HONDA

The Power of Dreams

"Fleet Analytics using MATLAB to build strategies for BS VI Development"

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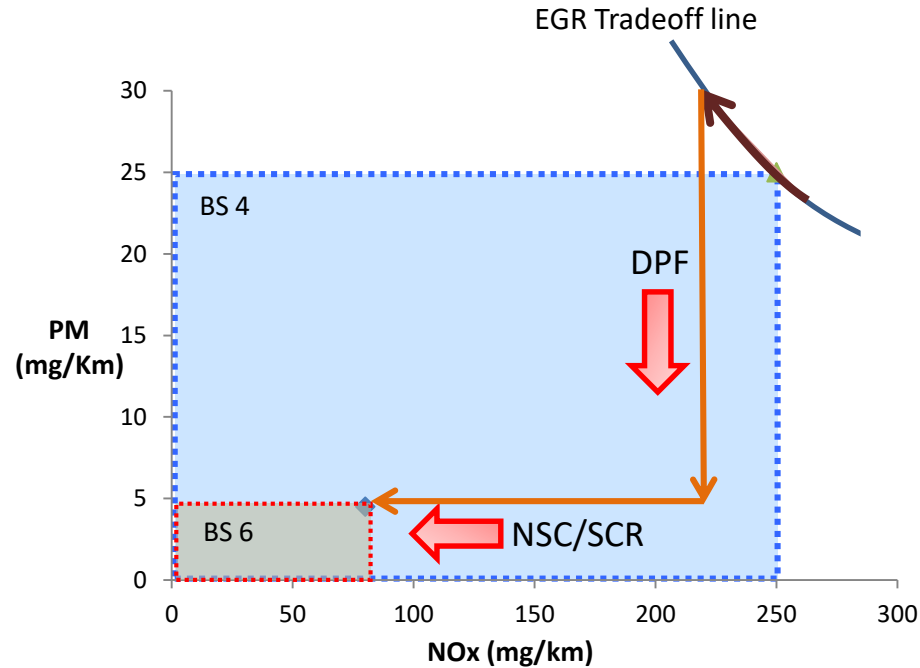**Honda Cars India Limited**

Content

- Abstract

- Introduction to Diesel Particulate Filter (DPF)

- DPF Regeneration Performance concern points

- Indian Market study

- Data Acquisition

- Data Analysis

- Result Interpretation

- Conclusion and Future scope

❖ Air pollution in India is at all time high, So life in Indian Cities is getting worse and risk of health hazards like respiratory and skin problems are increasing at an alarming rate, One of the contributors for this scenario are Automobiles.

❖ Considering this situation Government has decided to implement stringent emission norms by leapfrogging from BSIV to BSVI skipping BSV Emission norms.

❖ Honda being a responsible company is determined to deliver its low emission products as per by government policies .
Therefore we have used latest technology of DPF Systems to deliver cleaner vehicles as per our environmental commitment of "*Blue skies for our children* ".
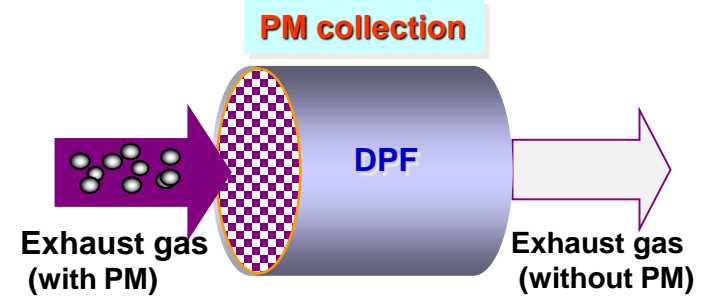
BLUE SKIES FOR OUR CHILDREN

HGID Honda R&D Automobile India

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❑ BSVI Emission norms for Diesel Vehicle

EGR Tradeoff line

PM (mg/Km)

BS 4

DPF

NSC/SCR

BS 6

NOx (mg/km)

❑ DPF Schematic

PM collection

DPF

Exhaust gas (with PM)

Exhaust gas (without PM)

