General Overview of Highway Network
The road network excluding urban roads is about 385,000 km in length.
**DG TURKISH HIGHWAYS (31.12.2017)**

**Divided roads**
- 26.017 km (% 38.5)

**Surface type (67.620 km)**
- BHM
  - 13 748 km (% 20.4)
  - 9 811 km (% 14.6)
- ST
  - 16 206 km (% 24.0)
  - 24 522 km (% 36.1)
- OTHER
  - 3 333 km (% 5.0)
- Double C.

**Road network (67.620 km)**
- Motorway
  - 33 897 km (% 50.1)
- State road
  - 31 066 km (% 45.9)
- Provincial road
  - 2 657 km (% 3.9)

**Number of Bridges**
- Number 8,441
- Km 556

**Number of Tunnels**
- Number 341
- Km 433

**127,997 Billion vehicle x km**

**75-80 Billion $ (Asset Value of Highways)**
(This value is higher than the GDP of 130 countries)
NATIONAL HIGHWAY NETWORK (67.620 km)

- Turkish Road Network under General Directorate of Turkish Highways’ responsibility.
DOMESTIC PASSENGER & FREIGHT TRANSPORT

**PASSENGER TRANSPORT**

- Railways: 1,0%
- Airlines: 9,4%
- Highways: 89,0%

**FREIGHT TRANSPORT**

- Railways: 4,2%
- Sea Route: 0,6%
- Highways: 90,2%

---

*Passenger Transport*  
Highways: 89 %

*Freight Transport*  
Highways: 90,2 %
TRAFFIC VOLUME
Million Km (2003)

52,349
Total Vehicle-Km

TRAFFIC VOLUME
Million Km (2017)

127,997
Total Vehicle-Km
144 % increase in vehicle-km
PERCENTAGE OF GDP USED FOR HIGHWAY INFRASTRUCTURE INVESTMENT

INVESTMENT 2017 Fixed Price (Billion $)  
Perc. Of GDP (%)
THE BREAKDOWN OF GDH’s TOTAL BUDGET

In 2017, Total budget of Turkish Highway amounted to 6,05 Billion US $.

Out of total budget,

- 60% on state and provincial road construction & upgrading
- 4% on motorway rehabilitation and operation,
- 7% on routine maintenance,
- 4% on routine road safety works,
- 6% on personnel expenditure,
- 17% on expropriation
- the remaining 2% on other current expenditures.

KGM's 2017 total expenditures is about 0.71% of Gross Domestic Product (GDP)
Road Maintenance Works
REGIONAL DIVISIONS OF GDH

- 18 Regional Divisions
- 118 Subdivisions
- 288 Maintenance Houses

- 25 Motorway Maintenance and Operation Offices
- 2 Equipment and Supply Directories
ROAD MAINTENANCE WORKS

ROUTINE MAINTENANCE
Removing surface deformation on asphalt roads, corrugation and rutting on surface of stabilized road, repairing structures, such as, bridge, culvert, structures, clearing drainage systems, ditch and culverts as well as vegetation, etc.

SNOW AND ICE REMOVAL
Snow and ice removal has a considerable place in maintenance works. Removing snow and ice on roads during winter and providing a secure and smooth traffic flow are among these works.

EMERGENCY REPAIR
Maintenance in case of emergency and disasters

PERIODIC MAINTENANCE
To preserve the structural integrity of the road, or to enable the road to carry increased axle loadings.
ROUTINE MAINTENANCE

Patching

Surface Treatment

Ditch Cleaning

Maintenance of traffic signs and engineering structures

Verge Cutting
<table>
<thead>
<tr>
<th>Routine Maintenance Works in 2017</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance Works carried out by</td>
<td>406 (118 Subdivision, 288 Maintenance Houses)</td>
</tr>
<tr>
<td>Maintenance Crew</td>
<td>9.392</td>
</tr>
<tr>
<td>Machinery &amp; Equipment</td>
<td>7.703</td>
</tr>
<tr>
<td>Aggregates used for asphalt patching</td>
<td>1.528.318 m³</td>
</tr>
<tr>
<td>Bitumen used for asphalt patching</td>
<td>169.670 Tonnes</td>
</tr>
<tr>
<td>Number of Planted Seedling (yearly average)</td>
<td>1.681.481</td>
</tr>
<tr>
<td>Number of GRP (Glass Reinforced Plastic) plates</td>
<td>969.419</td>
</tr>
</tbody>
</table>
## Snow & Ice Removal Works in 2017-2018 Winter

