Innovative Method of Deploying MATLAB Based Application Across Organization Using MathApps - A Web-based Platform

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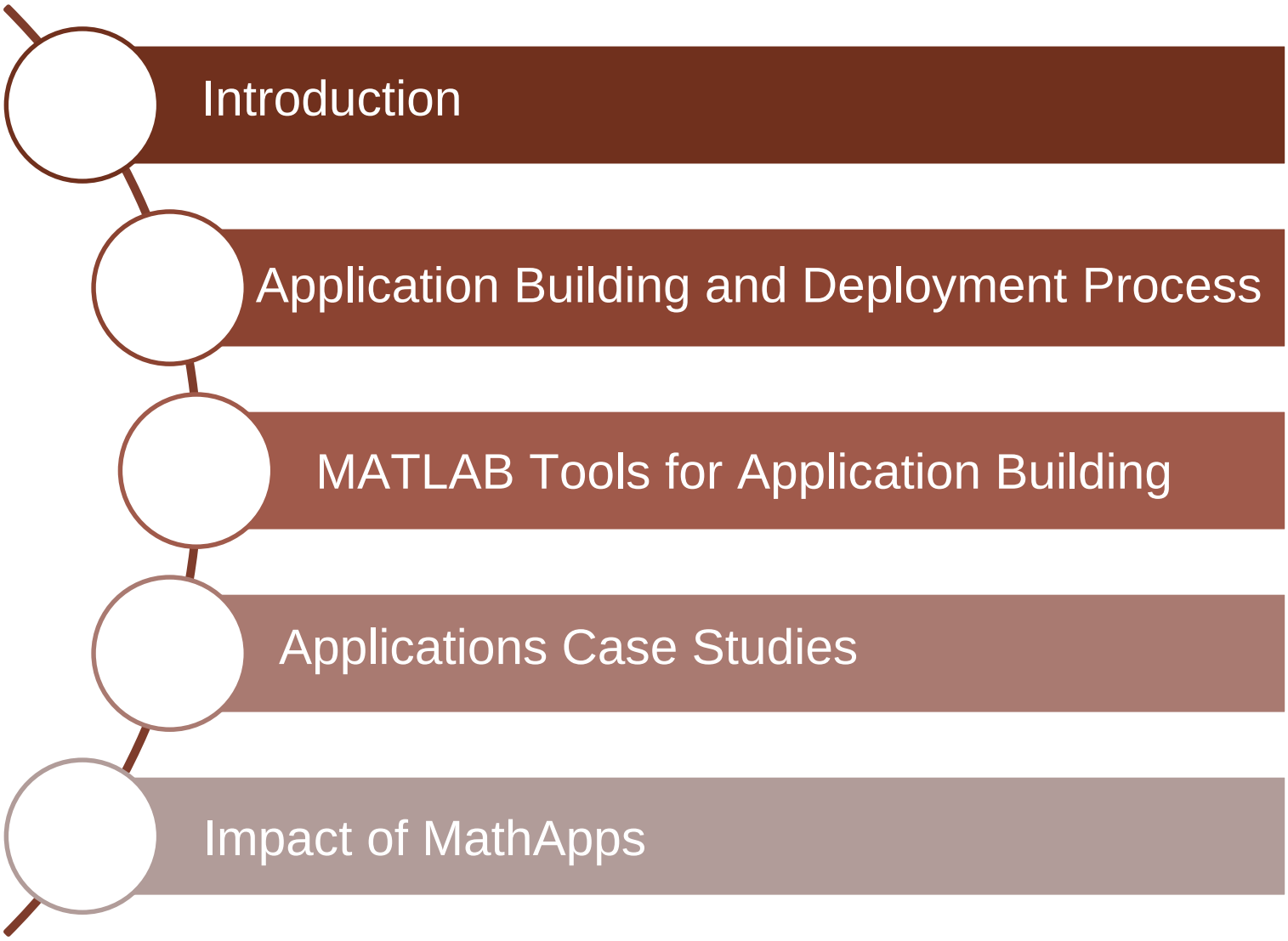
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Methods Development Group

Introduction

MathApps

MISSION: To strengthen frontloading, standardization of design calculations across product development functions of Auto Farm Sector companies through low fidelity high impact concept simulations.

Design Calculation

*Quick design calculations based on **analytical/empirical equations***

E.g. Beam deflection calculation

Physics based Modelling

Model based simulation** for performance analysis and prediction of system behaviour, including **multi-physics simulation