❑ DPF Regeneration Flow

DPF system

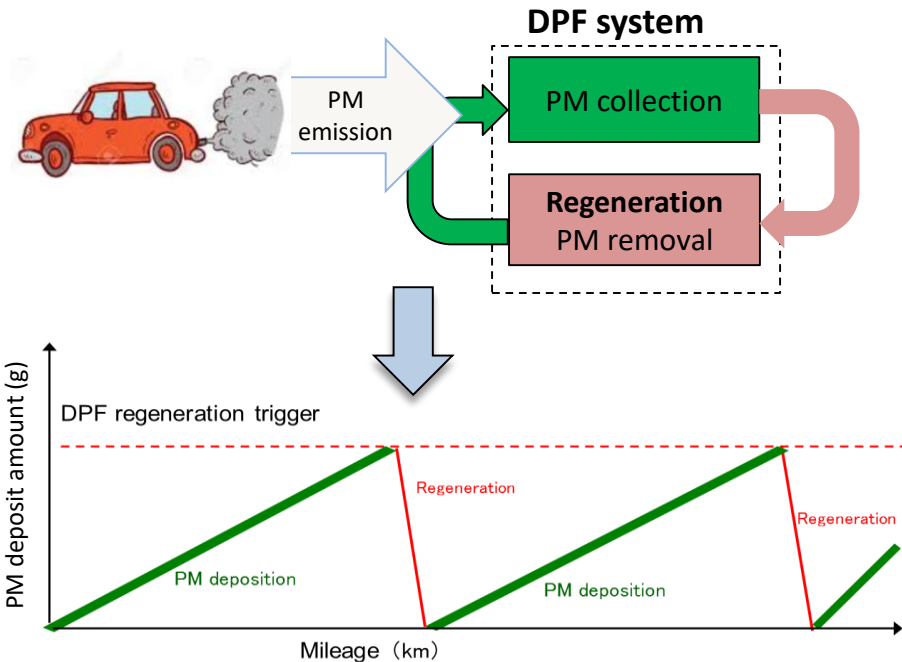PM emission

PM collection

Regeneration PM removal

❑ DPF Regeneration Control

- ❖ When estimated PM amount is over the threshold, DPF system will burn PM by increasing **exhaust gas temperature**.

- ❖ **High vehicle speed** is the desired condition for regeneration as the Exhaust temperature is high.

PM deposit amount (g)

DPF regeneration trigger

Regeneration

Regeneration

PM deposition

PM deposition

Mileage （km）

DPF is required to meet BS VI 2020 emission norms in Diesel vehicles

CONCERN

VALIDATION

Traffic condition

Heavy traffic : Exhaust temp cannot rise to desired value to trigger regeneration due to low vehicle speed and frequent start stops.

