (DOT forces or contractor).

Ex 3A - Number of Events. Range of Dates. Execution.

1. Open the CU-Alabama database in Access. Select Queries, and double click on Ex 3A Events, Dates, Execution. The query operates with the events table only. The data fields here are event_guid, complete date, and execution.
2. Export the query to an Excel file. Use Excel's max and min functions to get the earliest and latest dates for maintenance events in this dataset. The earliest event is in 1966, and the latest is in 2007.

Earliest Event	9/5/1966
Latest Event	7/24/2007

- The number of maintenance events for each year is collected. In Excel, YEAR() functions are applied to each record, and placed in column E. From this new column, the distribution of events per year is generated using COUNTIF() functions (columns G:H).

Year	Number of Events
1966	1
1988	2
1994	72
1995	265
1996	215
1997	180
1998	224
1999	216

Year	Number of Events
2000	280
2001	354
2002	119
2003	243
2004	213
2005	24
2006	1441
2007	3642

- Entries for execution are filtered for unique values and placed in column K. 'DOT Crew' indicates maintenance of a state-owned bridge by DOT personnel. 'Contract' indicates maintenance by a contractor. 'In-House' indicates maintenance of a non-state bridge by the bridge owner. Counts for each are formed using Excel's COUNTIF() function.

Event Execution	Number of Events
Contract	643
DOT Crew	4982
In-House	1866

- The completed example is found in the Excel workbook Example 3.xls
- Similar results are obtained for Colorado and for Ohio. An Ex 3A query is found in each of the CU-Colorado and CU-Ohio databases. Filtering and counting are completed in Excel. The work is shown in Example 3.xls Results are summarized below.

Colorado Events, Dates and Execution

Earliest Event	7/3/2000
Latest Event	9/22/2005

Year	Number of Events
2000	2003
2001	4524
2002	4167
2003	6343
2004	7398
2005	4678

Event Execution	Number of Events
DOT crew	29097
Contract	16

Ohio Events, Dates and Execution

Earliest Event 1/3/2006

Latest Event 12/29/2006

All Ohio events are in the year 2006, and all events are executed by Ohio DOT crews.

Ex 3B - Number of Structures

A query is used to collect the structures that had maintenance events. The results of this query are sent to Excel for counting of distinct structures, and multiple events at same structures.

1. Open the CU-Alabama database. Under Queries, select Ex 3B Events, Structures. This query operates with the event table, and retrieves data fields event_guid, structure_guid and complete_date. The query yields 7491 event records.
2. Export the query to Excel. A data filter is used to retrieve the unique structures. From the filtered listing we see that the Alabama include 2914 structures.
3. A COUNTIF() function is applied, and the list of structure IDs is sorted by this count. A few structures have 100 or more events associated with them. These events are bridge inspections in some cases, or movable bridge operation in other cases. Repeated maintenance at structures is also here, both as application of different actions and re-application of same actions over time. The examination of repeated maintenance actions is treated in Example 7.
4. Similar queries and Excel work are performed on databases CU-Colorado and CU-Ohio. Colorado data include 3510 structures. Two structures have 100 or more events associated with them. Sometimes, these include work on consecutive dates. Maintenance completed over several days will generate multiple event records. The consolidation of these records is treated in Example 7.
5. Ohio data include 2260 structures. Some structures have twenty or more associated maintenance events. Usually, these are repeated actions on different, though nearby, dates.
6. All results are found in the Excel workbook Example 3.xls

Example 4 - Event Quantities. Accomplishment. Cost.

EX 4a - List of Events and Quantities.

Alabama quantities are summed for individual maintenance actions. Here are the steps:

- 1) Open the Access database for CU-Alabama maintenance data. Under Queries, find Ex4 Events, Accomplishment. This query finds all events, all actions associated with each event, and reports action quantities in DOT units (always) and in NBMD units where available.
- 2) The query lists the 10,000+ records in event_actions found in Alabama data. Double-click on the query to open a table view. The table view is sorted first on event_guid, and next on event_action_guid. Consider two excerpts from the table view. The first excerpt shows two events performed at Alabama structure number 000271. In January of 2007, this bridge was inspected. In May of 2007, the deck was cleaned. Inspection is reported under a general Bridge - Maintenance action. Deck cleaning is an explicit NBMD action. The default NBMD unit is deck area in square meters. Alabama data contains labor hours only. No conversion to NBMD units is available. The two events occurred in the same year (2007), but are separate because different actions were performed and the events are about four months apart.

Ex 4A Events, Accomplishment									
event_guid	event_act_key	NBMD Action	NBMD Title	qty	NBMD Unit	DOT Action	DOT name	DOT qty	DOT unit_id
AL{000271} 2007 01 17	AL{000271} 2007 01 17 11 0 0	11	Bridge - Maintenance -		sq.m.	B37	Bridge Inspection	8	hours
AL{000271} 2007 05 11	AL{000271} 2007 05 11 1 1 0	1.01	Deck - Clean / Clear		sq.m.	B01	Deck Cleaning	8	hours

The second excerpt is a set of four events of Deck - Repair performed on Alabama structure 000327. The repairs were performed on January 25, 26 and 29, 2007. Note that there are four records of actions and three records of events. The Alabama data system has four entries for crew work, and these generate four separate entries of *actions* in NBMD. The three *events* arise from the three separate dates of work at the bridge.

Ex 4A Events, Accomplishment									
event_guid	event_act_key	NBMD Action	NBMD Title	qty	NBMD Unit	DOT Action	DOT name	DOT qty	DOT unit_id
AL{000327} 2007 01 25	AL{000327} 2007 01 25 1 4 0	1.04	Deck - Repair	12.3	sq.m.	B06	Minor Deck Repair - Concrete	132	sq feet
AL{000327} 2007 01 26	AL{000327} 2007 01 26 1 4 0	1.04	Deck - Repair	8.2	sq.m.	B06	Minor Deck Repair - Concrete	88	sq feet
AL{000327} 2007 01 29	AL{000327} 2007 01 29 1 4 0	1.04	Deck - Repair	8.9	sq.m.	B06	Minor Deck Repair - Concrete	96	sq feet
AL{000327}	AL{000327} 2007	1.04	Deck -	0.7	sq.m.	B06	Minor Deck	8	sq feet

Ex 4A Events, Accomplishment									
event_guid	event_act_key	NBMD Action	NBMD Title	qty	NBMD Unit	DOT Action	DOT name	DOT qty	DOT unit_id
2007 01 29	01 29 1 4 0		Repair				Repair - Concrete		

Should these records be combined to form a single event? Probably, yes. But that is a step to be completed outside of the NBMD data system, and under the guidance of combining rules selected by the user. A combining rule might sum all identical actions provided that: 1) All actions occur on the same structure, and 2) All actions are performed within a 1 week interval (or other, user-specified time frame).

The full listing of actions and quantities for Alabama is found in the table view of query Ex 4A Events. Similar queries for Colorado and Ohio data are found in the CU-Colorado and CU-Ohio Access databases.

Ex 4B Summary of Events, Actions and Quantities

The number of events, number of actions and total quantities are summed.