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network In Operation</td>
<td>54,514 Km</td>
</tr>
<tr>
<td>Network In Operation (If Possible)</td>
<td>8,904 Km</td>
</tr>
<tr>
<td>Maintenance Works carried out by</td>
<td>412 (118 Subdivision, 270 Maint. Houses, 24 Motorway Maint. Houses)</td>
</tr>
<tr>
<td>Maintenance Crew</td>
<td>11,288</td>
</tr>
<tr>
<td>Machinery &amp; Equipment</td>
<td>7,994</td>
</tr>
<tr>
<td>Aggregates used</td>
<td>383,637 m³</td>
</tr>
<tr>
<td>Salt Used</td>
<td>481,340 Tonnes</td>
</tr>
<tr>
<td>Length of snow fence</td>
<td>613 Km</td>
</tr>
<tr>
<td>Chemicals used for anti icing</td>
<td>562 Ton</td>
</tr>
</tbody>
</table>
SNOW & ICE REMOVAL WORKS
MAINTENANCE IN CASE OF EMERGENCY AND DISASTERS
HIGHPWAY INFORMATION & PUBLIC RELATIONS

7/24 HIGHWAY INFO LINE

Public Service Announcements

Educational Publications

Online Surveys

DRIVING IN WINTER
Be Prepared, Be Safe

KGM SERVICE LINE
ALO 159
0-312-415 88 00

KGM KAMU SPOTU
PERIODIC MAINTENANCE
## DEFINITIONS OF ROAD INVESTMENTS

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Resurfacing</strong></td>
<td>Placing a new surface of an existing road in order to service in good condition, to increase skid resistance, to seal by aiming to preserve road from negative atmospheric conditions, to increase driver comfort, to extend pavement life, etc. The aim is not to increase the bearing capacity of pavement however to extend lifetime by preserving the road from bad weather conditions.</td>
</tr>
<tr>
<td><strong>Resurfacing by Strengthening</strong></td>
<td>Renewing of road surface with reinstalling bituminous layer either by directly or by removing determined depth of pavement by milling in order to increase bearing capacity of road and to eliminate road defects.</td>
</tr>
<tr>
<td><strong>Pavement Replacement</strong></td>
<td>Renewing of the pavement either by removing the total thickness of all paving layers, existing asphalt layers from an existing roadway or not, and providing a new paved surface without changing capacity or geometry of the road, i.e. without changing subgrade.</td>
</tr>
<tr>
<td><strong>Reconditioning</strong></td>
<td>Reconditioning includes improvement of grades, curves, intersections or sight distances in order to improve traffic safety or changing the subgrade to widen shoulders or to correct structural problems in addition to resurfacing or pavement replacement.</td>
</tr>
<tr>
<td><strong>Reconstruction</strong></td>
<td>Total rebuilding of both pavement and subgrade of an existing highway. Work which either changes the location of the existing subgrade shoulder points or removes all of the existing pavement and base course for at least 50% of the length of the project. In other words it is the rebuilding of an existing roads’ pavement and subgrade to correct road geometry, to increase road safety, to ease maintenance works and to increase preservation.</td>
</tr>
<tr>
<td><strong>Expansion (Capacity Improvement)</strong></td>
<td>Same as reconstruction and also involves the construction of additional through travel lanes beyond the work associated with reconstruction.</td>
</tr>
<tr>
<td><strong>New Construction</strong></td>
<td>There is not any existing road for this kind of project. It is totally new building of a road with all parts; subgrade, pavement, structures, etc.</td>
</tr>
</tbody>
</table>
Asset Management System
Implementation Units

- Department of Maintenance
- Department of R&D
- Department of Structures
- Department of Traffic Safety

Standards Setting

- Department of Maintenance
- Department of R&D
- Department of Structures
- Department of Traffic Safety

