Research and Development on the Planning Simulator for the Maintenance System Optimization Test-Car

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Development of New Rolling Stock

209 series (introduced early 1993)
Reducing total life cycle cost and saving energy consumption

Bolsterless bogie
Reduction of expendable parts and simplification of the structure

Traction inverter and APS (Auxiliary Power Supply)
Reduction of wear parts and relay contact by introducing the electronic devices

Multi-function monitoring devices
Reduction of the maintenance effort by monitoring condition of a train

These new technologies have been designed for the introduction of the "new maintenance system" (Common Scheme for Rolling Stock) in the future.
Common Scheme Platform for Rolling Stock Maintenance

Conventional vs. Common Scheme for Rolling Stock (JR East)

We introduced the “Common Scheme for Rolling Stock” (CSRS) and implement CSRS to the new train of 209 series on April 1, 2002.

Just manufactured or overhauled

Conventional

[Every 90 days] [Every 4 years or every 0.6 million km] [Every 8 years]

Common Scheme for Rolling Stock

[Every 90 days and every 1 year] [0.6 million km] [1.2 million km] [2.4 million km]

(Air conditioning · Pantograph etc) (Bogie · Main Morter) (Car body · Electronics)

Function check
Replacement of consumables

Main Device

Maintained at Rolling Stock Center

Overhaul

Maintained at General Rolling Stock Center

Maintenance term can be extended by optimizing maintenance period for each device
About Katsuta Rolling Stock Center

Location and management section

Mito Brench Office, JR East
White lines are
The Joban, Mito and Suigun Line

Koriyama General Rolling Stock Center
Katsuta Rolling Stock Center
Tokyo station

JR Hokkaido
JR East
JR Central
JR West
JR Shikoku
JR Kyushu
### About Katsuta Rolling Stock Center

**Trains of Katsuta Rolling Stock Center**

<table>
<thead>
<tr>
<th>Local train</th>
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</thead>
<tbody>
<tr>
<td><img src="image1.jpg" alt="Local train Image 1" /></td>
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<tr>
<td><img src="image2.jpg" alt="Local train Image 2" /></td>
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<tr>
<td><img src="image3.jpg" alt="Local train Image 3" /></td>
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<table>
<thead>
<tr>
<th>Limited express train</th>
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<tr>
<td><img src="image4.jpg" alt="Limited express train Image 1" /></td>
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<td><img src="image5.jpg" alt="Limited express train Image 2" /></td>
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<td><img src="image6.jpg" alt="Limited express train Image 3" /></td>
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<table>
<thead>
<tr>
<th>Inspection train</th>
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<td><img src="image8.jpg" alt="Inspection train Image 2" /></td>
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<table>
<thead>
<tr>
<th>Special train</th>
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<tr>
<td><img src="image9.jpg" alt="Special train Image 1" /></td>
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<tr>
<td><img src="image10.jpg" alt="Special train Image 2" /></td>
</tr>
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</table>

We are in charge of operation, inspection, and repair of more than 650 cars on the Joban and Mito Lines.

**Mix of old and new nine car models**
Optimizing the Maintenance System

New approach to the cost reduction vs. regulations for safety

Just manufactured or overhauled

Common Scheme for Rolling Stock

[Every 90 days and every 1 year]  [0.6 million km]  [1.2 million km]  [2.4 million km]
(Air conditioning • Pantograph etc) (Bogie • Main Morter) (Car body • Electronics)

Function check
Replacement of consumables

Maintained at Rolling Stock Center

Main Device

Maintained at General Rolling Stock Center

Overhaul

We manage the train operation and set up inspections in accordance with 90 day/1 year

Prevention of equipment failure
Compliance with regulations

We coordinate the timing of our inspections as close as that in regulations

Cost reduction
Optimizing the Maintenance System

- Maintenance at Koriyama
  - Periodic inspection
  - Periodic replacement of equipment
  - Periodic repair of equipment
  - Repair of defective equipment

- Extension of maintenance cycle
  - Realization of optimal maintenance cycle
  - Cost reduction

※Koriyama General Rolling Stock Center conducts maintenance every 0.6 million km
Optimizing the Maintenance System

Test-car at Katsuta Rolling Stock Center

Maintenance at Koriyama

Required maintenance per regulation

Mileage extended beyond regulations

Extraordinary maintenance at Koriyama

Mileage

Tested equipment

- Operation check
- Visual inspection

Periodic inspection

Periodic replacement of equipment

Periodic repair of equipment

Repair of defective equipment

Verification

Periodic replacement of equipment

Verification

Periodic repair of equipment

Test-car

E653

E531

※Koriyama General Rolling Stock Center conducts maintenance every 0.6 million km
### Operation of the Test-car at the Katsuta Rolling Stock Center