1. In the CU-Alabama Access database, the query Ex 4A is used again, but now the results are exported to Excel, and counting functions are used to create summaries of actions.
2. First a summary of events, actions and quantities are formed in terms of NBMD standard actions. An Excel data filter is used to collect a list of unique NBMD actions. These are placed in column L and M. Next a SUMIF() function is used to collect quantities for each NBMD action. NBMD units are brought along using a VLOOKUP() function. The results are found in columns L to O, and also shown below. Note that most NBMD actions report zero quantity. This is due to the lack of a conversion from DOT units to NBMD units.

NBMD Title	qty	units
Deck - Clean / Clear	0	sq.m.
Deck - Repair	3173	sq.m.
Joints - Repair	2047	m
Joints - Repair - Re-attach / Re-anchor	2570	m
Drains - Clean / Clear	28	m
Railings - Repair	13826	m
Bearings - Maintenance	0	each
Bearings - Repair	0	each
Superstructure - Repair	0	sq.m.
Substructure - Clean / Clear	0	sq.m.
Substructure - Repair	0	sq.m.
Approach/ Embankment - Clean / Clear - Vegetation / Trees	0	sq.m
Approach/ Embankment - Coat / Paint - Chemical treatments	0	sq.m
Channel - Clean / Clear - Debris / Drift	0	sq.m

Channel - Repair - Re-attach / Re-anchor	0	sq.m
Culvert - Clean / Clear	0	sq.m.
Culvert - Repair	0	sq.m.
Bridge - Maintenance -	0	sq.m.
Bridge - Reset - Consumable	120	each
Bridge - Coat / Paint - Paint	478603	sq.m
Bridge - Coat / Paint - Spot paint	0	sq.m
Bridge - Repair	0	sq.m.
Movable Bridge - Maintenance -	0	sq.m.
Non Maintenance	0	
Non Bridge	0	

3. Next, a summary of action quantities is prepared in terms of DOT actions and quantities. First, a data filter is used to collect unique DOT actions. The list of unique actions is placed in column Q. DOT units are retrieved using VLOOKUP() functions. Quantities for each DOT action are summed using SUMIF() functions. The results are shown in columns Q to T, and in the table below.

DOT Action	DOT name	qty	units
B01	Deck Cleaning	15842	hours
B02	Curb/Rail/Fence Repair	45461	feet
B03	Joint Repair - Open	6232	feet
B04	Joint Repair - Sealed	492	feet
B05	Minor Deck Repair - Steel	182	sq feet
B06	Minor Deck Repair - Concrete	7123	sq feet
B07	Minor Deck Repair Timber	8353	sq feet
B08	Major Deck Repair - Steel	1959	sq feet
B09	Major Deck Repair - Concrete	1842	sq feet
B10	Major Deck Repair - Timber	14730	sq feet
B11	Minor Superstructure Member Repair - Steel	1561	hours
B12	Minor Superstructure Member Repair - Concrete	1814	hours
B13	Minor Superstructure Repair Timber	292	hours
B14	Major Superstructure Member Repair - Steel	2305	hours
B15	Major Superstructure Member Repair - Concrete	5177	hours
B16	Major Superstructure Member Repair - Timber	1846	hours
B17	Minor Substructure Member Repair - Steel	34591	hours
B18	Minor Substructure Member Repair - Concrete	1232	hours
B19	Minor Substructure Repair Timber	2120	hours
B20	Major Substructure Member Repair - Steel	4945	hours
B21	Major Substructure Member Repair - Concrete	320573	hours
B22	Major Substructure Member Repair - Timber	5701	hours
B23	Bridge Painting - Spot	686	sq feet
B24	Bridge Painting - Partial	33041	sq feet
B25	Bridge Painting - Complete	5006099	sq feet

B26	Bridge Culvert Cleaning	69869	hours
B27	Bridge Culvert Repair	769	hours
B28	Light and Navigation-Light Repair	1124	hours
B29	Drift Removal	5660	hours
B30	Slope and Shore Protection Repair	20608	hours
B31	Accident Repair	8305	hours
B32	Vandalism Repair	204	hours
B33	Moveable Span Maintenance	128	hours
B34	Moveable Span Operations	4235	hours
B35	Tunnel Maintenance	154	hours
B36	Tunnel Operations	91	hours
B37	Bridge Inspection	41295	hours
B38	Other Structure Maintenance	10459	hours
B39	Construction Engineering and Inspection	4372	hours
B40	Construction Materials Testing	40	hours
B41	Drain/Joint Cleaning	2552	hours
B42	Bent Cap / Beams and Beam Seals	1780	hours
B43	Major Bearing Devices and Assemblies - Installation / Maintenance / Repair	1670	hours
B44	Minor Bearing Devices and Assemblies - Maintenance / Repair	1597	hours
B45	Joint Sealing- Installation	8484	feet
B46	Vegetation Control	4801	hours
B47	Beaver Control	207	hours
B99	Bridge Maintenance Overhead	7359	hours

4. Results for Colorado and Ohio are developed in similar use of Access queries and Excel functions. The results for Colorado are found in Example 4.xls and listed below (in DOT units only).

DOT Action	DOT title	Quantity	Unit
102	Plan + schedule	130	hour
103	Training/meetings	19	hour
104	Leave	3553	hour
152	Patching/minor rep	1593	sq yard
152.08	Patching-minor rep	1	sq yard
152.1	Rigid pavement patch/minor rep	20	sq yard
152.2	Rotomilling flexible pavements	28800	sq yard
152.3	Rotomilling rigid pavements	4500	sq yard
154	Patching-machine	5307	ton
154.08	Patching-machine	0	ton
156	Crack-joint seal	193	gallon
156.08	Crack-joint seal	95	gallon
156.09	Crk sl flex pvt hnd prev mtc	2169	gallon
162	Restore shoulder	3	feet
163	Restore shoulder	7930	feet

DOT Action	DOT title	Quantity	Unit
164	Base stab & repair	0	cu yard
202	Clean drain struct	126	each
206	Mtc/ditc/streambed	2250	feet
207	Salt/sand cleanup	77	ton
210	Slope repair	392	cu yard
216	Fence / gate maintenance	105	feet
217	Soundbarrier maintenance	65	feet
218	Litter trash clean	32	cu yard
220	Sweeping machine	2023	mile
222	Sweeping hand	932	hour
252	Veg ctrl mach mow	17	mile
254	Hand mowing	302	hour
256	Herb-pest applicat	1	acre
258	Veg control irrig	20	hour
260	Tree plant+trim	79	each
302	Single post signs	54	each
304	Del posts mtnce	5712	each
306	Guard rail repair	105067	feet
307	Con guard rail mtn	1301	feet
310	Pave marking hand	11	sq yard
312	Roadway sign lighting	0	each
316	Attenuator maint	536	each
320	Elect wire refurb	0	hour
326	Mast inter maintenance	0	each
329	Courtesy patrol	355	
351	Bridge/structural visual inspection/monitoring	33499	each
352	Cleaning or washing	45143	each
353	Bridge deck repair/ etc.	754736	sq yard
353.08	Pavement crack sealing.	65	sq yard
353.1	Crack/joint seal rig brdg deck	8940	gallon
353.2	Rotomil flex pave bridge deck	509179	sq yard
353.3	Rotomil flex pave bridge deck	54022	sq yard
353.4	Crack seal flex bridge deck	39584	gallon
354	Superstructure maintenance	1796	each
354.08	Bridge structure maintenance	0	each
355	Bridge painting	9856	gallon
356	Bridge rail repair	627364	feet
356.08	Bridge rail repair	3570	feet
357	Bearings/ maintenance	977	each
358	Substructure maintenance	1629	each
358.08	Substructure maintenance	10	each
360	Approach slabs and slope protection repair	2585	each
360.08	App slab/slope rpr	2	each
364	Expansion joints	60867	feet
364.08	Expansion joint	1148	feet