Indian Market Study

Indian Customer Driving Data Collection
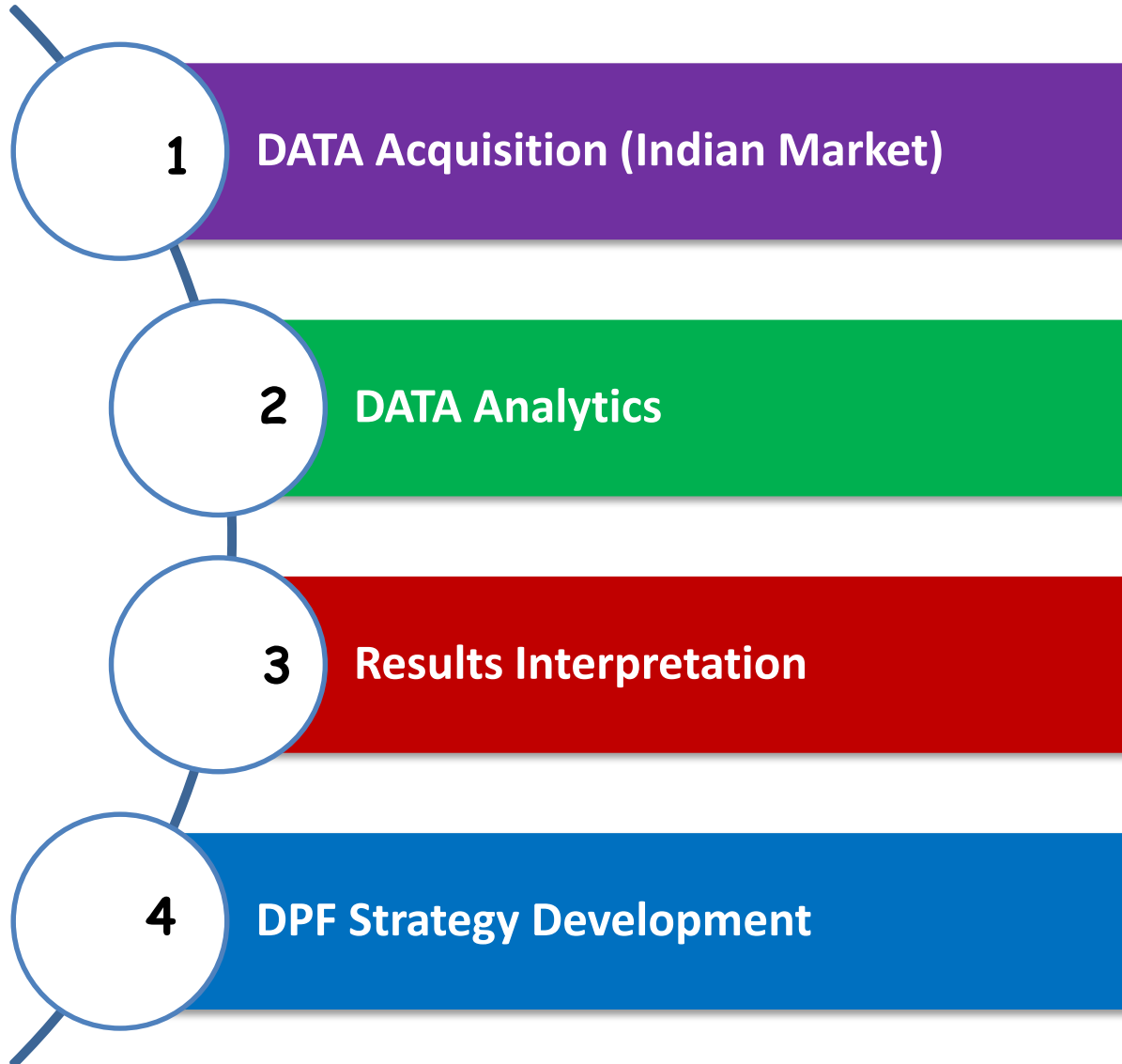
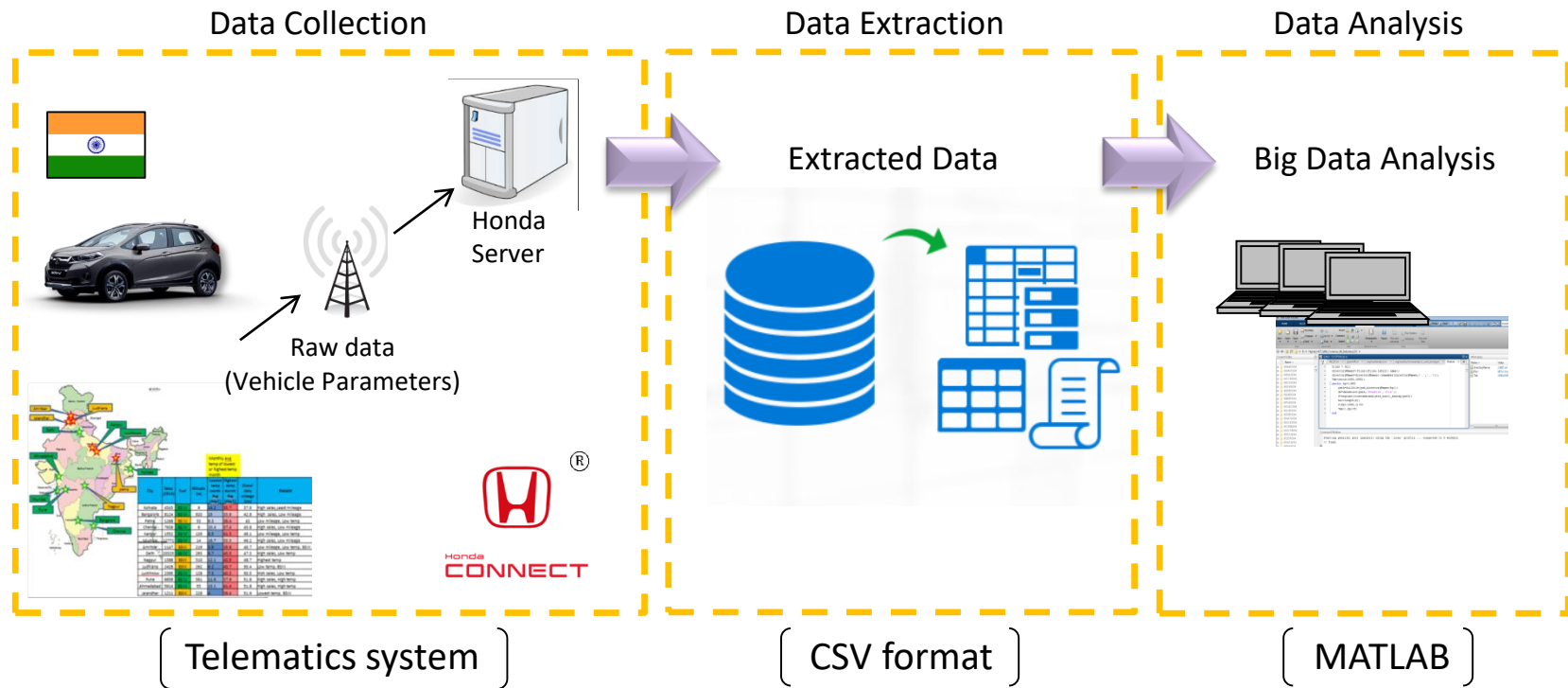↓