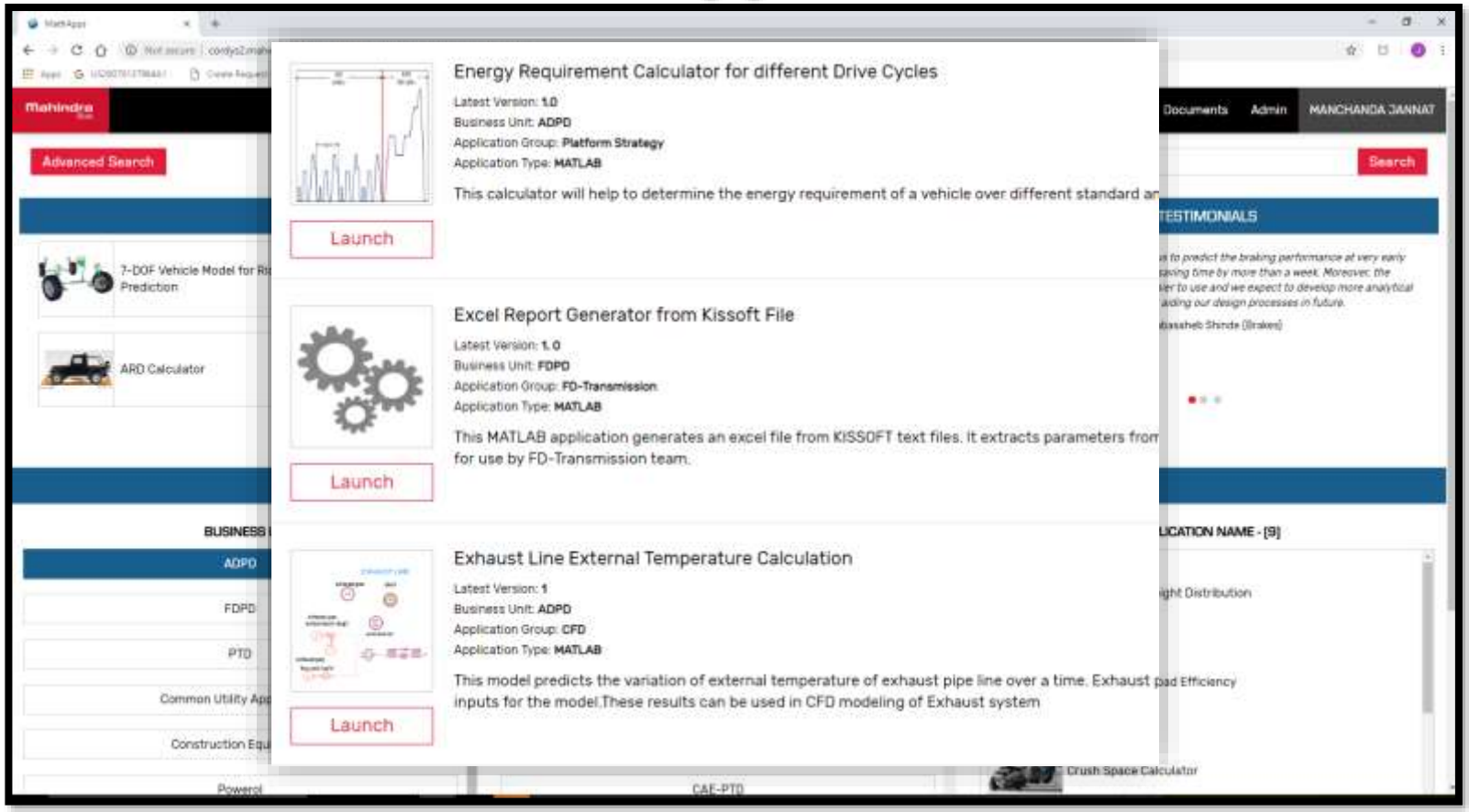
E.g. Vibro-acoustics of steering hose

Engineering Analytics

***Experimental data analysis** and **data-driven modelling** - development of applications to process data, derive meaningful conclusions and generate useful reports.*

E.g. Brake FI Attribute Test Data Analysis.

Introduction: MathApps



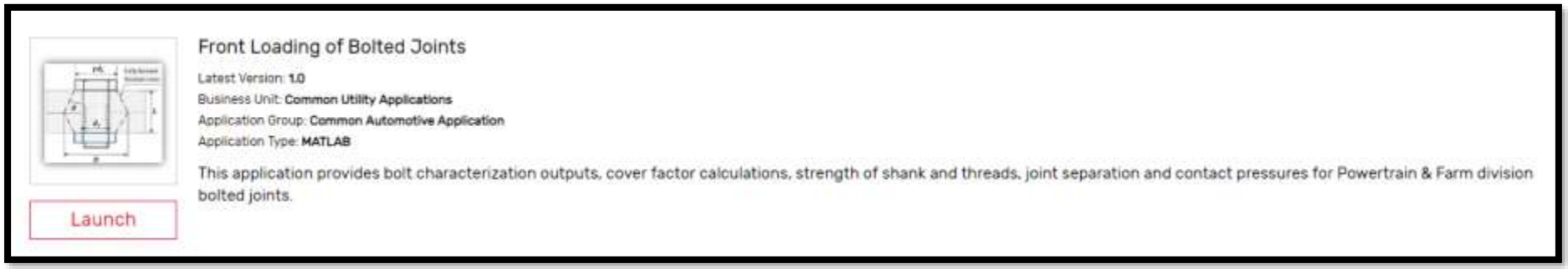
MathApps: Mahindra's enterprise level design calculator portal

- Concept design calculator
- Frontloading designs

- Reduce product lead time
- Power of calculations to all designers at their disposal by leveraging MATLAB's capabilities

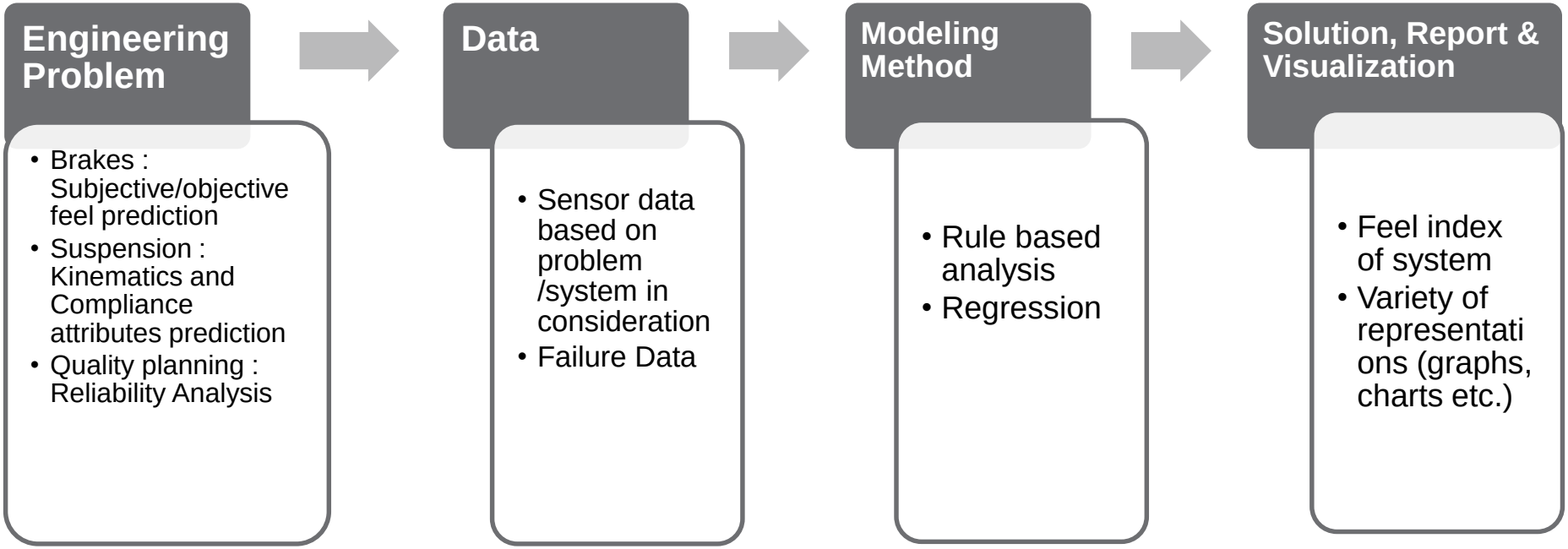
Introduction: MathApps

- The applications are made accessible to the designers through a web browser viz Google Chrome, Internet Explorer etc. and can be run from their workstations without the need to install additional software.
- All applications are restricted for internal use by integration with server-based database and two stage authentications