DOT Action	DOT title	Quantity	Unit
364.09	Expansion joint	120	feet
402	Snow removal+sand	592	mile
403	Ice ctr drain-hand	179	hour
406	Sn/removal/sp eq.	60	hour
454	Stockpile/ hauling	380	ton
458	Equipment maintenance	28	hour
460	Building+grounds	1400	hour
502	Tunnel operations	41	hour
504	Tunnel washing	22740	sq yard
506.1	Tunnel traff contl	24	hour
512	Tunnel structural	80	hour

5. Ohio results are shown below (DOT units only)

DOT Action	DOT Title	Quantity	Unit
6151	Bridge Cleaning	2304	each
6152	Bridge Painting	3006	sq feet
6153	Bridge Deck Repair	39927	sq feet
6154	Bridge Joint Repair	3276	feet
6155	Substructure Repair	3223	hours
6156	Superstructure Repair	2655	hours
6157	Bridge Railing Repair	1629	feet
6160	Add Channel Protection for Bridges	1664	ton
6161	Sealing Bridge Decks/Gutters/Curbs/Railing	297153	sq feet
6162	Seal Bridge Abutments/Seats/Backwalls/Piers	634	sq feet
6165	Extending Bridge Scuppers	29	each
6351	Bridge Betterment	6	each

Ex 4C Cost of Events, Cost of Actions.

Ohio data include the greatest extent and detail of cost information among trial maintenance data for project 14-15. Alabama data have costs for contract maintenance only. Colorado data has costs for a few contract bid items.

Alabama DOT reports total costs for each of its actions completed by contract. For each case, a single, total cost for each action is reported. To view these costs:

1. Open the CU-Alabama database in Access. Under Queries, select Ex 4C Event, Action Cost. Double click on the query to get a data table view.
2. A summary of actions and costs is obtained by exporting the query to Excel and using COUNTIF() and SUMIF() functions. The workbook Example 4.xls shows the work.

3. In Excel, a data filter is used to collect unique NBMD actions. COUNTIF() functions collect the number of events for each. SUMIF() functions collect total expenditures for each action. The results are found in columns G to J. The results are shown below.

NBMD Action	Actions	Total Cost, \$
Deck - Clean / Clear	16	10296
Deck - Repair	12	3795
Joints - Repair	2	4080
Railings - Repair	13	146655
Superstructure - Repair	2	457356
Substructure - Repair	98	2044233
Channel - Clean / Clear - Debris / Drift	4	15360
Channel - Repair - Re-attach / Re-anchor	27	2535373
Culvert - Clean / Clear	2	64423
Bridge - Maintenance -	289	26472
Bridge - Coat / Paint - Paint	202	13979138
Bridge - Repair	13	4935
Non Maintenance	25	75648

4. A similar query is made for Colorado data, where costs for a few maintenance contracts are reported.

NBMD Action	Actions	Cost, \$
Joints - Replace - Complete	7	569236
Bridge - Reset - Reposition	6	115670
Bridge - Repair - Patch	3	239048

5. Ohio data include extensive cost data. These are costs of materials, equipment and labor used in maintenance by DOT crews. The query on events and costs yields the summary below.

NBMD Action	Actions	Cost, \$
Deck - Coat / Paint - Seal surface	61	154339
Deck - Repair	588	719128
Joints - Repair	113	100035
Drains - Modify - Strength / Capacity	5	1679
Railings - Repair	28	12960
Superstructure - Repair	142	59024
Substructure - Coat / Paint - Seal surface	7	1320
Substructure - Repair	139	98830
Channel - Modify - Protection	27	35257
Bridge - Clean / Clear	2125	434452
Bridge - Coat / Paint - Paint	5	1989
Bridge - Modify	50	25316

Ex 4D Unit Costs

Alabama and Ohio data include costs for deck repairs, and both DOTs report accomplishment in square feet. Unit costs can be computed and compared.

1. Open the CU-Alabama database in MS Access. Under Queries, find Ex 4D Unit Cost. This query collects deck repair actions, their costs, and the accomplishment in square feet. The query yields 131 records.
2. Export the query to Excel. A data filter is applied to collect unique event_action_guids. SUMIF() functions collect quantities and costs for each event. MIN, MAX and Average functions yield unit cost summaries, shown below. Complete work is in Example 4.xls

Min cost	2.00	\$/SF
Max cost	103.00	\$/SF
Average cost	16.07	\$/SF
Total area	31355	SF
Total cost	\$611957	
Bulk average	19.52	\$/SF

3. Similar query and summary are prepared with Ohio data on deck repairs. There are 571 records. Results are shown below.

Min cost	1.55	\$/SF
Max cost	1311.45	\$/SF
Average cost	61.09	\$/SF
Total area	7789	SF
Total cost	\$153184	
Bulk average	19.67	\$/SF

Example 5 – Resources

Resources for maintenance actions include labor, equipment and materials. These are stored as standard NBMD identifiers, as descriptive strings, and as identifiers collected from DOT data.

Alabama data present labor only as a resource for maintenance events. Labor types are identified as regular DOT labor, overtime DOT labor and convict labor. Colorado data are less detailed. Labor is reported only as total hours.

Ohio data are more detailed. Ohio reports labor, equipment and materials. Labor hours are reported for a set of job titles, ranging from maintenance worker, to engineer, to manager. Unit costs are available for Ohio resources, and total costs can be computed for specific resources, for the sum of resources separately as labor, material and equipment, and for complete actions and events.

5A – Basic List of Resources

Resources are listed in the event_resources table. A portion of the table for Alabama is shown below. Alabama data report labor only, but a single event and action may include more than one type of labor, and the same type of labor may be reported on more than one crew card. The event_resources table preserves individual DOT entries, but if the event and action are the same, then multiple entries are identified by the same guid. One or more NBMD descriptors provide standard designations for labor and can be used for filtering and summary.

event_resource								
event_act_key	resource_id	description	DOT quantity	DOT unit	source	notes	NBMD 1	NBMD 2
AL{000426} 2007 01 17 11 0 0	labor	2 person crew	15.0	hour	DOT	Total hours	labor	
AL{000426} 2007 01 17 11 0 0	labor	2 person crew	1.0	hour	DOT	Total hours	labor	overtime
AL{000517} 2007 05 03 3 1 0	labor	2 person crew	56.0	hour	DOT	Total hours	labor	
AL{000517} 2007 05 03 3 1 0	labor	2 person crew	48.0	hour	DOT	Total hours	labor	convict

Colorado data also report labor hours, but do not provide any differential among types of labor.

