TACTICS FOR TTC TIRE FORCE & MOMENT DATA PROCESSING

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Purpose:

- Show Method(s) for creating user driven tire model formulations
- Demonstrate Matlab Applications
- Encourage “New School” Engineering Tool Constructions and Use.
- Guide FSAE Students into and out of the Tire Testing Swamp.

Introduction

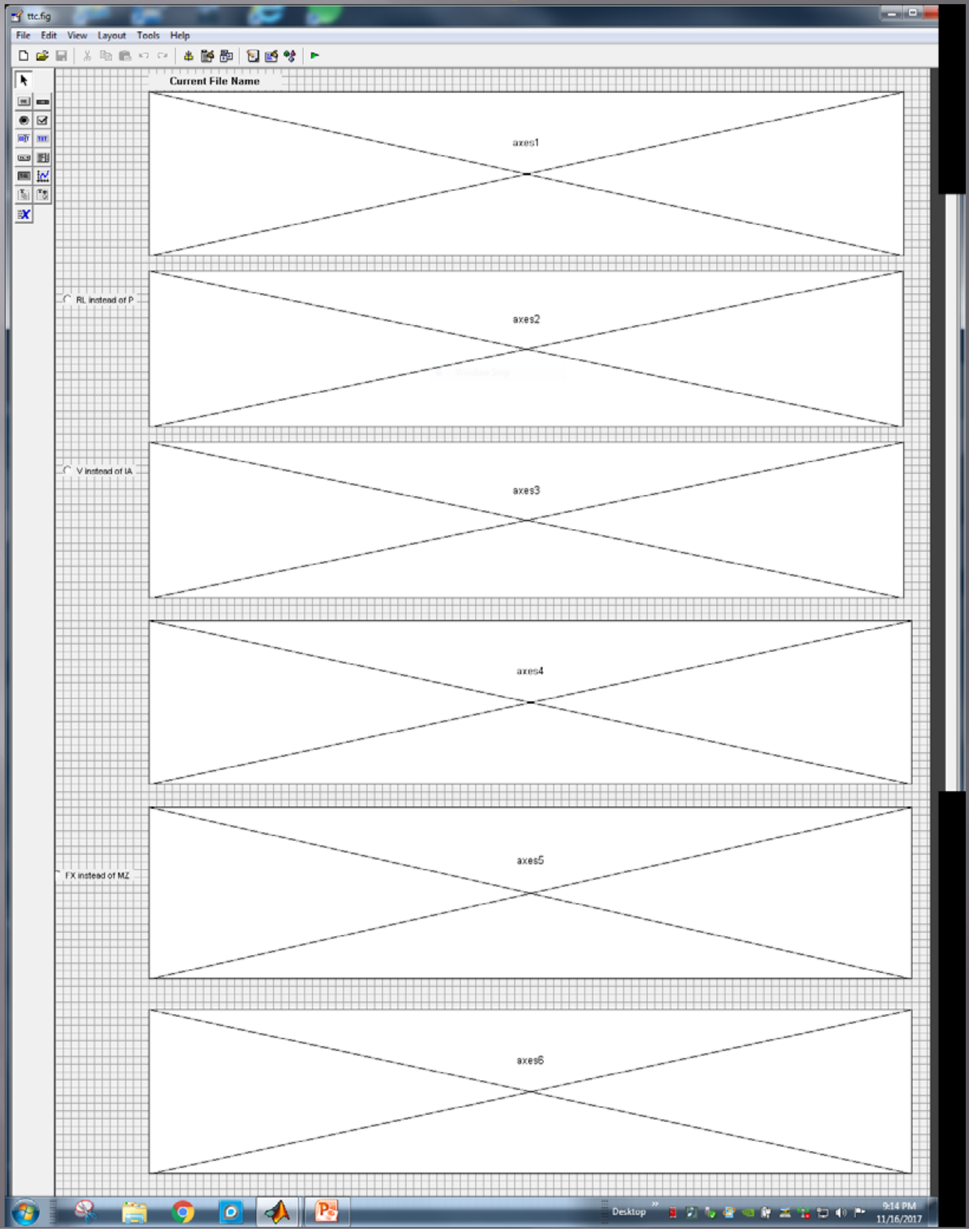
- TTC Forum members have inquired many times about tire modeling tactics and methods.
- TIRF Tire Data can be found in .mat file form. (.mat form is Direct Matlab Loadable format).
- There has been NO single data template used by TIRF during Round 1 through Round 7.
  - Programs to process raw data into tire model parameters have to be altered for just about every round.
- Data for tires selected for potential use MUST be scrutinized to ensure it "makes sense".