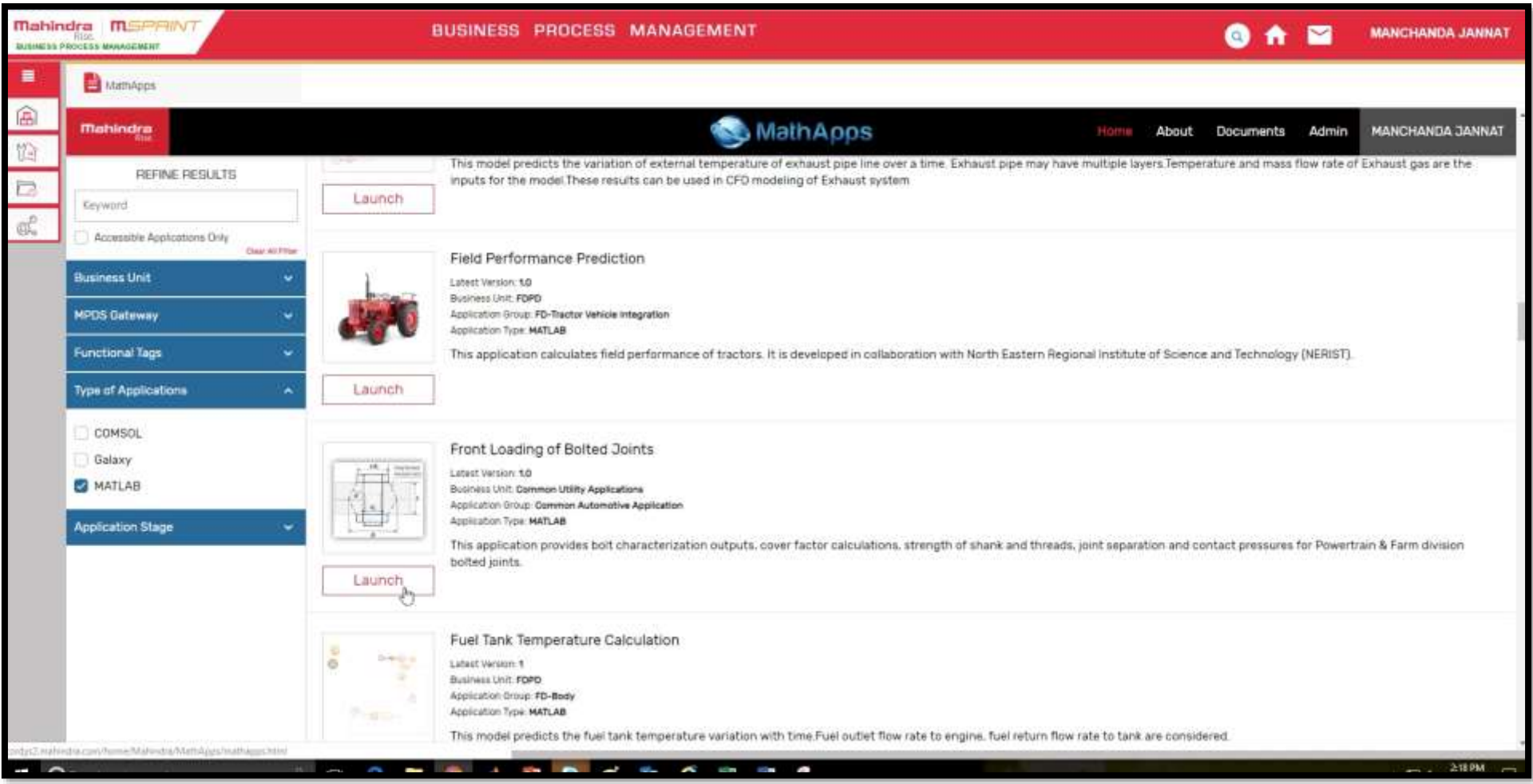


Example Application: Bolt Design Calculator; This application can be directly launched from MathApps

MathApps Workflow



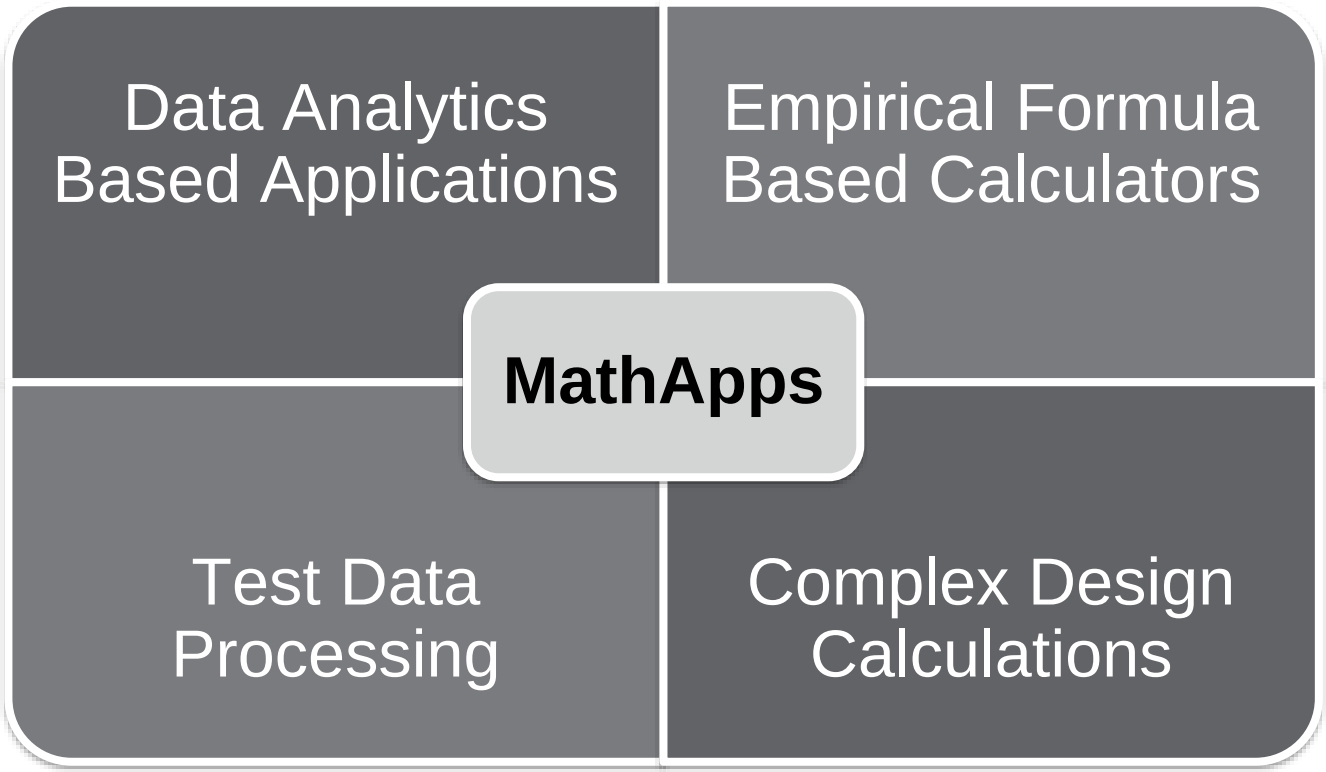
Application Example: Bolt Joint Analysis