Ohio data includes detailed lists of resources used in maintenance actions. An examples is shown below. There are 25 records of resources for deck repairs made to Ohio structure 1001299 on July 5 and 6, 2006. Two NBMD events are generated; one for each of the two work dates. Clearly, a user may wish to treat these as a single event. Labor is performed by a DOT crew that includes a bridge worker, three highway technicians and two seasonal workers. The crew is the same on both work dates. Equipment includes an air compressor, a dump truck, two stake trucks and a utility truck. The same equipment is used both days. Materials include about 4.5 tons of asphalt concrete and 3 bags of concrete patching material. The patch material is identified as Emaco Set-45.

The data fields for resource description, DOT quantity and DOT unit are taken unchanged from Ohio data. The data field resource_id contains DOT codes for resources, if available. In Ohio data, codes are available for materials, but not for labor and equipment. Cost data for materials are obtained from the Ohio DOT Office of Purchasing. Costs data for equipment are obtained from the Ohio DOT Office of Equipment Management. Average pay rates for job titles are obtained from the Ohio Division of Administrative Services.

The data fields NBMD 1 through NBMD 3 provide standard keywords to identify resources. Fields NBMD 4 and NBMD 5 identify specific material products and manufacturers. As a set, NBMD 1 to NBMD 5 allow filtering, summarizing and searching of resources.

event_resource

event_guid	event_act_key	resource_id	Description	DOT quantity	DOT unit	DOT unit cost	cost	source	NBMD 1	NBMD 2	NBMD 3	NBMD 4	NBMD 5
OH{1001299} 2006 7 5	OH{1001299} 2006 7 5 1 4 0	equipment	Sullair 185dpqjd- air co	1.50	hour	22.88	34.32	DOT	Machine	Air compressor			
OH{1001299} 2006 7 5	OH{1001299} 2006 7 5 1 4 0	equipment	93 intl 4900- dump truck	72.00	mile	1.71	123.12	DOT	Vehicle	Truck	Dump		
OH{1001299} 2006 7 5	OH{1001299} 2006 7 5 1 4 0	equipment	82 gmc tc31008- 1ton stake	58.00	mile	0.66	38.28	DOT	Vehicle	Truck	Stake		
OH{1001299} 2006 7 5	OH{1001299} 2006 7 5 1 4 0	equipment	98 intl 4900- 2.5t stake	126.00	mile	1.09	137.34	DOT	Vehicle	Truck	Stake		
OH{1001299} 2006 7 5	OH{1001299} 2006 7 5 1 4 0	equipment	3 dodge 2500- 3/4tn util	39.00	mile	0.55	21.45	DOT	Vehicle	Truck	Utility		
OH{1001299} 2006 7 5	OH{1001299} 2006 7 5 1 4 0	labor	Bridge wkr 2	10.00	hour	16.96	169.63	DOT- regular	labor				
OH{1001299} 2006 7 5	OH{1001299} 2006 7 5 1 4 0	labor	Dot seasonal	8.00	hour	0.00	0	DOT- regular	labor				
OH{1001299} 2006 7 5	OH{1001299} 2006 7 5 1 4 0	labor	Dot seasonal	8.00	hour	0.00	0	DOT- regular	labor				
OH{1001299} 2006 7 5	OH{1001299} 2006 7 5 1 4 0	labor	Highway tech 2	10.00	hour	15.95	159.52	DOT- regular	labor				
OH{1001299} 2006 7 5	OH{1001299} 2006 7 5 1 4 0	labor	Highway tech 2	10.00	hour	15.95	159.52	DOT- regular	labor				
OH{1001299} 2006 7 5	OH{1001299} 2006 7 5 1 4 0	labor	Highway tech 2	8.00	hour	15.95	127.61	DOT- regular	labor				

event_guid	event_act_key	resource_id	Description	DOT quantity	DOT unit	DOT unit cost	cost	source	NBMD 1	NBMD 2	NBMD 3	NBMD 4	NBMD 5
OH{1001299}2006 7 5	OH{1001299}2006 7 5 1 4 0	42030492	Asphalt concrete-404	2.23	ton	55.00	122.65	DOT	Bituminous	Asphalt concrete			
OH{1001299}2006 7 6	OH{1001299}2006 7 6 1 4 0	42020420	Cement- set 45	3.00	bag	16.80	50.4	DOT	Concrete	Cement		Emaco Set-45	BASF
OH{1001299}2006 7 6	OH{1001299}2006 7 6 1 4 0	equipment	Sullair 185dpqjd- air co	1.00	hour	22.88	22.88	DOT	Machine	Air compressor			
OH{1001299}2006 7 6	OH{1001299}2006 7 6 1 4 0	equipment	93 intl 4900-dump truck	71.00	mile	1.71	121.41	DOT	Vehicle	Truck	Dump		
OH{1001299}2006 7 6	OH{1001299}2006 7 6 1 4 0	equipment	82 gmc tc31008-1ton stake	41.00	mile	0.66	27.06	DOT	Vehicle	Truck	Stake		
OH{1001299}2006 7 6	OH{1001299}2006 7 6 1 4 0	equipment	98 intl 4900-2.5t stake	110.00	mile	1.09	119.9	DOT	Vehicle	Truck	Stake		
OH{1001299}2006 7 6	OH{1001299}2006 7 6 1 4 0	equipment	3 dodge 2500- 3/4tn util	41.00	mile	0.55	22.55	DOT	Vehicle	Truck	Utility		
OH{1001299}2006 7 6	OH{1001299}2006 7 6 1 4 0	labor	Bridge wkr 2	10.00	hour	16.96	169.63	DOT-regular	labor				
OH{1001299}2006 7 6	OH{1001299}2006 7 6 1 4 0	labor	Dot seasonal	8.00	hour	0.00	0	DOT-regular	labor				
OH{1001299}2006 7 6	OH{1001299}2006 7 6 1 4 0	labor	Dot seasonal	8.00	hour	0.00	0	DOT-regular	labor				
OH{1001299}2006 7 6	OH{1001299}2006 7 6 1 4 0	labor	Highway tech 2	10.00	hour	15.95	159.52	DOT-regular	labor				
OH{1001299}2006 7 6	OH{1001299}2006 7 6 1 4 0	labor	Highway tech 2	8.00	hour	15.95	127.61	DOT-regular	labor				

event_guid	event_act_key	resource_id	Description	DOT quantity	DOT unit	DOT unit cost	cost	source	NBMD 1	NBMD 2	NBMD 3	NBMD 4	NBMD 5
OH{1001299} 2006 7 6	OH{1001299} 2006 7 6 1 4 0	labor	Highway tech 2	10.00	hour	15.95	159.52	DOT- regular	labor				
OH{1001299} 2006 7 6	OH{1001299} 2006 7 6 1 4 0	42030492	Asphalt concrete- 404	2.19	ton	55.00	120.45	DOT	Bituminous	Asphalt concrete			

Ex 5A - Summary of Resource Costs by Component

Using Ohio data, costs for maintenance are collected by bridge component in three categories: labor, equipment and material.