Here are the tactics I used:

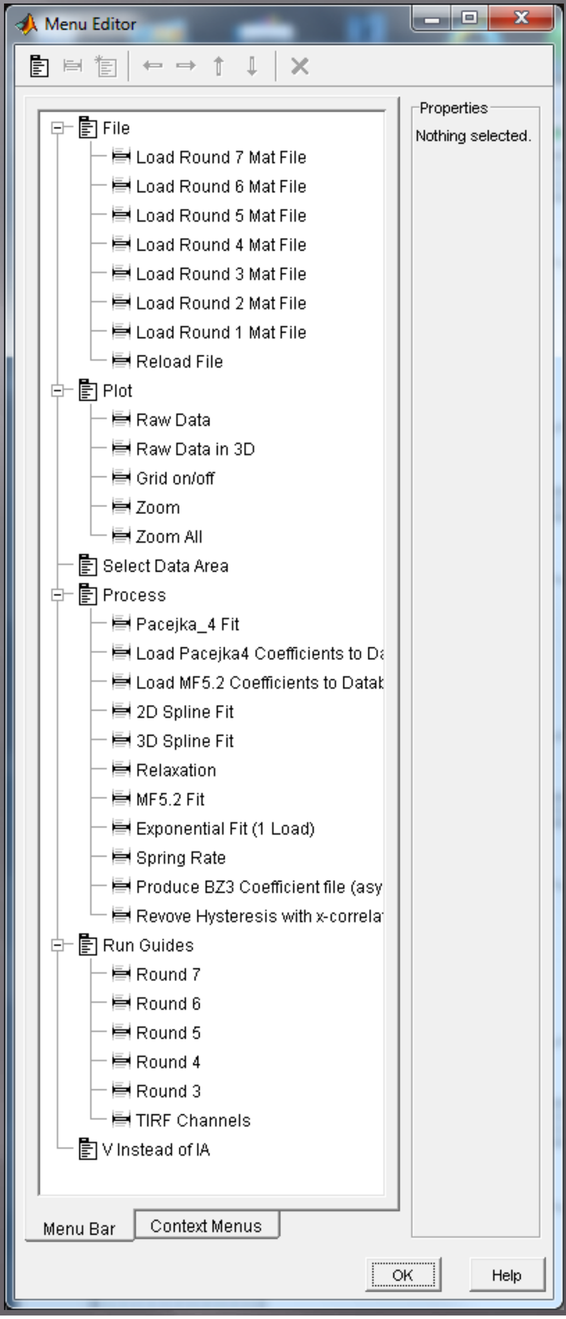
Use the Matlab "GUIDE" program

- GUI builder.
- Much easier to debug code scripts.
- Menu constructor.
- Text box, plot axes, mouse click, push-buttons, tab panels and dialog boxes provided.
- Data storage and processing flow provided by a built-in Handles database.
- Object Oriented Programming 'think':
  - Everything you see on the screen has a name, values, colors, labels, data, size, font, line type and width and many other programmable features.