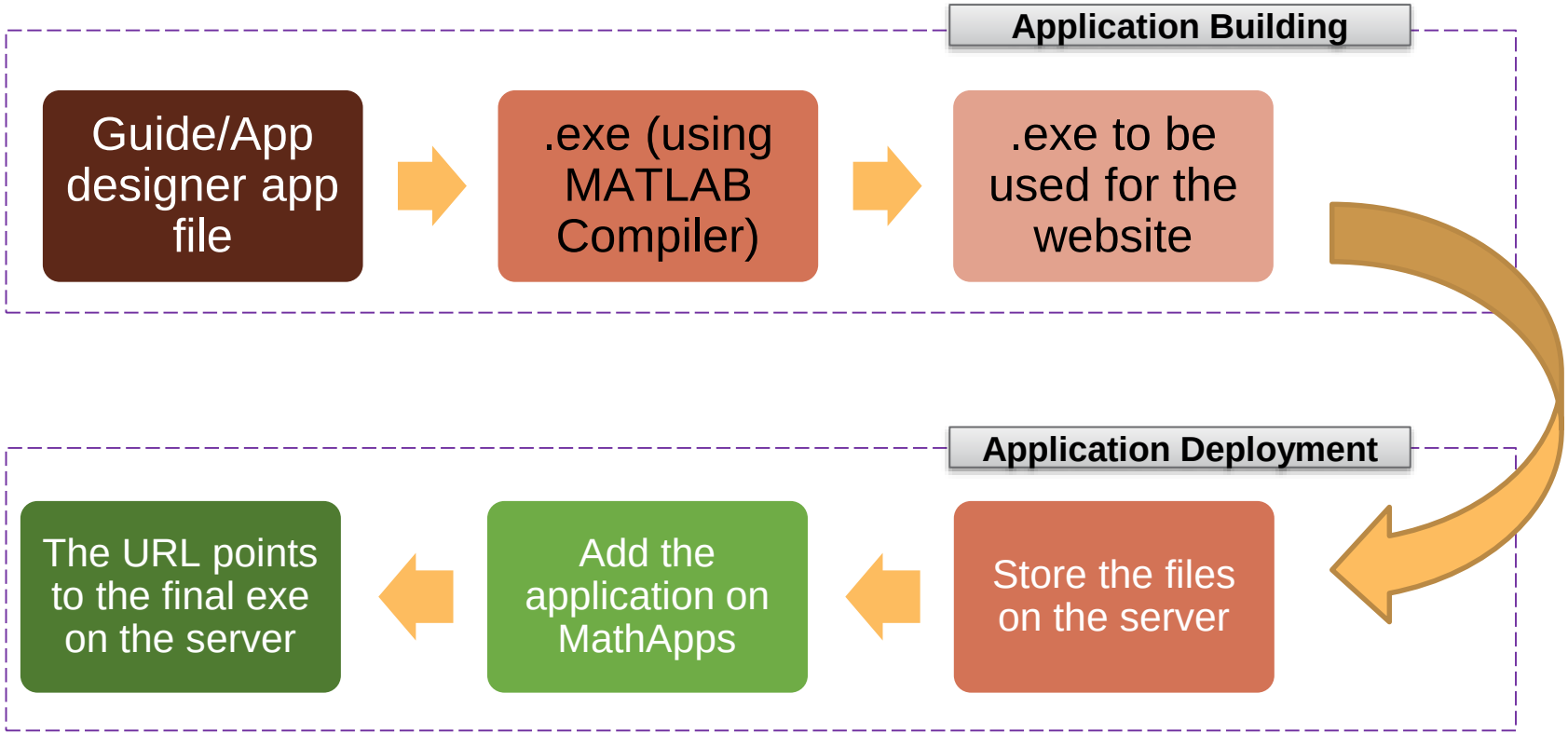
Why MathApps

- Avoid duplication of efforts
- Centralized repository for all the design front loading
- Automate workflows
- Avoid errors; maintain consistency in results
- Ease of access for users across different Mahindra divisions
- Collaborate with different design teams to create requirement specific applications
- Maintain uniformity in processes
- Increase efficiency: Getting quick and reliable results from MATLAB applications
- Applications from different tools are integrated in MathApps

Different MATLAB Applications Deployed on MathApps



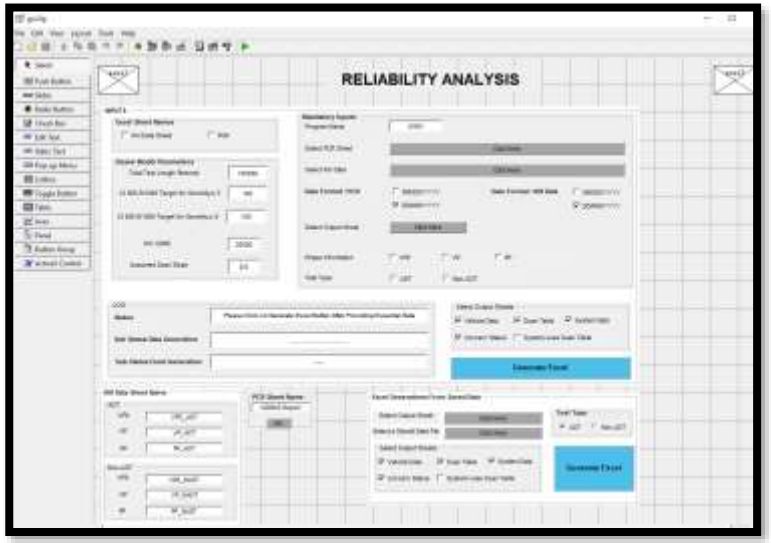
Application Building and Deployment Process



MATLAB Tools for Application building

MATLAB App Designer And Guide

App Designer



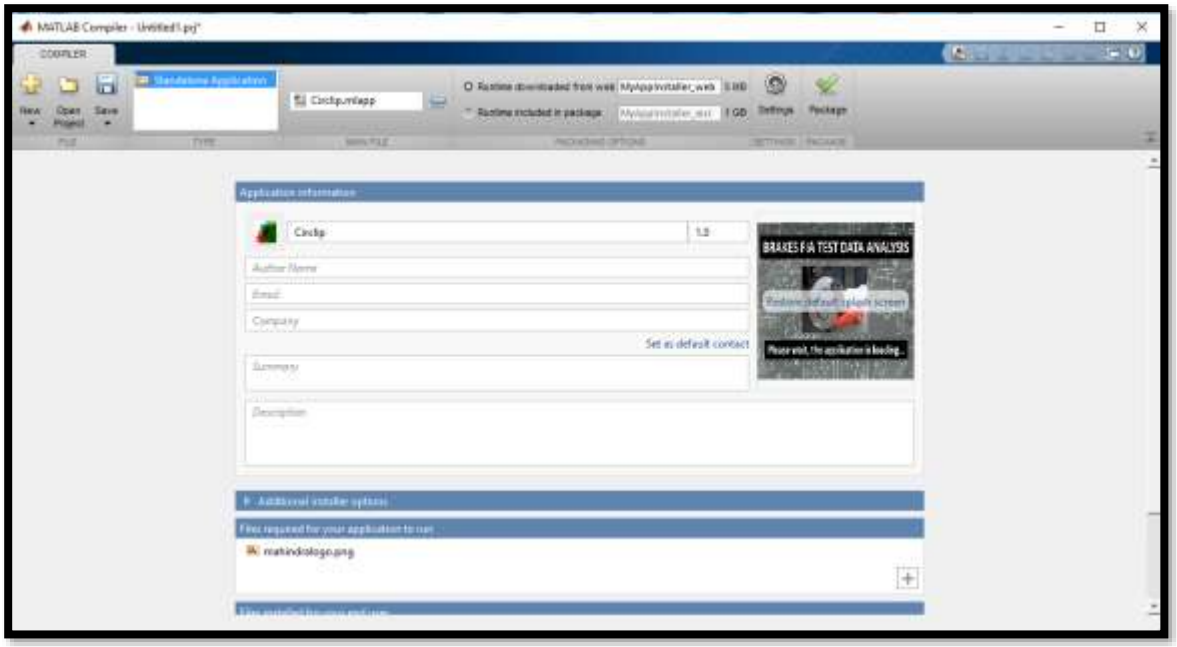
Guide

Methods team at MRV create numerous applications using MATLAB's App Designer and GUIDE. The physics model in converted to a mathematical model which is further written into the code for the application in the form of .mlapp and .m files for App Designer and .fig and .m files for MATLAB Guide.

MATLAB Tools for Application Building

MATLAB Application Compiler

- Packages MATLAB programs for deployment as standalone applications.
- This MATLAB generated .exe is deployed for use within MAHINDRA by a GUI created on MATLAB GUIDE.
- Link the generated EXE to MathApps application link, a secondary EXE file needs to be generated which points to the main EXE file generated through MATLAB compiler.