1. Open the CU-Ohio database in MS Access. Under Queries, find Ex 5A Resource Summary. This query collects bridge components, resource categories and costs for resources. The query is used three times; once each for resource_id equal to labor, to equipment, and to a numeric material code.
2. The three uses of the query are exported to Excel as three separate sheets. Costs are summed by bridge component. The overall summary appears below. The work appears in Example 5.xls

Bridge Component	Labor, \$	Equip, \$	Mat'l, \$
Deck	329860	152231	391376
Joints	50001	18288	31746
Drains	1114	269	296
Railings	6514	1980	4466
Superstructure	29143	12225	17657
Substructure	46191	22825	31135
Channel	7685	9855	17717
Bridge	218787	233275	9694

Ex 5B - Use of Specific Products

The data fields NBMD 4 and NBMD 5 allow for search and summary of use of specific products in maintenance events. Ohio data provides the examples here. First, we will obtain a list of products and manufacturers in Ohio data.

1. Open the CU-Ohio Access database. Under Queries, find Ex 5B Products. The query is set up to retrieve DOT quantity, DOT unit, and the keyword fields NBMD 4 and NBMD 5 for the condition that either field is not blank.
2. The query contains 353 records of use of named products. Export the query to Excel for data filtering and sorting. The work appears in Example 5.xls
3. In Excel, the list of products is filtered for unique products, and COUNTIF() function is used to count the number of actions that used each product. The results are shown below.

NBMD 4 (product)	NBMD 5 (manufacturer)	No. of Actions
Emaco Set-45	BASF	51
Flexset	Rocklin Systems Inc	39
Flowmix	Rocklin Systems Inc	29
Kold Flo	Unique Paving Materials	3
Pathfinder II		21

NBMD 4 (product)	NBMD 5 (manufacturer)	No. of Actions
Pre-Prime 167	Devoe Coatings	1
Pyrament	Lone Star Industries	127
Quikrete 5000	Quikrete	1
Quikrete FastSet	Quikrete	3
Rapid set	CTS Cement	58
Reho Build 1000	BASF	4
Roadsaver 515	Crafco	1
Sakrete	Sakrete	3
Thoroc 1060	BASF	1

Ex 5C - Use of Large Equipment

Ohio DOT data are used to generate summaries of use of backhoes, excavators, or loaders.

1. Open the CU-Ohio database in MS Access. Under Queries, find Ex 5C Equipment. This query gets actions such that NBMD 1 is Machine and NBMD 2 is backhoe, excavator or loader. There are 349 records of use of large equipment in Ohio's 2006 maintenance data.
1. Export this query to Excel. A data filter is used to collect unique equipment types (there are only the three types allowed by the query), and COUNTIF() functions get a summary of the instances of equipment use. Quantities of use are summarized. The results are developed in Example 5.xls, and the summary is listed below. Note that equipment use averages 2 to 3 hours per maintenance action.

NBMD 2 (equip)	Count	Quantity	
Backhoe	66	176	hours
Excavator	24	79	hours
Loader	259	611	hours

Ex 5D - Use of Trucks

Ohio DOT data are used to collect the kinds, instances and quantities of use of trucks in maintenance actions.

1. Open the CU-Ohio database in MS Access. Under Queries find Ex 5D Trucks. This query collects actions that use any type of truck. There are more than 6000 records.
2. Export the query to Excel. A data filter is used to collect unique truck types, COUNTIF() functions get the instances of use of each type, and SUMIF() functions get a summary of quantity of use of each type of truck. The results are developed in Example 5.xls. The summary is listed below.

NBMD 3 (truck)	No. of Uses	Quantity	Quantity units
Digger derrick	1	5	hour
Distributor	4	9	hour
Dump	2557	67128	mile
Pickup	2256	68390	mile
Stake	1301	51218	mile
Tractor	24	994	mile
Utility	455	17832	mile
Water tank	11	209	mile
Welder	1	25	mile

Example 6 – Resources in Contract Maintenance

Data on contract maintenance are available from Alabama and Colorado. Alabama data does not include resources for contracts. Colorado data includes bid item tabulations. Colorado data are examined here.

1. Open the CU-Colorado database in MS Access. Under Queries, find Ex 6A DOT Bid Items. This query uses three tables. From events, we identify contract maintenance work, from event_actions we get guides for the actions, from event_resources we get the list of resources. There are 167 records here.
2. Export the query to Excel. We use a filter to collect unique DOT bid items, VLOOKUP() functions to collect item titles and units, and COUNTIF() functions to collect the instances of uses. The results are found in the workbook Example 6.xls. The summary of Colorado DOT bid items is shown below.

DOT Bid Item	Description	Quantity	Unit	Count
202-00200	Rem Sidewalk	10.7	Sq Yd	1
202-00240	Rem Asphalt Mat (Planing)	16248	Sq Yd	3
202-00502	Rem Port Present Str	12.4	Cu Yd	2
202-00503	Rem Port Present Str	175	Sq Yd	1
202-00504	Rem Exp Device	409.3	Ln Ft	6
202-00821	Rem Sign Panel	1	each	2
202-05100	Sandblasting Reinf Steel	42	Sq Yd	2
208-00045	Conc Washout Str	4	each	4
208-00050	Storm Drain Inlet Protection	5	each	2
208-00205	Erosion Control Supervisor	8	Hour	1
210-01140	Res Gdrail Ty 4	100	LN FT	1
210-01300	Res Impact Attenuator	2	each	1
403-00720	HBP (Patching) (Asph)	122	ton	3
403-33871	HBP (Gr S) (100) (PG 76-28)	2195	ton	2
403-34454	HBP (Gr SX) (Asph) (96) (PG 64-22)	48	Ton	1
411-10255	Emul Asph (SS)	622	gallon	2
420-00500	Geotextile (Paving)	200	Sq Yd	2