Analyze the Customer Driving Data

↓

Results Comparison with Boundary Condition

↓

Finalize the DPF strategies for Indian Market

Indian Customers driving data was analyzed to finalize DPF strategy for Indian Market

Indian Market Study

1 DATA Acquisition (Indian Market)

2 DATA Analytics

3 Results Interpretation

4 DPF Strategy Development

Data Collection

Data Extraction

Data Analysis

Honda Server

Raw data (Vehicle Parameters)

Extracted Data

Big Data Analysis

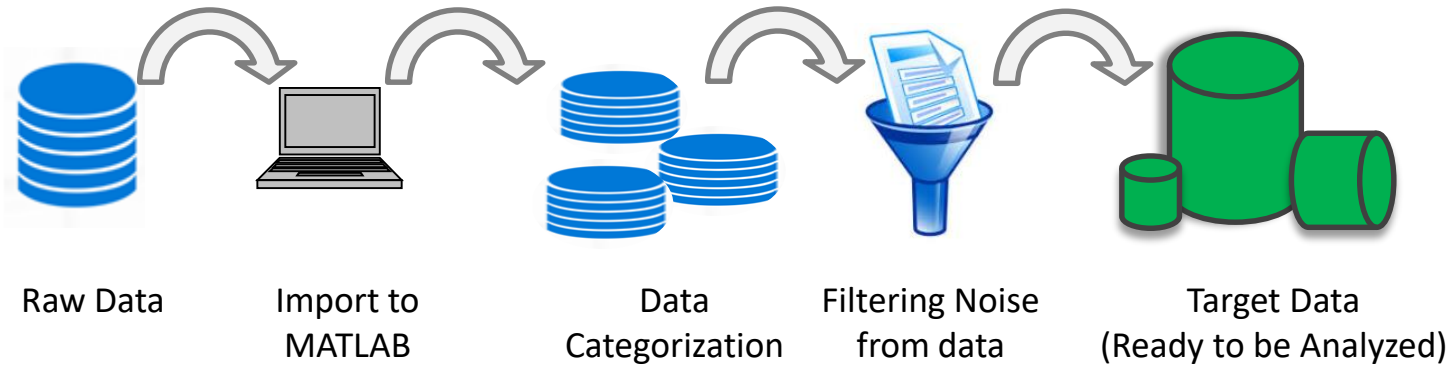Telematics system

CSV format

MATLAB

Telematics system was used to collect the data from vehicles, at **per second** sampling rate

Customers : **1000**
Data Size : **20 Gigabytes**
Mileage Covered: **1Million KM**
Driving Cycles : **150 Thousand**

This "**Big data**" is difficult to analyze by conventional tools like excel, So **MATLAB Distributed Computing Server** was helpful for this analysis .

DATA collected from the Market Survey was huge, conventional tools like excel were inefficient so MATLAB was used