MATLAB Application Compiler

Application Deployment Process

Folder Creation on servers.

- Creates a specified folder structure on Mahindra servers.

.bat generation

- A bat file is generated to execute certain DOS commands.

.vbs generation

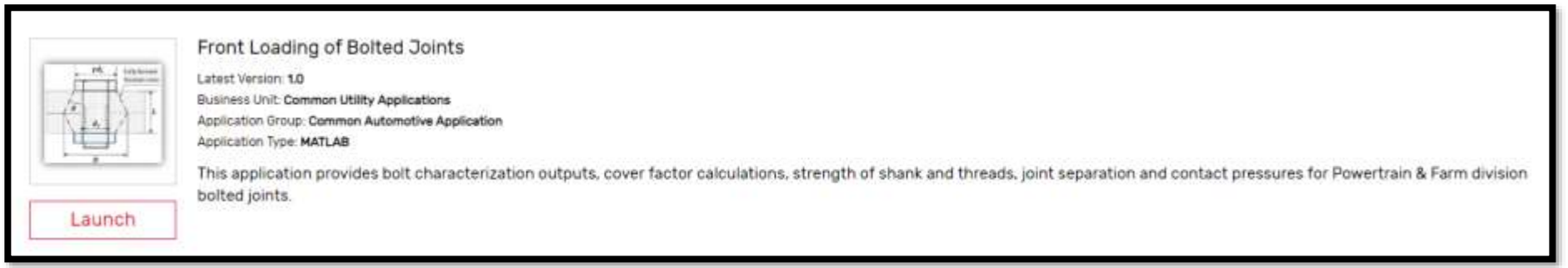
- Creates a Windows shell object

Wrapping .vbs to a standalone .exe

Application built using Guide for MATLAB Application Deployment

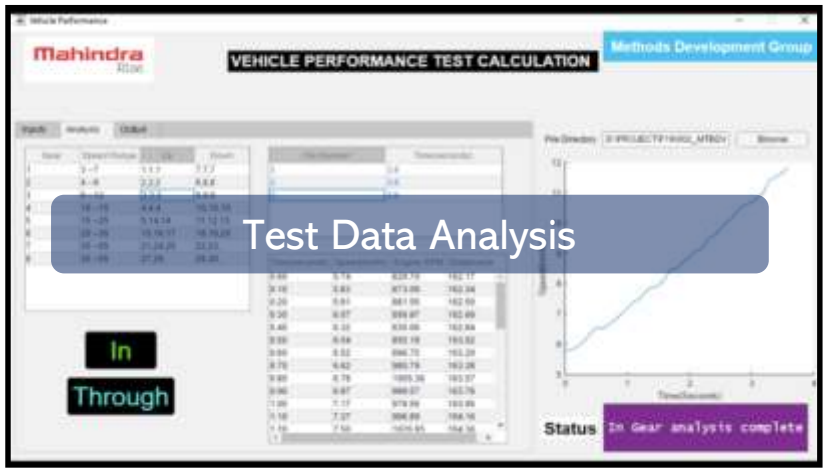
Deployment of MATLAB application on MathApps

- The main reason for this elaborate procedure (Conversion into a secondary exe) is that on directly downloading the exe at the user's system if the system didn't have the MATLAB Compiler Runtime installed it would pop an error.
- By this process the original MATLAB exe is not installed into the user's system; just a secondary exe is installed which points to the original exe stored at the server.