Traffic & Transportation Statistics

- Department of Traffic Safety

Budget

- Department of Strategy Development

Technological Background

- Department of Information Technologies
PAVEMENT ASSET MANAGEMENT SYSTEM FLOW CHART

Database Creation
- Inventory data
- Structural condition data
- Functional condition data
- Visual distress evaluations

Pavement Current Condition Analysis
- Structural condition analysis
- Functional condition analysis

Pavement Condition Modeling
- IRI modeling
- FWD modeling
- Skid Resistance modeling
- Surface distress modeling

Determination of Maintenance – Repair Alternatives

Benefit / Cost Analyses and Feasibility Analyses

Optimum Budget Management
ASSET MANAGEMENT SYSTEMS

Data Collection
- Inventory
- Riding Quality
- Surface Distress
- Pavement Strength
- Traffic flow/loading
- Bridges/Furniture

Database
- DBMS (RIMS)

Decision Support
- Analysis Models
  e.g. HDM-4

Management Information
- Standard & Custom Reports
PAVEMENT ASSET MANAGEMENT SYSTEM

- ROAD INVENTORY
- PAVEMENT INVENTORY
- PAVEMENT PERFORMANCE
- TRAFFIC COUNTS
- CLIMATE
- COST

DATABASE

ANALYSES
PAVEMENT ASSET MANAGEMENT SYSTEM
ROAD PERFORMANCE TESTS

SKID RESISTANCE TESTER
- 2 dual Transducer
- Wet and dry measurement
- Pavement temperature
- DGPS
- 1-5 s in Wheel breaking

FALLING WEIGHT DEFLECTOMETER

Service Levels and KPIs for Maintenance Works
PAVEMENT ASSET MANAGEMENT SYSTEM

IRI ANALYSES

IRI data collected by profilometer measuring device are classified according to the criteria established by General Directorate of Highways.

<table>
<thead>
<tr>
<th>Roughness Value (IRI - m/km)</th>
<th>Roughness Classification</th>
<th>Priority Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Absolute Perfect</td>
<td>6</td>
</tr>
<tr>
<td>0 - 0.71</td>
<td>Very Good</td>
<td>5</td>
</tr>
<tr>
<td>0.72 - 1.11</td>
<td>Good</td>
<td>4</td>
</tr>
<tr>
<td>1.12 - 1.58</td>
<td>Average - Good</td>
<td>3</td>
</tr>
<tr>
<td>1.59 - 1.80</td>
<td>Average</td>
<td>2</td>
</tr>
<tr>
<td>1.81 - 2.13</td>
<td>Bad</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 2.13</td>
<td>Very Bad</td>
<td></td>
</tr>
</tbody>
</table>
RUTTING ANALYSES

Rutting classification used in General Directorate of Highways.

<table>
<thead>
<tr>
<th>Rutting Value (TIO - mm)</th>
<th>Rutting Classification</th>
<th>Priority Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 5</td>
<td>Good</td>
<td>4</td>
</tr>
<tr>
<td>5 - 15</td>
<td>Average</td>
<td>3</td>
</tr>
<tr>
<td>15 -30</td>
<td>Bad</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 30</td>
<td>Very Bad</td>
<td>1</td>
</tr>
</tbody>
</table>

SURFACE DISTRESS ANALYSES

Surface and inventory images shot in every 20 m with high-resolution cameras of Profilometer are evaluated one by one.
PAVEMENT MANAGEMENT SYSTEM

Road Performance Tests

Structural Condition Tests

• Deflection Tests (FWD)
• PCI via Visual Inspection

Functional Condition Tests

• Roughness (IRI)
• Rutting (TIO)
• Skid resistance
• On-board sound intensity
## Pavement Asset Management System