DOT Bid Item	Description	Quantity	Unit	Count
506-00206	Riprap (6 In)	20	Cu Yd	2
515-00120	Waterproofing (Membrane)	300	Sq Yd	2
515-00400	Concrete Sealer	340.6	Sq Yd	2
515-00410	Concrete Sealer (Calcium Nitrite)	68.8	Sq Yd	2
518-01002	Br Expan Device (0-2 In)	118	Ln Ft	1
518-01004	Br Expan Device (0-4 In)	338.8	Ln Ft	4
518-01015	Br Expan Device (0-15 In)	70.5	Ln Ft	2
601-03000	Conc CL D	4.7	Cu Yd	1
601-03040	Conc CL D (Bridge)	33	Cu Yd	3
601-03041	Conc CL D (Bridge) (Spec)	12.4	Cu Yd	2
601-05040	Conc CL S (Bridge)	7	Cu Yd	1
601-06100	Conc (Patching)	58	CuYd	2
601-06150	Conc (Patching)	2133	Sq Foot	1
601-10250	Slab Jacking	12298	Lb	6
602-00020	Reinf Steel (Epoxy)	7465	lb	7
614-00013	Sign Panel (CL III)	121	Sq Ft	2
614-80355	Portable Mesg Panel	1	each	1
618-00005	Prestress Steel Bar	6.3	M Kip Foot	1
620-00020	Sanitary Facility	1	each	2
626-00000	Mobilization	2	L S	3
627-00005	Epoxy Pvmt Mkg	35	gallon	2
627-00012	Pvmt Mkg Paint (Low VOC Solvent Base)	30	gallon	2
630-00000	Flagging	2410	hour	7
630-00001	Pilot Car Operation	72	hour	1
630-00007	Traf Ctrl Inspection	28	day	4
630-00009	Traf Ctrl Vehicle (Truck)	1	each	1
630-00012	Traf Ctrl Mgmt	100	day	7
630-10005	Traf Ctrl	9	LS	9
630-80336	Barricade (3 M-B) (Temp)	8	each	2
630-80341	Const Traf Sign (A)	21	Each	6
630-80342	Const Traf Sign (B)	179	Each	7
630-80343	Const Traf Sign (C)	65	Each	6
630-80344	Const Traf Sign (Spec)	64	Sq Ft	2
630-80355	Port Mesg Panel	2	Each	1
630-80358	Flash Arrow Panel (C Ty)	10	Each	7
630-80359	Port Mesg Panel	70	day	5
630-80360	Drum Channel Dev	275	Each	7
630-80364	Drum Channel Dev (Light) (SB)	150	each	2
630-80380	Traffic Cone	1075	Each	4
630-85040	Impact Atten (T-M-A) (Temp)	3	each	3

6B – NBMD Description of Contract Resources

Colorado's contract resources are summarized in terms of NBMD keywords for resources.

1. Open the CU-Colorado database in MS Access. Under Queries find Ex 6B NBMD Items. This query finds the same records as Ex 6A, but the output is in terms of NBMD fields instead of DOT items. There are 167 records here.
2. Export the query to Excel. A data filter is used to collect unique combinations of NBMD fields. COUNTIF() functions are used to collect instances of each combination. Total costs are summed for each unique combination. The results are shown in the workbook Example 6.xls. The summary appears below.

NBMD 1	NBMD 2	NBMD 3	No. of Actions	Total Cost, \$
Bituminous	Asphalt concrete		6	132110
Bituminous	Emulsified asphalt		2	933
Concrete			20	303108
Concrete maintenance	Membrane		2	3900
Concrete maintenance	Sealer	Calcium Nitrite	2	2442
Concrete maintenance	Sealer		2	2477
Device	Expansion		7	192564
Drain	inlet		2	320
labor			50	344961
Paint	Pavement		4	3925
Site	Arrow board		7	4954
Site	Barricade		2	666
Site	Delineator	Barrel	9	9450
Site	Impact attenuator		3	19536
Site	Message board		7	11820
Site	Sanitary Facility		2	400
Site	Sign		23	15443
Site	Traffic cone		4	4365
Soil maintenance	geotextile		2	1800
Soil maintenance	Rock	Riprap	2	1300
Steel	Bar- prestressing		1	6048
Steel	Deformed bar	Epoxy-coated	7	11019
Vehicle	Automobile		1	5940
Vehicle	Truck		1	2785

Example 7 - Recurrent Actions. Intervals for Maintenance

Intervals for re-application of the same maintenance actions at the same bridges are important in at least two evaluations. The interval can indicate the service life of a maintenance product or procedure, or the interval reveals maintenance policies for deck washing, etc.

In this example, Colorado DOT data, the only multi-year data available in this demonstration, is first used to collect recurrent maintenance actions at bridges, and then further examinations of selected actions are made.

Ex 7A List of Recurrent Events

1. Open the CU-Colorado database in MS Access. Under Queries, find Ex 7A Recurrent Actions. This query yields a full list of event_action_guid, dates, structures and actions.
2. Export the query to Excel. Some actions are reported on more than one 'green sheet', the basic reporting unit for Colorado DOT crew maintenance. So we first collect a set of the unique event_action_guid, since these identify unique combinations of structure, action and date. This first data filter appears in columns G to K. Notice that the query produced nearly 38,000 records. The unique event_action_guids are fewer than 29,000.
3. Next, column M is filled with a formula that checks if, among adjacent rows, the action and the structure match, and whether the dates are more than 240 days apart. If all three conditions are satisfied, then this is a recurrent action, and a value 1 is shown in the cell. If the action or the structure don't match, or if the dates are too close, nothing appears in the cell. The number of recurring actions, at same structures, are summarized below

NBMD Action	No. of Repeats
Deck - Coat / Paint - Seal cracks	8
Deck - Repair	128
Joints - Maintenance	93
Railings - Repair	138
Bearings - Maintenance	8
Superstructure - Maintenance	55
Substructure - Maintenance	43
Approach/ Embankment - Clean / Clear - Vegetation / Trees	2
Approach/ Embankment - Repair - Patch	52
Culvert - Clean / Clear	1
Bridge - Maintenance -	2024
Bridge - Clean / Clear	2382
Bridge - Clean / Clear - Sweep	9
Bridge - Clean / Clear - Debris / Drift	1
Bridge - Coat / Paint - Paint	240
Bridge - Repair - Patch	6
Non Maintenance	12
Non Bridge	8

Ex 7B Interval for Bridge Cleaning

In this example, the 2382 recurring events for bridge cleaning are examined, the number of structures is found, and the average interval between cleanings is evaluated.

1. Open the CU-Colorado database in MS Access. Under Queries, find Ex 7B Cleaning Interval. This query is similar to Ex 7A, but it requires that the NBMD Action equal 11.02. The query yields nearly 13,000 records.

- Export the query to Excel, and filter for unique event_action_guids. Formulas are added to columns M and N. Like Ex 7A, column M contains an IF() construction to identify recurring actions. Column N computes the interval in days between cleanings. The number of values, extremes, and average are summarized below.

Number of recurrent cleanings	2382
Min Interval (day)	241
Max Interval (day)	1722
Average Interval (day)	515

Ex 7C Interval for Deck Repair

In this example the 128 recurring Deck Repair actions are listed, and intervals are evaluated.

- Open the CU-Colorado database in MS Access. Under Queries, find Ex 7C Deck Repair. This query finds all actions such that NBMD action equals 1.04. The query yields 3100 records.
- Export the query to Excel, and filter for unique event_action_guids. Formulas are added to columns M and N. Like other examples, column M contains an IF() construction to identify recurring actions. Column N computes the interval in days between repairs. The number of actions, extreme intervals and average interval are summarized below.

Recurrent deck repairs	128
Min Interval (day)	245
Max Interval (day)	1737
Average Interval (day)	592

Ex 7D Interval for Bridge Painting

In this example the 241 recurring Painting actions are listed, and intervals are evaluated.

- Open the CU-Colorado database in MS Access. Under Queries, find Ex 7D Painting. This query finds all actions such that NBMD action equals 11.0301. The query yields more than 1700 records
- Export the query to Excel and filter for unique event_action_guids. Formulas are added to columns M and N. Like previous examples, column M contains an IF() construction to identify recurring actions. Column N computes the interval in days between repairs. The number of actions, extreme intervals and average interval are summarized below.