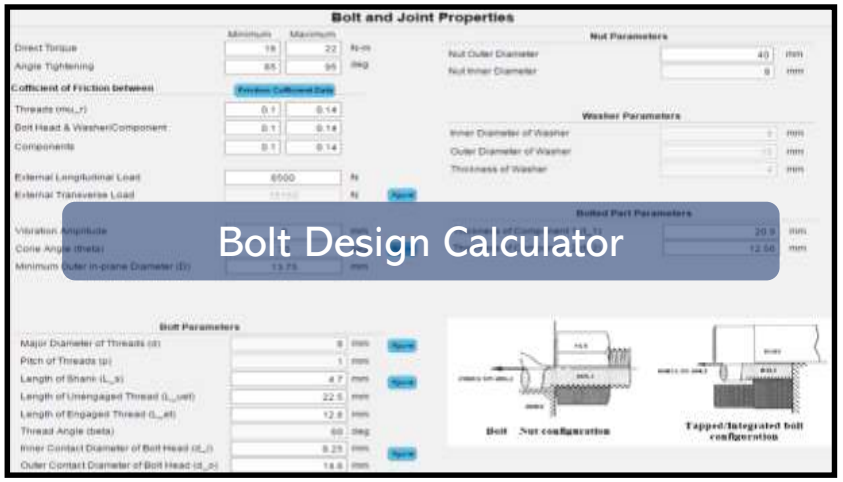


Case Studies

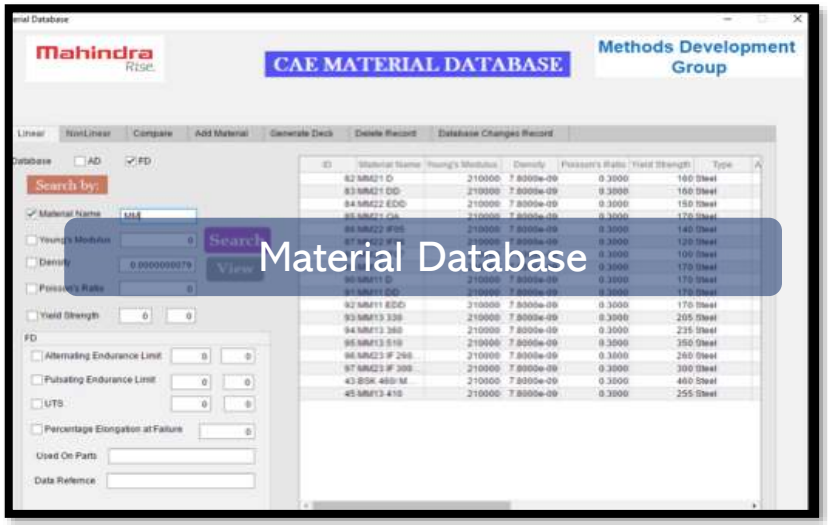
MathApps



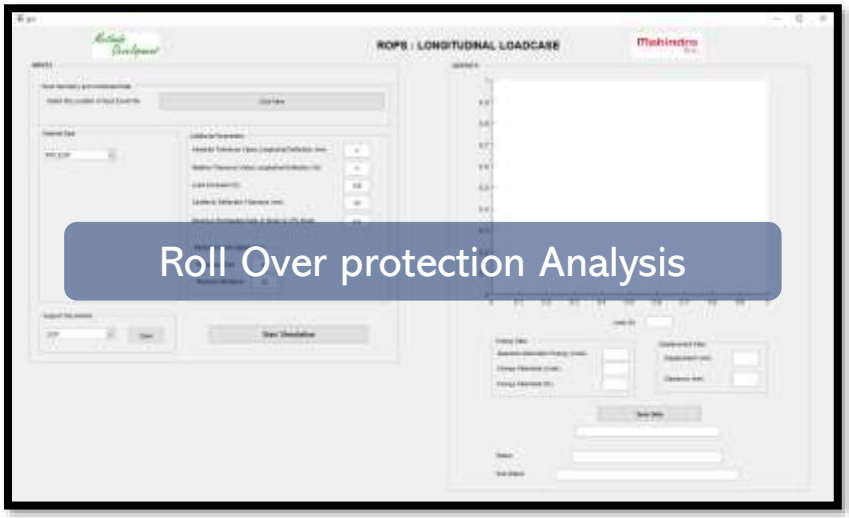
Test Data Analysis



Bolt Design Calculator



Material Database

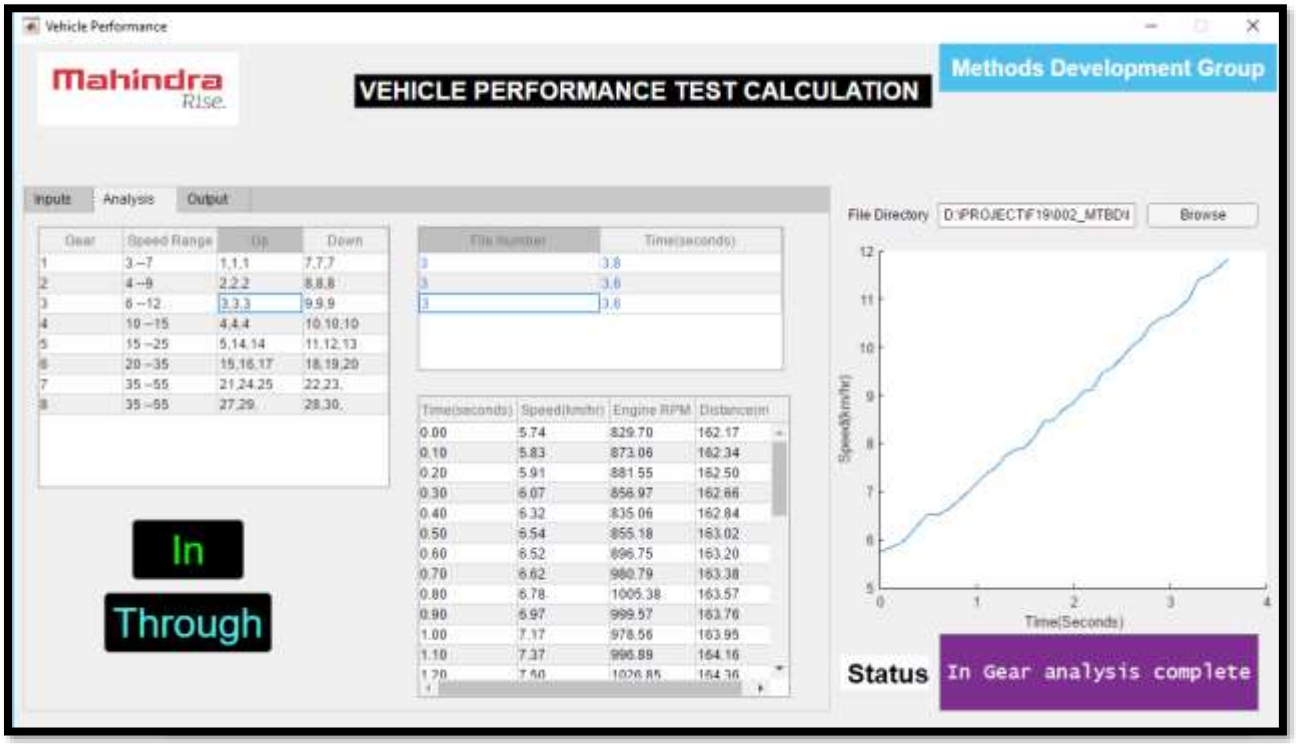


Roll Over protection Analysis

Case Study - 1

Vehicle Performance Test Calculation

Performs analysis on sensor data to calculate the performance of the Vehicle in different gears for different tests: IN Gear test and THROUGH Gear test.



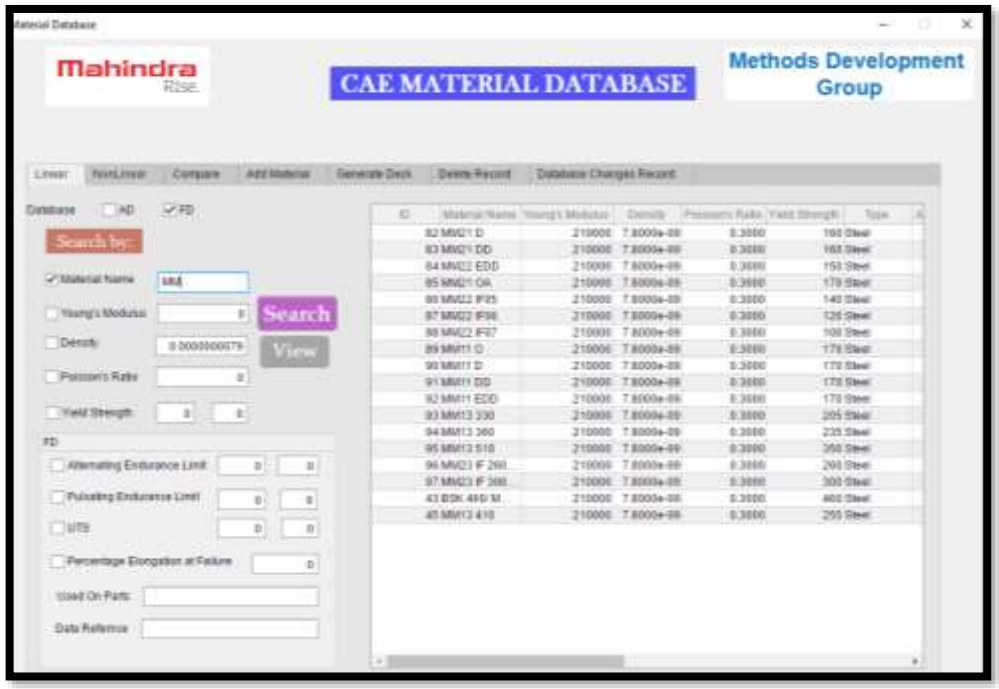
Impact: Previously done using Excel, after automating through MATLAB, saves 3-4 hours.