1 Data Pre-processing

| Raw Data | Import to MATLAB | Data Categorization | Filtering Noise from data | Target Data (Ready to be Analyzed) |

```
function All_DC = All_DC1(deviceID_Customer)
All_DC=cell(1,1);
for i=1:985
    T1=deviceID_Customer{i,1};
%     T=cell2table(T);
    a1=categorical(T1.tripstarttime);
    b1=unique(a1);
    h=length(b1);
    T1=table2cell(T1);
    DC1=cell(h,1);
for k=1:h
        ll=(a1==b1(k));
        B=T1(ll,:);
        DC1{k,1}=B;
end
    All_DC{i,1}=DC1;
    DC1=[];
end
end
%clearvars -except idle deviceID_Customer All_DC;
```
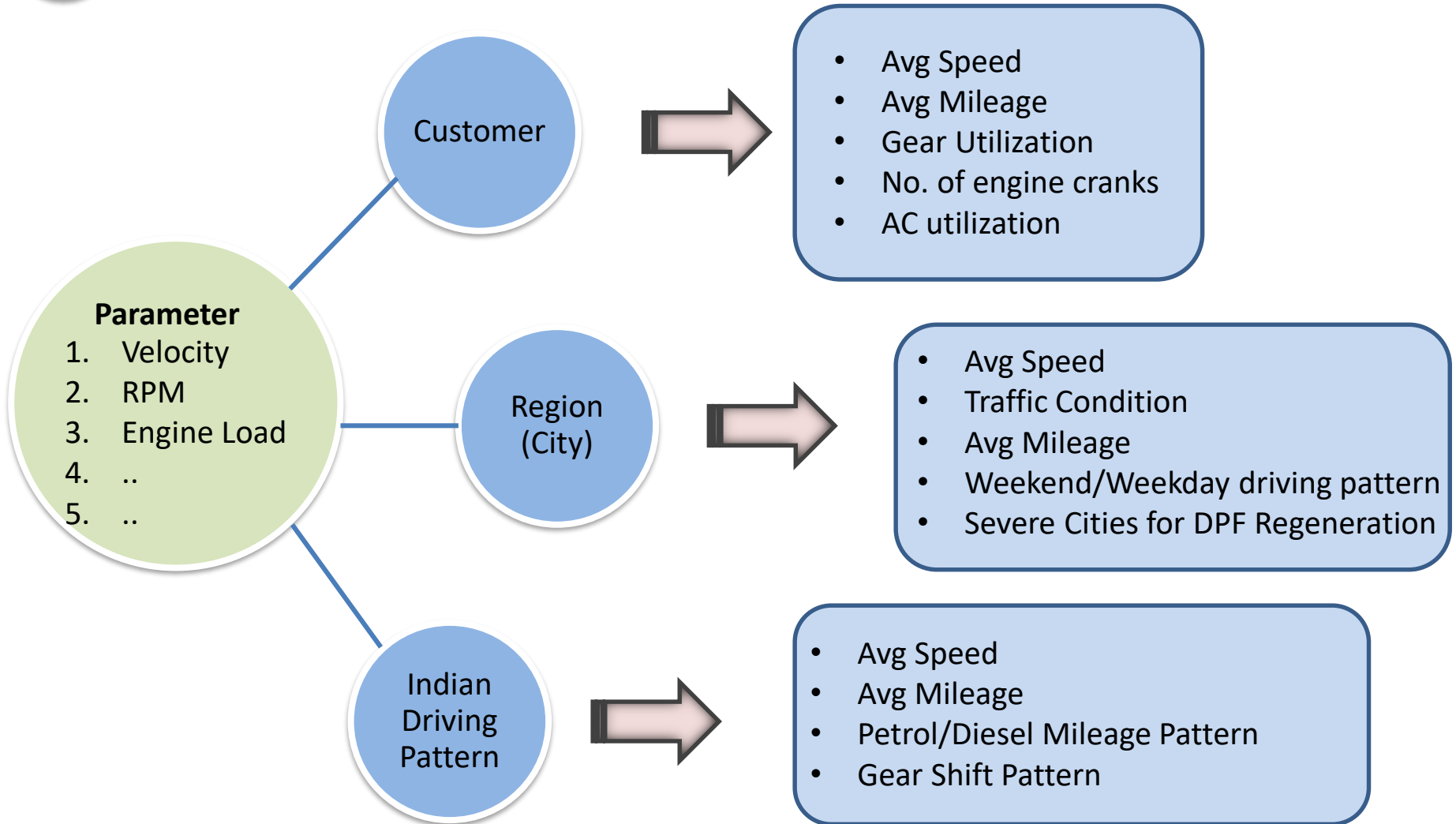
Program to segregate customers from raw data

- Initially the Raw Data was not categorized in the desired format.
- Using MATLAB this raw data was Categorized and filtered in the Desired format.