#### Maintenance at Koriyama

Required maintenance per regulation

- Mileage extended beyond regulations

#### Extraordinary maintenance at Koriyama

Mileage

---

**Car model** | **Periodic maintenance** | **Test mileage (extension of distance)**
--- | --- | ---
**E653** | Within 0.6 million km | Within 0.7, 0.8, 0.85, and 0.9 million km
| Within 1.2 million km | Within 1.6, 1.7 million km
| Within 2.4 million km | Within 3.2, 3.3 million km

---

*Koriyama General Rolling Stock Center conducts maintenance every 0.6 million km*
## Optimizing the Maintenance System

### Problem of the present system (Train Management System)

<table>
<thead>
<tr>
<th>Work</th>
<th>Periodic maintenance</th>
<th>Extraordinary maintenance</th>
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<tbody>
<tr>
<td>General car</td>
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<tr>
<td>Planning</td>
<td>○</td>
<td>Not supported</td>
</tr>
<tr>
<td>Confirmation of overdue</td>
<td>○</td>
<td>Not supported</td>
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<tr>
<td>maintenance</td>
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<td>Test-car</td>
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<tr>
<td>Planning</td>
<td>○</td>
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<tr>
<td>Confirmation of overdue</td>
<td>○</td>
<td>Three patterns only</td>
</tr>
<tr>
<td>maintenance</td>
<td></td>
<td>0.9, 1.7, 3.3million km</td>
</tr>
</tbody>
</table>
The principle of operation

Requirements of the simulation

Extraordinary maintenance (Test-car)

The target distance

Achievement rate (%)

Target date

Remaining operational mileage

Mileage

The results of the simulation

Achievement rate (%)

Target date

Remaining operational mileage

yy/mm/dd

Calculation by the System

yy/mm/dd
Main menu
(Buttons to start the various functions with manuals on the screen)

Planning and management for the usual maintenance and the Test-car maintenance

Any simulation of train operation (Planning of parts replacement and research)

Setting target trains and conditions of simulation

Maintenance function

Manual to use the simulator
### Simulation of maintenance period (Simulate maintenance period and deadline)

<table>
<thead>
<tr>
<th>No</th>
<th>編成番号</th>
<th>目標走行距離</th>
<th>現状走行距離</th>
<th>回帰日数</th>
<th>休車日数</th>
<th>達成率(%)</th>
<th>達成率(%)</th>
<th>2015/10/25</th>
<th>2013/4/1</th>
<th>2014/6/17</th>
<th>2015/9/9</th>
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<td>99.9</td>
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</table>

**Achievement rate to the target**

- **Any date**
- **Mileage in operation up to the target**
- **Any number of days in use**
- **Any number of unused days**

**Show the results of simulation**

**Input the conditions of simulation**

**Achievement rate under the given condition**

- **Date in under the given condition**
- **Remaining operation mileage under the given condition**
- **Number of days to use under the given condition**
- **Total unused days under the given condition**
### Simulation of maintenance period
(Simulate maintenance period and deadline)

<table>
<thead>
<tr>
<th>No</th>
<th>編番</th>
<th>目標走行距離</th>
<th>現状走行距離</th>
<th>回帰日数</th>
<th>休車日数</th>
<th>達成率(%)</th>
<th>達成対象年月日</th>
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<th>回帰日数</th>
<th>休車日数</th>
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<td>2015/10/25</td>
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<td>2013/10/14</td>
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<td>99.9%</td>
<td>2015/9/9</td>
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<td></td>
<td>2015/9/9</td>
<td>2349</td>
<td>23</td>
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</tr>
</tbody>
</table>

**Input the conditions of simulation**

**Show the results of simulation**

**ex）Simulate a targeted 1.2 million km in Achievement rate**

- **Achievement rate to the target**: 90%
- **1,080,000 km**
- **Date in under the given condition**: 2016.6.14
- **Remaining operation mileage under the given condition**: 120,000 km
- **Number of days to use under the given condition**: 1,646 day
- **Total unused days under the given condition**: 0 day
### Simulation of maintenance period (Simulate maintenance period and deadline)