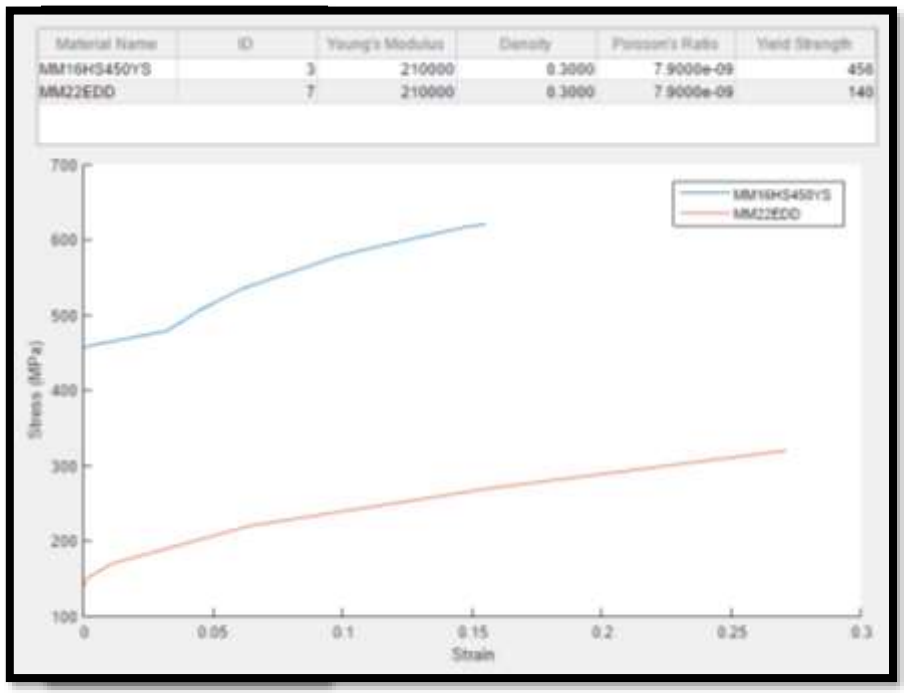
MathApps + MATLAB

Case Study - 2

CAE Material Database

This app offers a centralized Material Database for CAE users allows the user to perform various operations on a list of materials: Search, Compare, Update, Deck Export





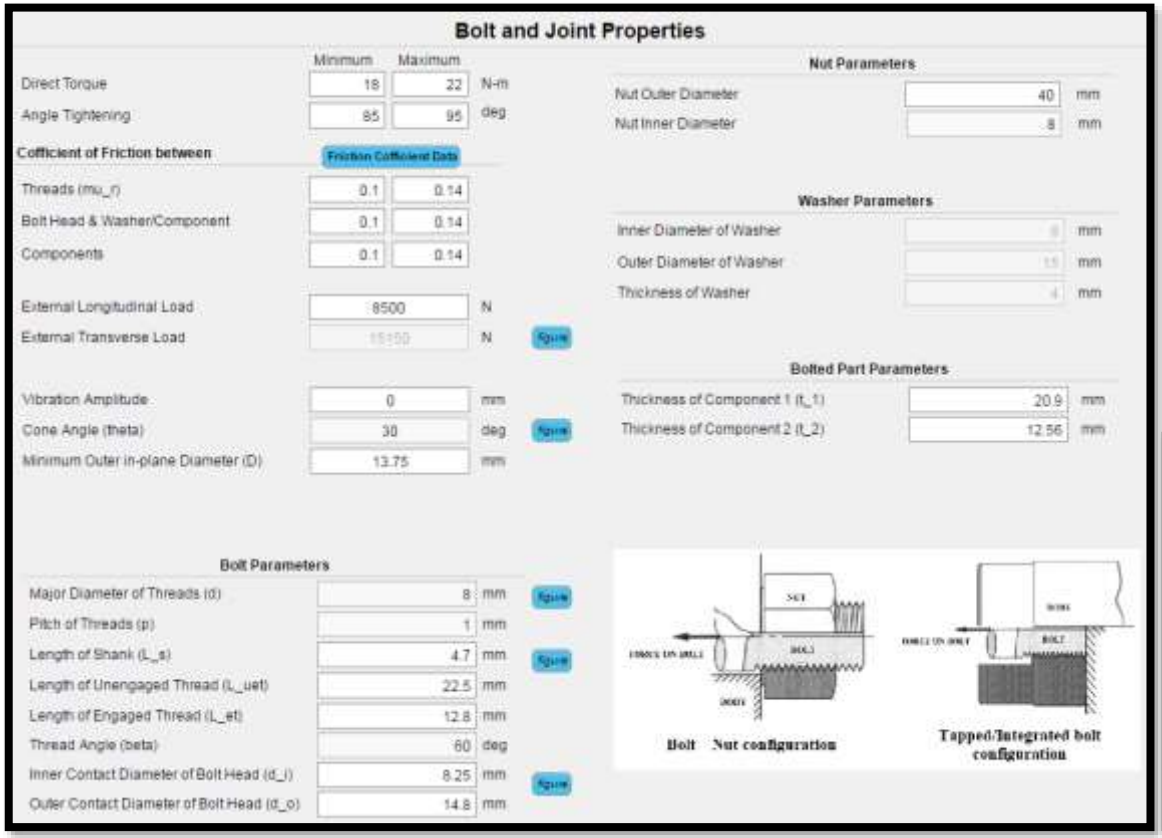
Impact: Easy comparison between materials being used in automotive and farm division. Nastran deck can be generated for different materials which can be directly used for simulation.

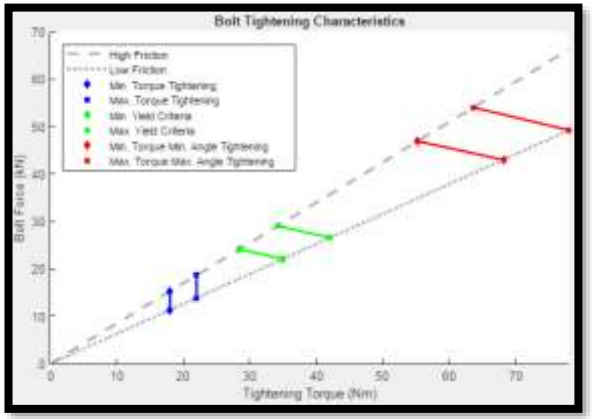
MathApps + MATLAB

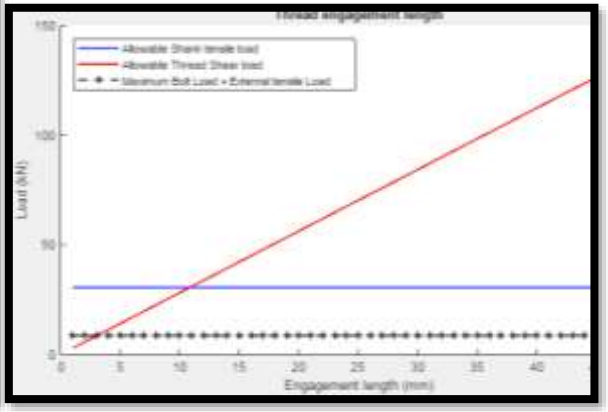
Case study - 3

Bolt Calculator

An integrated bolt calculator for catering the need of FD-CAE and CAE-PTD.





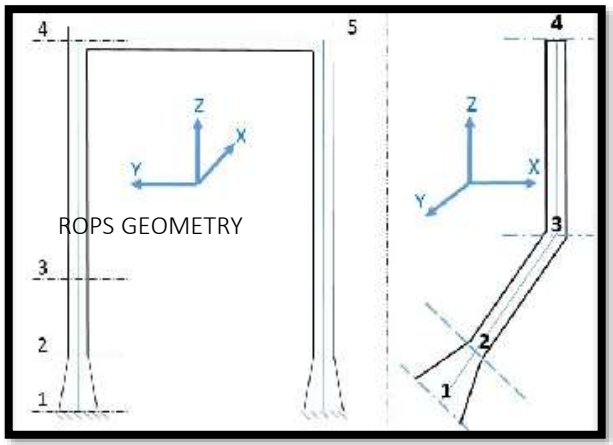


Impact: Single point for multiple calculations related to Bolts.