Recurrent painting actions	241
Min interval (day)	242
Max interval (day)	1737
Average interval (day)	628

Example 8 - Actions versus Elements

We examine the application of maintenance actions to various bridge elements. The NBMD XML schema, website and Organizer accept AASHTO's Commonly Recognized (CoRe) elements only. The CU Access databases work with any element set. Searches among diverse sets of bridge elements are mediated by standardized NBMD keywords.

First we'll have a look at some representative bridge elements, and then see how maintenance actions relate to element types.

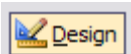
Ex 8A Bridge Elements

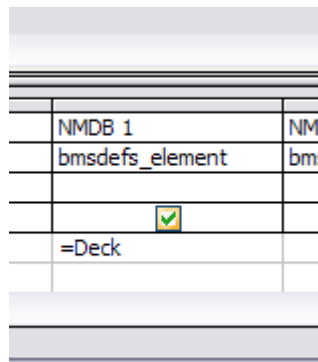
Colorado DOT uses the Pontis bridge management system. Colorado maintenance data can be related to CoRe elements.

The NBMD system contains a list of Colorado's bridge elements, and augments these with NBMD keywords. This is preserved in the table `bmsdefs_element`. A query is used here to collect some of the fields in this data table

1. Open the CU-Colorado database in MS Access. Under Queries, find Ex 8A Bridge Elements. The query collects element IDs, names, and NBMD descriptors. Double-click on the query name to view a data table of elements. There are 155 records.

2. We'll apply a filter in the query to collect Deck elements only. Close the data table view of the

query, and open the Design  view for the query. Find the column headed NBMD 1. Below the checkbox, type in Deck. Now close this view, and respond Yes in the dialog that asks whether to save changes.



3. Double-click to open the table view for this query. There are now 27 records of the Deck elements only. Note the other NBMD descriptive fields. We could search on deck construction material, on presence/absence of overlays, and on presence/absence of coated reinforcing steel.
4. Alabama and Ohio data have elements, too, but not AASHTO CoRe elements. Alabama uses an extended NBI record to list the types of pier, abutments, bearings, railings, and joints. To these

we add structure type and deck type from NBI fields 43, 107 and 108. To view Alabama's elements (at least the ones present among bridge in 2006 maintenance events), open the CU-Alabama database in MS Access. Under Queries, find Ex 8A Bridge Elements. Double click the query to open a data table view. The Alabama bridge management system recognizes many elements. More than 800 are listed here.

5. Deck elements are listed in the query Ex 8A Deck Elements. Double-click the query to get a data table view of the 60 Alabama deck types
6. To view Ohio bridge elements and deck elements, open the CU-Ohio database in MS Access. Under Queries, find Ex 8A Bridge Elements and Ex 8A Deck Elements. Ohio data include only the NBI-derived elements for bridge type and deck type.

Ex 8B - Deck Repair Actions Histogram with Element Type

We obtain the distribution of deck repair actions as a function of deck type. We'll collect all repairs to decks, and then subsets of repairs to bare decks, decks with overlays, and decks with membranes (these are a subset of decks with overlays).

1. Open the CU-Alabama database in MS Access. Under Queries, find Ex 8B Deck Repairs. The query collects events for deck repairs, and reports the element number and NBMD keywords for the element. The query yields 147 records.
2. Export the query to Excel. A data filter is used to collect unique events. A second filter collects unique instances of keywords in NBMD 1 and NBMD 2. With these, summaries of deck construction material, and deck wearing surface are formed. The summary is shown below.

NBMD 2	NBMD 3	No of Repairs
Concrete	(bare)	49
Concrete	Asphalt overlay	10
Concrete	Concrete overlay	9
Timber		58
Timber	Asphalt overlay	1

3. A similar query and summary are prepared from Colorado DOT data. Open the CU-Colorado database in MS Access. Under Queries find Ex 8B Deck Repairs. The query collects events for deck repairs, and reports the element number and NBMD keywords for the element. The query yields 9300 records.
4. Export the query to Excel. A data filter is used to collect unique events. A second filter collects unique instances of keywords in NBMD 1 and NBMD 2. With these, summaries of deck construction material, and deck wearing surface are formed. The summary is shown below.

NBMD 2	NBMD 3	No of Repairs
Concrete	(bare)	308
Concrete	Asphalt overlay	865
Timber		2

Timber	Asphalt overlay	158
--------	-----------------	-----

5. A similar query and summary are prepared from Ohio DOT data. Open the CU-Ohio database in MS Access. Under Queries find Ex 8B Deck Repairs. The query collects events for deck repairs, and reports the element number and NBMD keywords for the element. The query yields 517 records
6. Export the query to Excel. A data filter is used to collect unique events. A second filter collects unique instances of keywords in NBMD 1 and NBMD 2. With these, summaries of deck construction material, and deck wearing surface are formed. The summary is shown below.

NBMD 2	NBMD 3	No of Repairs
Concrete	(bare)	218
Concrete	Asphalt overlay	65
Concrete	Latex-modified overlay	210
Timber	Asphalt overlay	1

Ex 8C Deck Repairs, Elements, and Products

Ohio DOT data include deck and pavement repair products. We make a list of deck repairs, collect element types and repair products.

1. Open the CU-Ohio database in MS Access. Under Queries, find Ex 8C Deck Repairs, Elements, Products. This query collects deck repairs and named products. The query yields 276 records.
2. Export the query to Excel. In Excel, we concatenate the NBMD keywords in column K. This will allow identification and counting of unique combinations of deck types and repair products.
3. Next a data filter is applied to collect the unique combinations of deck types and products. COUNTIF() functions get the number of occurrences of each combination.

Product	Number of Events	
	Deck Type	
	Concrete (bare)	Concrete, Latex overlay
Rapid Set	65	40
Emaco Set-45	18	19
Flexset	18	18
Thoroc 1060	10	17
Quikrete FastSet	15	14

Example 9 - Actions versus Condition Rating

Bridge condition ratings are preserved for all bridges in the same year as their maintenance event. This example examines repairs to deck, superstructure and substructure. All events and condition ratings are from 2005.

1. Open the CU-Alabama database in MS Access. Under Queries, find Ex 9A Condition. The query collects all events for one component, and condition ratings for the bridge at the time of the maintenance action. In the Design view, notice that the component_id is set to 1 (Deck), and that the dkrating is reported. The query yields 152 records.
2. Export the query to Excel. Here, COUNTIF() functions are used to collect the number of repair actions at each NBI condition rating. The condition ratings for repaired decks, superstructures and substructures in Alabama are shown below. Complete work is shown in Example 9.xls

Condition Rating	Number of Repairs		
	Deck	Superstructure	Substructure
9	3	3	0
8	4	69	7
7	31	60	90
6	34	122	89
5	35	11	59
4	22	1	35
3	13	0	6
2	0	0	4
1	0	0	0
0	2	1	1
N	7	0	3

3. A similar query is made for Colorado DOT data. Open the CU-Colorado database in MS Access. Under Queries, find query Ex 9A, for deck repairs, superstructure repairs, and substructure repairs. Note in these queries include a restriction of records to fiscal year 2005. Only Deck repairs are found in Colorado data for 2005.