Here's my GUIDE Figure for the "TTC" program



Here's my GUIDE Built Menu for the "TTC" program



Helps to have a Popup Figure
Image Identifies which Tire File to Select

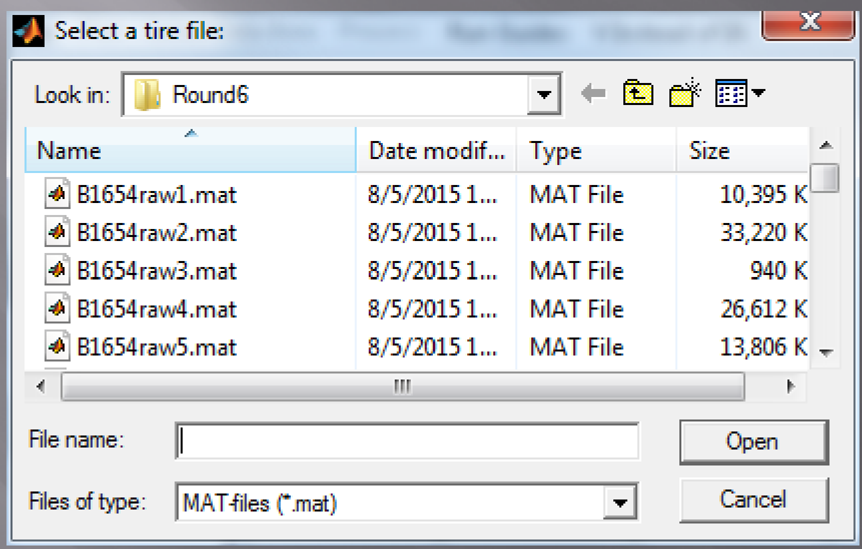
Figure 1: TTC: Round 6 Test Matrix

FSAE TTC -- ROUND 6 RUN GUIDE

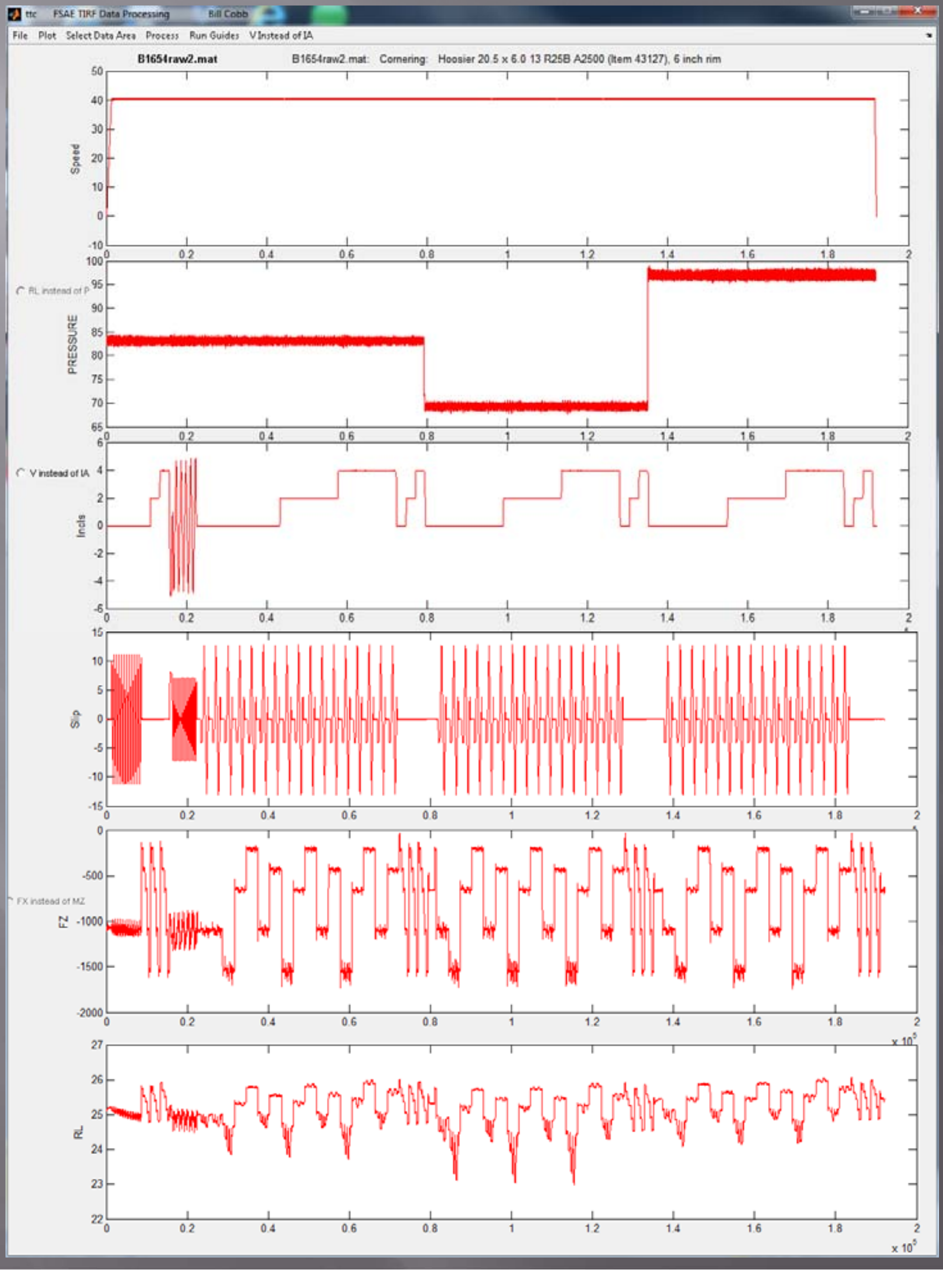
Run numbers correspond to the data files, such as "A1654run17.dat" for Run 17.