Codes

```
function [deviceID_Customer,T,a,b1]=trial4_10sec_30(pwd,a1)
    ds=datastore(pwd,'ReadSize','file','delimiter',',');
    ds.SelectedVariableNames =('deviceId','timestamp','tripstarttime'
    ds.SelectedFormats=('%q','%q','%q','%q','%f','%f','%f','%f');
    T=readall(ds);
    clear ds;
%     stamp1=datetime(T.timestamp,'InputFormat','eeee MMMM dd yyyy HH
%     K=height(T)-2;
%     stamp2=stamp1(end-K:end,:);
%     stamp1(end)=[];
%     difference=stamp1-stamp2;
%     difference(end+1)=duration(00,00,01);
%     T.timestamp=difference;
%     clear stamp1 stamp2 difference;
    a=categorical(T.deviceId);
    %a1=categorical(VIDD.V_ID);
    b=unique(a);
    %b=unique(d);
    h=length(b);
    deviceID_Customer=cell(h,1);
    %T=table2cell(T);
%    v=1;
for i=1:h
        ll=(a==b(i));
        deviceID_Customer{i,1}=T(ll,:);
```

Program to segregate Driving cycle of each customer

Raw data needs to be Categorized and filtered before it can be used for feature extraction.

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2 Feature Extraction

```
Parameter
1. Velocity
2. RPM
3. Engine Load
4. ..
5. ..
```

Customer →
- Avg Speed
- Avg Mileage
- Gear Utilization
- No. of engine cranks
- AC utilization

Region (City) →
- Avg Speed
- Traffic Condition
- Avg Mileage
- Weekend/Weekday driving pattern
- Severe Cities for DPF Regeneration

Indian Driving Pattern →
- Avg Speed
- Avg Mileage
- Petrol/Diesel Mileage Pattern
- Gear Shift Pattern

Domain level expertise and MATLAB programming was used to extract all mentioned and not mentioned features from the limited target parameters

3 Challenges

i. **Data processing time was very long** due to the huge amount of data, Hence Code optimization and parallel-processing tools were required.