Condition Rating	Number of Repairs
	Deck
9	0
8	35
7	255
6	252
5	238
4	72
3	44

	Number of Repairs
Condition Rating	Deck
2	3
1	0
0	0
N	16

4. A similar query is made for Ohio DOT data. Open the CU-Ohio database in MS Access. Under Queries, find Ex 9A for deck repairs, superstructure repairs and substructure repairs. Ohio results are summarized below.

NBI Rating	Number of Repairs		
	Deck	Superstructure	Substructure
9	7	2	5
8	17	18	5
7	84	20	15
6	147	5	27
5	63	2	14
4	53	1	3
3	0	0	0
2	1	0	0
1	0	0	0
0	0	0	0
N	2	0	1

Example 10 - Actions versus Structure Properties

Ex 10A - Age of Structures at Maintenance

Maintenance in various operations may be a function of structure age. Here we collect number of maintenance operations for bridges up to 10 years age, 11 to 20 years age, etc. All components are combined. A further (fancier) summary would break these counts down by components as well.

We begin with Alabama maintenance data.

1. Open the CU-Alabama database in MS Access. Under Queries find the query Ex 10A Structure Age. The query collects maintenance action guides, maintenance operations, and year of construction of the bridge. In the first application of the query, construction year must be 1995 or more recent. Later queries collect construction years in ranges, 1985 – 1994, 1975 – 1984, etc.

- Export the query to Excel. A data filter is used to collect unique event_action_guids. A second data filter collects unique maintenance operations. COUNTIF() functions count the number of occurrences of each maintenance operation.
- The Ex 10A query is used repetitively to collect maintenance operations in several 10-year intervals. The Alabama results are summarized below.

	Year of Construction						
	1944-	45-54	55-64	65-74	75-84	85 - 94	1995+
Maintenance	389	105	229	398	399	176	77
Clean / Clear	256	329	391	401	271	457	338
Reset	2	0	5	18	17	10	9
Coat / Paint	68	33	28	83	31	28	1
Repair	223	176	325	317	146	186	168
non Bridge	46	168	190	73	65	150	205
non Maintenance	2	5	8	8	1	2	1

- Similar queries and summaries are prepared from Colorado data. The query Ex 10A is found in the CU-Colorado database. Colorado results are:

	Year of Construction						
	1944-	45 - 54	55 - 64	65 - 74	75 - 84	85 - 94	1995+
Maintenance	2370	1066	2318	2576	1259	1896	262
Clean / Clear	1396	621	2516	2240	1193	1611	317
Reset	5	1	10	1	1	9	1
Coat / Paint	286	154	357	223	148	414	57
Repair	724	304	761	1050	252	366	78
Replace	1	0	2	4	0	3	0
non Bridge	3	0	10	1	0	7	0
non Maintenance	26	18	26	33	9	38	5

- Similar queries and summary are prepared for Ohio data. The query Ex 10A is found in the CU-Ohio database. Ohio results are:

	Year of Construction						
	1944-	45 - 54	55 - 64	65 - 74	75 - 84	85 - 94	1995+
Clean / Clear	68	97	524	596	126	190	110
Coat / Paint	5	1	4	5	3	5	31
Repair	27	13	274	364	49	47	21
Modify	3	3	9	22	0	1	1

Ex 10B Maintenance & ADT

In this example the ADT at bridges are compared to the number and type of maintenance operations.

- Open the CU-Alabama database in MS Access. Under Queries find Ex 10B ADT, Maintenance. This query collects event_action_guids, maintenance operations, and ADTtotals. The Alabama data yield 9938 records.

Modify	0	4	5	5	4	4	2	0
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Ex 10C Decks - Repaired Area

In this example, data on accomplishment in deck repairs is compared to deck area for each bridge, and the percentages of repaired area are reported.

1. Open the CU-Alabama database in MS Access. Under Queries, find Ex 10C Deck Repair Extent. This query collects structure numbers, completion dates, DOT quantity accomplished, and bridge deck area for bridges having action 1.04 Deck Repair.
2. Export the query to Excel, and open the file. Some bridges have deck repairs on separate by nearby dates. In column I, an IF() construction check for matching structure numbers and proximate dates. Column J combines accomplishment indicated by column I. Column K reports the separate events after combinations. Alabama's results are shown below. The work is found in Example 10.xls

Repaired decks	102
Min Area, %	0.001
Max Area, %	17.6
Average Area, %	2.1

3. A similar query is found in the CU-Colorado database. Export to Excel, and combination of events is performed. Colorado results indicate that deck repairs usually affect more than 100 percent of the deck area. For deck repairs in which labor is reported on multiple 'green sheets', accomplishment may be repeated on each sheet. But Colorado data are not consistent in this, so correction of accomplishment values is not possible. Complete work is found in Example 10.xls
4. A similar query is found in the CU-Ohio database. Export to Excel, and combination of events is performed. Ohio results are shown below. Complete work is found in Example 10.xls

Repaired decks	299
Min Area, %	0.000
Max Area %	18.9
Average Area, %	1.2

Table A4- 1 NBMD Demonstration materials

Demonstration feature	Download file
Example files	Example.zip
Access databases for Examples	Uncompressed MS Access files: CU-Alabama.mdb CU-Colorado.mdb CU-Ohio.mdb
Excel workbooks for Examples	A set of ten uncompressed MS Excel files
XML Data files	Zipped XML files
NBMD web portal	Zipped file available for entire web portal and sample data.
NBMD Organizer	Zipped file available for Organizer and user's manual.

Table A4- 2 NBMD Examples

Example 1	Listing and count of maintenance actions. A - Basic list and count of NBMD actions B - List and count using DOT titles
Example 2	Uses of the NBMD standard catalog of maintenance actions A - Summary of actions by bridge component B - Summary of actions by maintenance operation
Example 3	Maintenance events, dates and execution. A - List and count of events, their range of dates, and their mode of execution B - List and count of structures with maintenance actions.
Example 4	Maintenance event accomplishments and costs. A - List of maintenance events and accomplishment B - Cost of maintenance actions. C - Unit cost of maintenance actions.
Example 5	Resources for DOT maintenance events. A - Basic list of resources used B - Use of specific repair products C - Use of large equipment D - Use and type of vehicles
Example 6	Resources in contract maintenance A - Listing in DOT units B - Listing in NBMD descriptors
Example 7	Recurrent maintenance actions. Intervals for maintenance. A - List of recurrent events B - Interval for bridge cleaning C - Interval for deck repair D - Interval for bridge painting
Example 8	Maintenance events and bridge elements. A - Bridge elements. B - Deck repairs versus deck type C - Deck repairs, deck type and repair products
Example 9	Maintenance actions and bridge conditions A - Condition ratings versus repairs
Example 10	Maintenance actions versus bridge properties A - Maintenance operations versus year of construction B - Maintenance operations versus ADT C - Extent of deck repairs