### Pavement Pointing Table

<table>
<thead>
<tr>
<th>Road Name:</th>
<th>Personal Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date:</td>
<td>Name - Surname:</td>
</tr>
<tr>
<td>Time:</td>
<td>Position:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Starting KM:</th>
<th>End KM:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Distress Type</th>
<th>Points</th>
<th>LOW (0.4)</th>
<th>MEDIUM (0.7)</th>
<th>HIGH (1)</th>
<th>VERY LOW (0.6)</th>
<th>LOW (0.7)</th>
<th>MEDIUM (0.8)</th>
<th>HIGH (0.9)</th>
<th>VERY HIGH (1)</th>
<th>Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alligator Crack</td>
<td>10</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.8</td>
</tr>
<tr>
<td>Edge Cracking</td>
<td>5</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.8</td>
</tr>
<tr>
<td>Transverse Crack</td>
<td>10</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.2</td>
</tr>
<tr>
<td>Longitudinal Crack</td>
<td>15</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.8</td>
</tr>
<tr>
<td>Block Cracking</td>
<td>10</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Rutting</td>
<td>10</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Waves</td>
<td>5</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.45</td>
</tr>
<tr>
<td>Local Settlement</td>
<td>5</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.45</td>
</tr>
<tr>
<td>Patch</td>
<td>5</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.2</td>
</tr>
<tr>
<td>Pothole</td>
<td>10</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.4</td>
</tr>
<tr>
<td>Bleeding</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Stripping</td>
<td>10</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8</td>
</tr>
</tbody>
</table>

Total Damage = 53.1
Total Structural Damage = 23.6
100 - Total Structural Damage = PSP = 75.4
100 - Total Damage = PP = 48.9
Pavement Condition = Low

### Roughness Value (IRI - m/km)

<table>
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</tr>
<tr>
<td>&gt; 2.13</td>
<td>Very Bad</td>
<td>1</td>
</tr>
</tbody>
</table>

### Rutting Value (TL0 - mm)

<table>
<thead>
<tr>
<th>Rutting Value (TL0 - mm)</th>
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</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>5 - 15</td>
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</tr>
<tr>
<td>15 - 30</td>
<td>Bad</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 30</td>
<td>Very Bad</td>
<td>1</td>
</tr>
</tbody>
</table>

---

Service Levels and KPIs for Maintenance Works
PAVEMENT ASSET MANAGEMENT SYSTEM
DECISION TREE FOR ASPHALT CONCRETE ROADS
PAVEMENT ASSET MANAGEMENT SYSTEM

**Maintenance Strategies based on PCI (%):**

- PCI 100 - 90: Very good, No action
- PCI 90 - 75: Good, Routine maintenance
- PCI 75 - 65: Fair, Maintenance/Overlay
- PCI 65 - 40: Poor, Thick Overlay
- PCI < 40: Very poor, Reconstruction
PAVEMENT ASSET MANAGEMENT SYSTEM

PMS provides a tool to select the right road for the right treatment at the right time and a road network operation with high performance pavement can be made with minimum cost.
Image-Based Information Management System
The purpose of the project is:

- to establish an image-based information management system with fast, reliable, efficient, highly accurate dynamic data acquisition,
- to meet the needs of 67,620 km road network.
WHY DO WE NEED THIS SYSTEM?

Road inventory data have been collected manually using GNSS and tablet PC since 2007.

Difficulties

- Costly and time consuming
- Vehicles must stop during data collection and production.
- Laser meters or classical hand meters are used
- If images are needed vehicles should be stopped
Image-Based Information Management System

In the scope of Pilot Project

- Data collected,
- Suitable technologies were determined
- Similar applications and technologies observed.
  - State of Utah ‘Roadway imaging/Inventory Program,
  - Wien Mobile Mapping System,
  - Switzerland The Federal Roads Office (FEDRO) infra3d system etc..
Image-Based Information Management System

New Project; lidar, image based technologies, automated data collection.

Pilot Project was made;

- Mobil Lidar Technology and Stereo Imaging Technology,
- 1000 km sample road section within Ankara provincial borders.
The existing situation was analyzed

Data production was carried out by collecting different technological systems and road inventory information.

Tender for the contract on June 2018 (technical provisions completed)
CONCLUSION

• It is important that road maintenance works are made on time to avoid negative effects on economic life of infrastructure.

• Proper road maintenance contributes to reliable transport at reduced cost, as there is a direct link between road condition and vehicle operating costs and travel time.

• Establishing and developing Road maintenance/Pavement management systems are crucial in order to use the limited budget more efficiently.

• Combining all asset management systems is important to give better decisions for the investments considering all of the assets of our road network.
Thank you for your attention

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Director of Strategic Planning Division
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