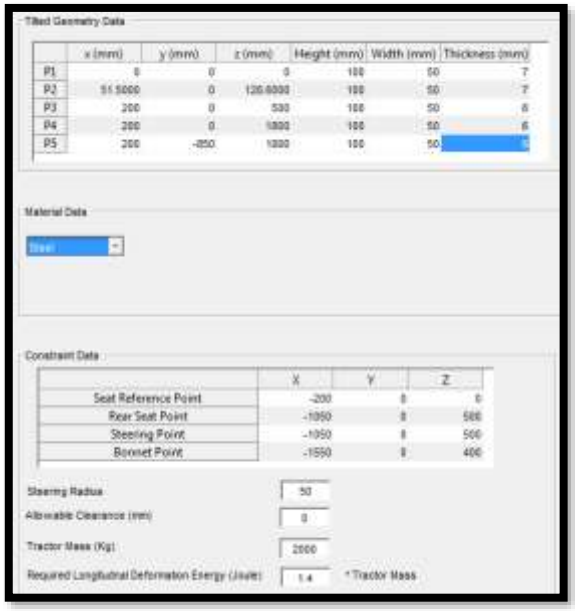
Case study - 4

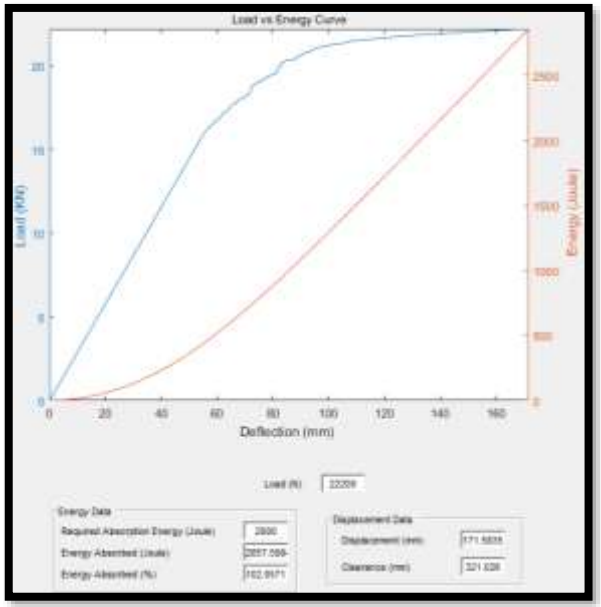
Non-Linear Structure - ROPS

- This tool performs Non-Linear Structural Analysis on a parametric tractor ROPS (for Longitudinal Load Case) according to OECD Code-4.
- The Elasto-plastic material behavior is approximated in the form of a bi-linear stress-strain curve.



- **Geometric parameters**
- **Material Properties**
- **Vehicle Parameters**





Impact: CAE : 2-3 hours MathApps: 5 minutes

MathApps + MATLAB

Impact of MATLAB

MathApps

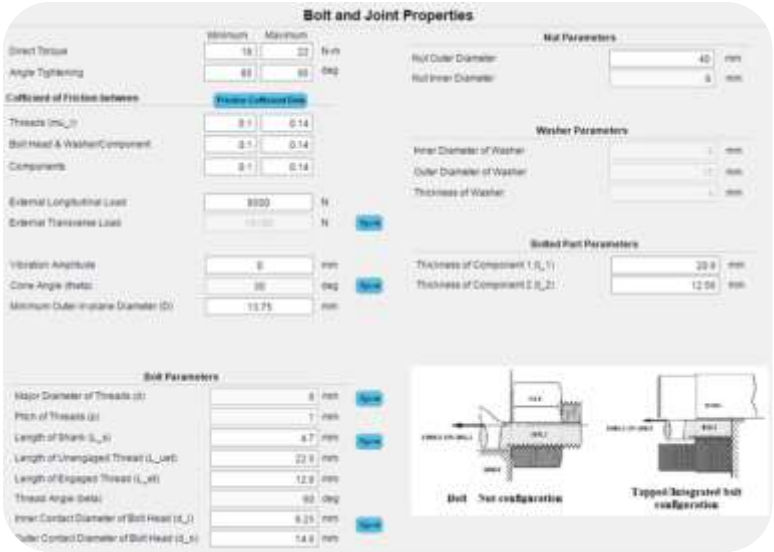
Without MATLAB	With MATLAB through MathApps
Design calculations not easily accessible to everyone	Easy access to designers throughout the organization
Formulas being used varies which increases errors	Maintains uniformity of the calculations
Time Consuming	Processes and calculations are automated: Saves time

Excel

emale thread shear strength	τ_f	260.00	MPa
Bolt shear strength	τ_b	600.00	MPa
External tensile load	L_x	28	kN
External transverse Load	L_y	5	kN
Applied Torque	T	0	Nm
Distance from the torque axis to bolt axis	x	1	mm
Vibration amplitude	a	0	mm
Output parameters	**Symbol**	**Value**	**Unit**
Bolt preload	F	51.886	kN
Tightening torque	T.		N-m
Tensile stress due to preload	σ	615.7	MPa
Critical slippage	S_{cr}	0.96	mm
Shear stress	τ	59.33	MPa
Bolt shearing		No	
Bolt joint loosening		No	
Total tensile stress (Preload+external load)	σ_t	666.4	MPa
Min length of thread engagement	Ler	12.5	mm
Distance between bolts fro leak proof joint		40.7	mm
Crushing Stress		152.9	
Total stress		674.31	MPa
Total stress to Bolt yield strength ratio		75%	
Calculations:	**Symbol**	**Value**	**Unit**

Calculator | Comparison | Instruction | Sheet1 | ⊕

MATLAB



Current Issues

- The correct version of Matlab Runtime should be installed in the user's machine to run the MATLAB exe
- Applications created in different versions would require different versions of runtime requiring the user to have all the Matlab Compiler Runtimes (MCRs) installed
- Though the process is automated here at MRV, it is only for a single version of MCR
- Across different Mahindra divisions: Mahindra Trucks and Buses in Pune, Mahindra Electric in Bangalore and Swaraj in Mohali it becomes a tedious task to ensure runtime installation in users' machines and always requires the local IT to intervene for the installation

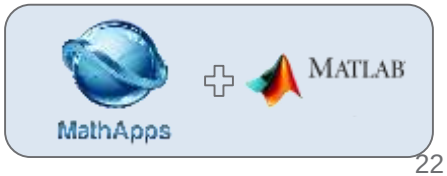
What Next?

Projects

- 1D mechanical system modeling using Simscape
- Enhancing Data Analytics capabilities using Deep Learning and Computer Vision toolbox

MATLAB's Web Apps

- Web apps are MATLAB apps that can run in a web browser
- Hosted using MATLAB Web App Server. Each web app has a unique URL and can be accessed from a web browser using HTTP or HTTPS protocols
- Web apps are designed to run only within a trusted intranet environment, not in the open Internet
- Apps and components can be shared as both standalone desktop applications and as software components to integrate with web and enterprise applications



Key Takeaways

- MATLAB GUIDE/App designer helps create customize UI based on the application requirements
- Using the Compiler we are able to create a standalone MATLAB application that doesn't require MATLAB license
- The MATLAB application is integrated with MathApps, which is a unified web portal covering –MATLAB and multiple platforms catering to the needs of all the system designers
- MathApps also acts as a repository for all the Knowledge Management Documents
- User Statistics helps gauge impact of the developed applications

MathApps

QUESTIONS?

Thank you

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