<table>
<thead>
<tr>
<th>No.</th>
<th>編番</th>
<th>目標走行距離</th>
<th>現状走行距離</th>
<th>回帰日数</th>
<th>休車日数</th>
<th>達成率(%)</th>
<th>達成年月日</th>
<th>残り走行距離</th>
<th>回帰日数</th>
<th>休車日数</th>
<th>達成年月日</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>K458</td>
<td>800,000.0</td>
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<td>519</td>
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<td>99.0</td>
<td>2015/10/25</td>
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<td>1,400.0</td>
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<td>0</td>
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<td>2</td>
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<td>2,253,309.2</td>
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<td>3</td>
<td>91.2%</td>
<td>2013/10/25</td>
<td>2,000,000</td>
<td>1,400.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
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<td>1,230,558.0</td>
<td>259</td>
<td>2</td>
<td>99.8%</td>
<td>2013/10/14</td>
<td>2,000,000</td>
<td>1,400.0</td>
<td>0</td>
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</tr>
<tr>
<td>4</td>
<td>K468</td>
<td>600,000.0</td>
<td>248,713.8</td>
<td>578</td>
<td>19</td>
<td>99.8%</td>
<td>2014/6/17</td>
<td>1,100.5</td>
<td>1,400.0</td>
<td>19</td>
<td>0</td>
</tr>
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<td>62,886.7</td>
<td>96</td>
<td>0</td>
<td>99.9%</td>
<td>2016/6/14</td>
<td>1,200,000</td>
<td>1,164.0</td>
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<td>36,076.8</td>
<td>47</td>
<td>0</td>
<td>55.2%</td>
<td>2013/4/1</td>
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<td>1,200,000.0</td>
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<td>1,500.0</td>
<td>2,348.0</td>
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</tr>
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</table>

#### Example

Simulate a targeted 1.7 million km while the Remaining operation mileage is 2,000 km.

- **Achievement rate to the target**: 99.9%
- **Date in under the given condition**: 2013.10.14
- **Remaining operation mileage under the given condition**: 2,000 km
- **Number of days to use under the given condition**: 2,398 days
- **Total unused days under the given condition**: 2 days
### The Developed System (Katsuden.SIM)

#### Simulation of the train operation (Simulation for any mileage)

<table>
<thead>
<tr>
<th>No.</th>
<th>編成番号</th>
<th>目標走行距離</th>
<th>新製後走行キロ</th>
<th>起算日からの走行キロ</th>
<th>起算日</th>
<th>新製後キロ</th>
<th>達成率(%)</th>
<th>目標年月日</th>
<th>達成率(%)</th>
<th>達成率(%)</th>
<th>余分走行キロ</th>
<th>残り走行キロ</th>
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<td></td>
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</tr>
</tbody>
</table>

- **Start date of simulation**: The date when the simulation begins.
- **Mileage at the time of the start**: The distance traveled at the start of the simulation.
- **Achievement rate to the target**: The percentage of the target distance achieved.
- **Any date**: Any specific date for reference.
- **Mileage in operation up to the target**: The distance traveled up to the target.
- **Achievement rate under the given condition**: The percentage of the distance achieved under specific conditions.
- **Date under the given condition**: The date under specific conditions.
- **Remaining operation mileage under the given condition**: The remaining distance to be traveled under specific conditions.
System maintenance

We can manipulate the maintenance system without the knowledge of the problem.
The Developed System (Katsuden.SIM)

Complement TMS

- To plan maintenance period
- To predict the maintenance expired period
- To plan equipment replacement

Simulation conditions

- Mileage of regulations
- Any mileage
- Mileage of Test-car

Result of Simulation

- Achievement rate (%)
- Target date
- Remaining operational mileage

Simulation
The Developed System (Katsuden.SIM)

Automated prediction of maintenance term expiration

Enter the daily mileage performance

Confirmation of overdue maintenance

Mileage after maintenance
The number of in operation days after maintenance

TMS
Applied to all trains

Katsuden.SIM

Extraction of data

The most accurate data

The spreadsheet of mileage after maintenance

Prior work
Predicted by manual calculation

Plan the maintenance schedule

Predict the expiration period of maintenance
System configuration

Shared server (in-house)
- Information sharing
- Correspondence of sudden inquiry
- For examination, confirmation

Simulate
- Extraordinary maintenance
- Periodic maintenance
- Mileage in any date

TMS

Operation on the server

[Independently operated by bringing up the system]

Simulate
- Extraordinary maintenance
- Periodic maintenance
- Mileage in any date

for the confirmation in a meeting
for the decision during the meeting
### Effect of the system introduction

#### Work associated with the Test-car (year) ; 54% (7.5h) reduction

<table>
<thead>
<tr>
<th>Work</th>
<th>Conventional (Prior work)</th>
<th>Katsuden.SIM</th>
<th>Reduction rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraordinary maintenance planning of Test-car</td>
<td>2 h</td>
<td>0.5 h</td>
<td>75 %</td>
</tr>
<tr>
<td>Overdue maintenance predict of Test-car</td>
<td>1 h / month</td>
<td>0.5 h / month</td>
<td>50 %</td>
</tr>
</tbody>
</table>

We have improved operational efficiency of our system in significant degrees!!
Conclusion

- Reduction of the working hours for the planning of the Test-car
  - 75%, 1.5-hour reduction

- Automated confirmation for the maintenance term expiration period of test-car
  - 50%, 0.5-hour reduction / every month

- This system is capable of operating in a shared server
  - Sharing of information efficiency

- No need to change the program by the maintenance function
  - Anyone can manage and operate this system