Solution

Desktop

Cluster of multiple servers

Image Source : MathWorks
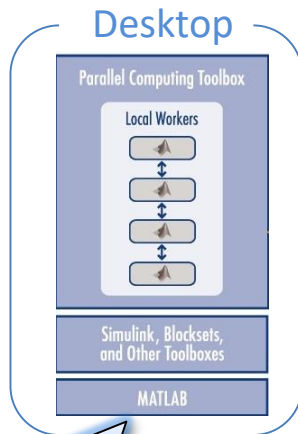
Parallel Computing
This toolbox allows the desktops to use their multicore processing capability by executing applications on workers that run locally .
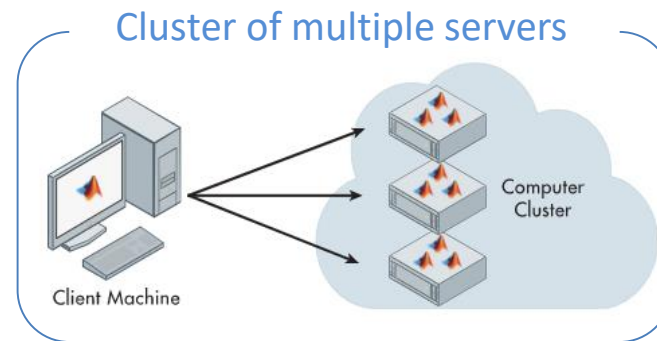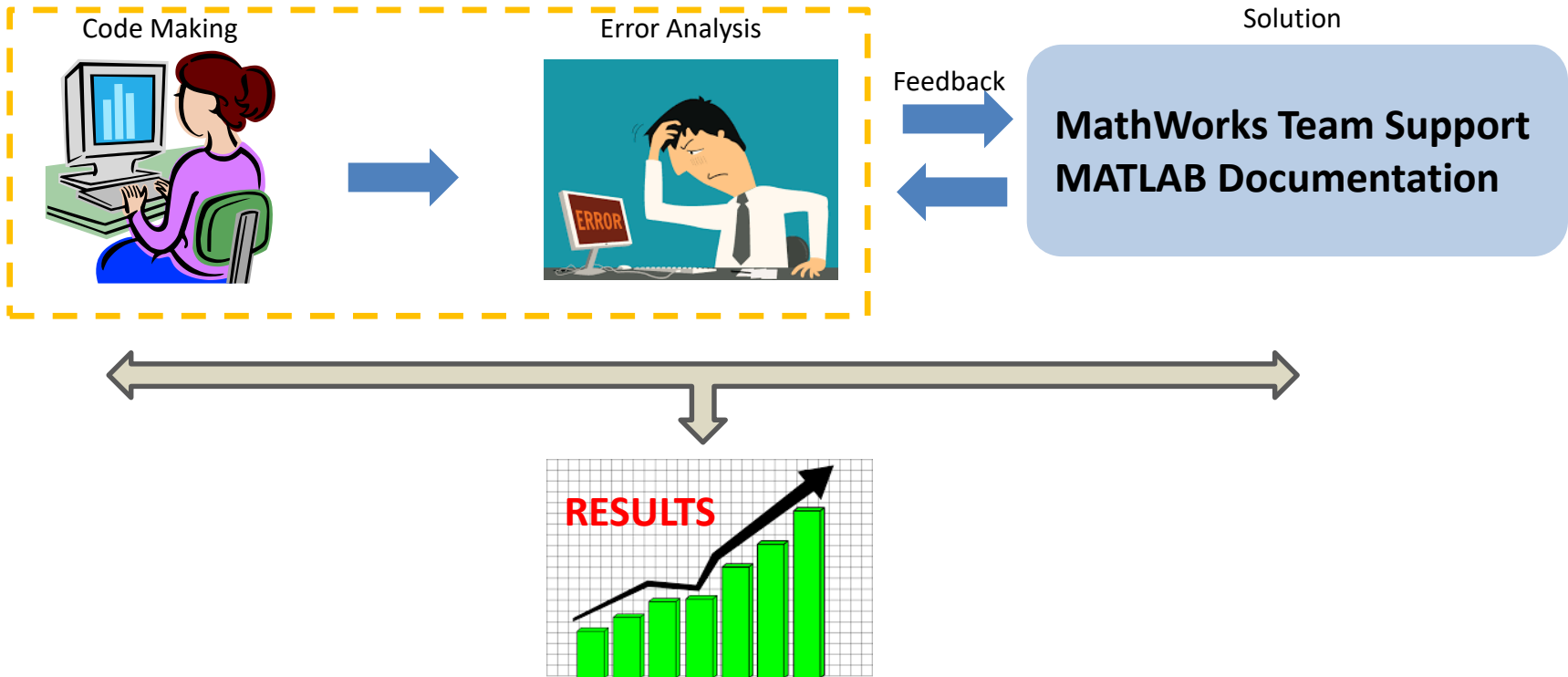
MATLAB Distributed Computing Server (MDCS)
Allows to run programs on computer clusters, and then scale up to many computers by running it on MDCS.

The **Processing time was considerably reduced using these toolboxes and in future also we can easily scale up to Terabytes of data through Honda internal servers and MathWorks tools.**

3 Challenges

ii. **MATLAB Coding :** As per our Development goals, Advance MATLAB Coding Skills were required to be attained in limited time to meet project timelines.

Solution

Code Making

Error Analysis

Feedback

Solution

MathWorks Team Support
MATLAB Documentation

ERROR

RESULTS

Through trainings and multiple trials, required coding skills were developed with the support of MATLAB team which was useful for our Project Completion and future developments .
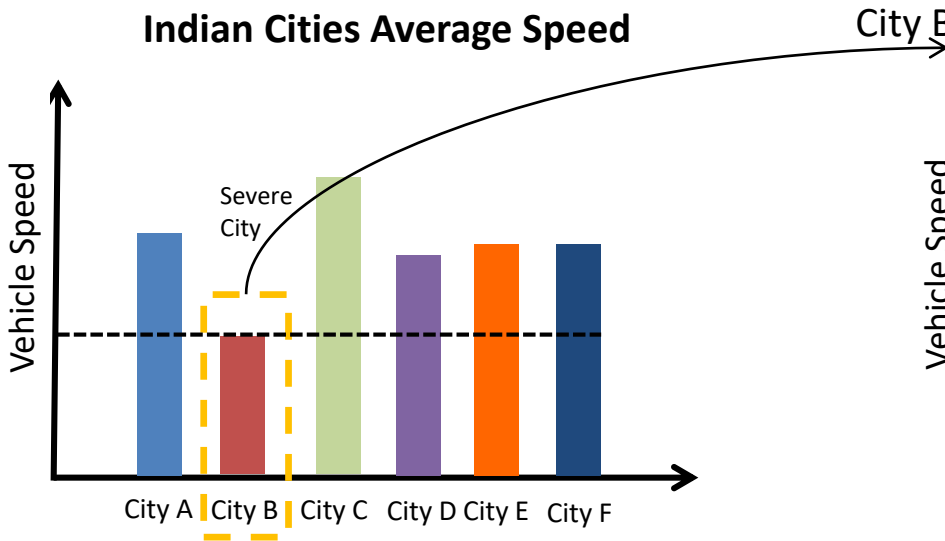
Customers Average speed

(chart: Sample vs Vehicle Speed)
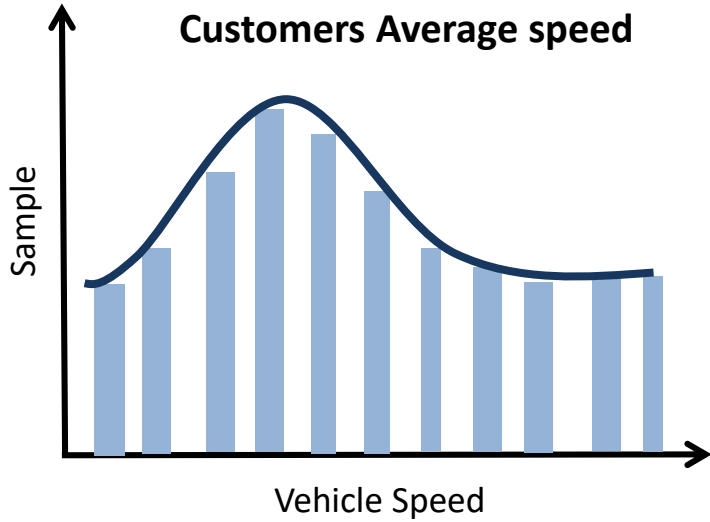
Customer Results were analyzed on the basis of different parameters like average speed, average mileage, etc for
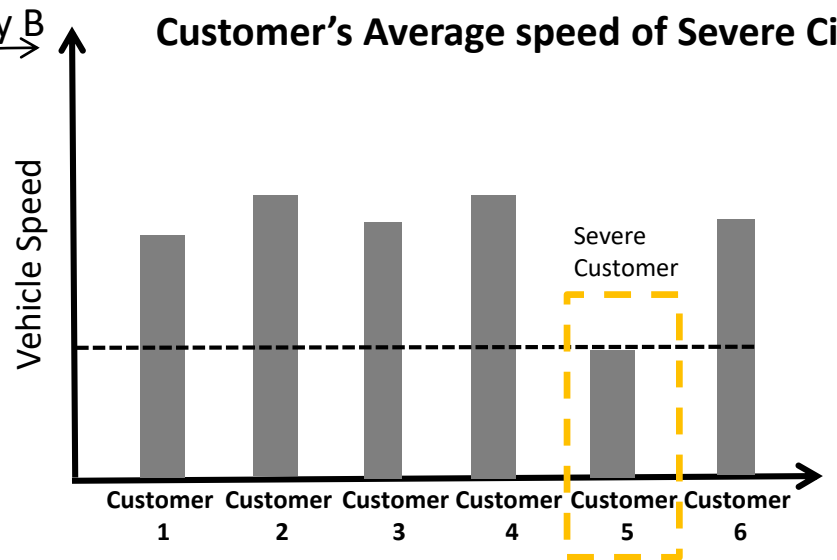**a. Individual Customer**
b. Region (City)
For deciding Final DPF Strategy and Calibrations for Indian Market.

Indian Cities Average Speed

City B

Severe City

Vehicle Speed

City A   City B   City C   City D   City E   City F

Customer's Average speed of Severe City

Vehicle Speed

Severe Customer

Customer 1   Customer 2   Customer 3   Customer 4   Customer 5   Customer 6

These results were necessary in determining Honda's strategy for BSVI Development

CONCLUSION

❑ Indian Customer's Driving Pattern and Indian Traffic Conditions were analyzed using MATLAB which were used to decide Honda's BSVI strategy.

❑ MATLAB tools were found very effective for this type of analysis and the support from MathWorks engineers is appreciated.

❑ Through this project Honda have developed know how and infrastructure to handle big data, so in future this type of analysis will be used for further development of research models.

FUTURE SCOPE

❑ Honda will continue Big data Collection and Analysis for development of Hybrid & Electric Vehicles

❑ MATLAB GUI for fleet analytics will be prepared to reduce testing and development time

THANK YOU

QUESTIONS AND DISCUSSIONS