Rim Diameter, in	Tire		Rim Width, in	Free-Rolling (Cornering)					
				[1]Transient	[2]Initial 12 psi	10, 14 psi	8 psi	[3]Final 12 psi	[4]Speed test
13	Hoosier	20.5 x 6.0 13 R25B A2500 (Item 43127)	6	1	2	2	3, 4	3, 4	3, 4
13	Hoosier	20.5 x 6.0 13 R25B A2500 (Item 43127)	7	5	6	6	7	7	7
13	Hoosier	20.5 x 7.0 13 R25B A2500 (Item 43163)	7	8	9	9	10	10	10
13	Hoosier	20.5 x 7.0 13 R25B A2500 (Item 43163)	8	11	12	12	13	13	13
13	Continental	205/510R13 (4914)	7	14	15	15	16	16	16
13	Continental	205/510R13 (4914)	8	17	18	18	19	19	19
10	Hoosier	18.0 x 7.5 10 R25B (Item 43105)	7	20	21	21	22	22	22
10	Hoosier	18.0 x 7.5 10 R25B (Item 43105)	8	23	24	24	25	25	25
10	Hoosier	18.0 x 6.0 10 R25B (Item 43101)	6	28	29	none	none	none	29
10	Hoosier	18.0 x 6.0 10 R25B (Item 43101)	7	26	27	none	none	none	27
10	Hoosier	6.0 / 18.0 10 LCO C2000 (Item 41100)	6	30	31	none	none	none	31
10	Hoosier	6.0 / 18.0 10 LCO C2000 (Item 41100)	7	32	33	none	none	none	33

Selector Dialog: ‘uigetfile’
Choose a file and load it



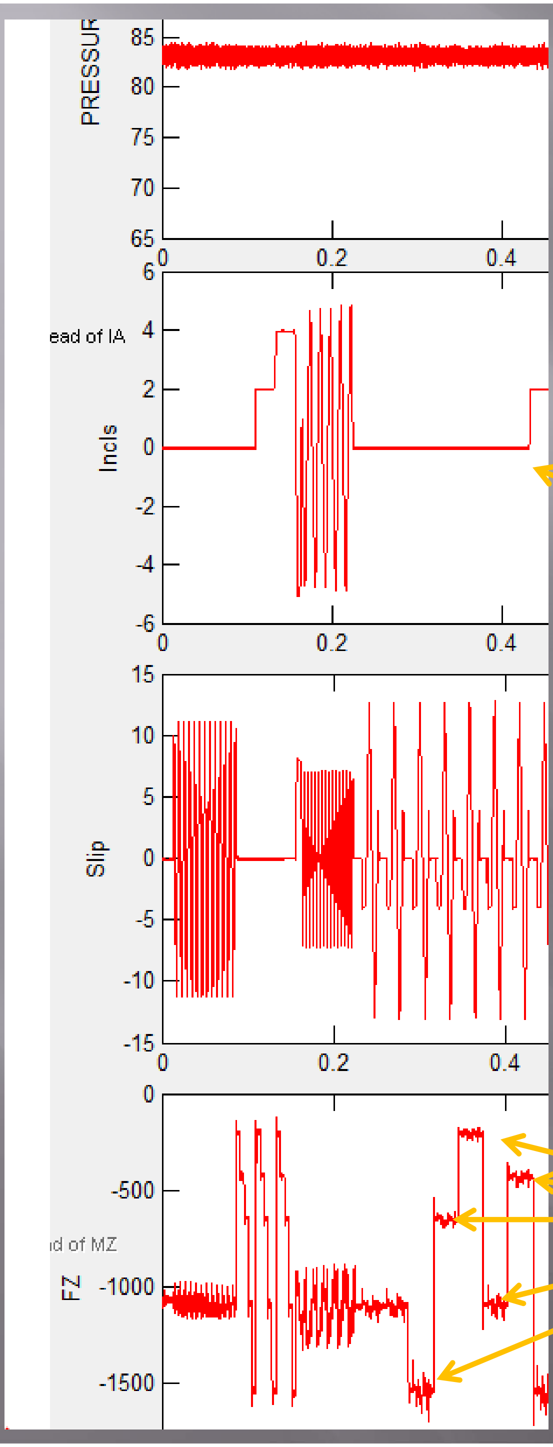
Splash Your Favorite Data Channels



Now Focus on the Needs of your Particular Tire Model

- For Example:
  - The Pacejka4 LapSim Tire Model in its current form uses just 1 Inclination Angle data Group.
  - So now we want to extract just the zero camber angle data.
  - Note that the TIRF procedure called for 5 Fz loads to be run, BUT:
  - There is a warmup Fz load used that's a duplicate.
    - We don't want to include those scans in the data segment. This has been a problem in most of the test Rounds.
  - Best solution? Chose the data window with the Mouse !

Data Section Zoom



Zero INCL (Camber)

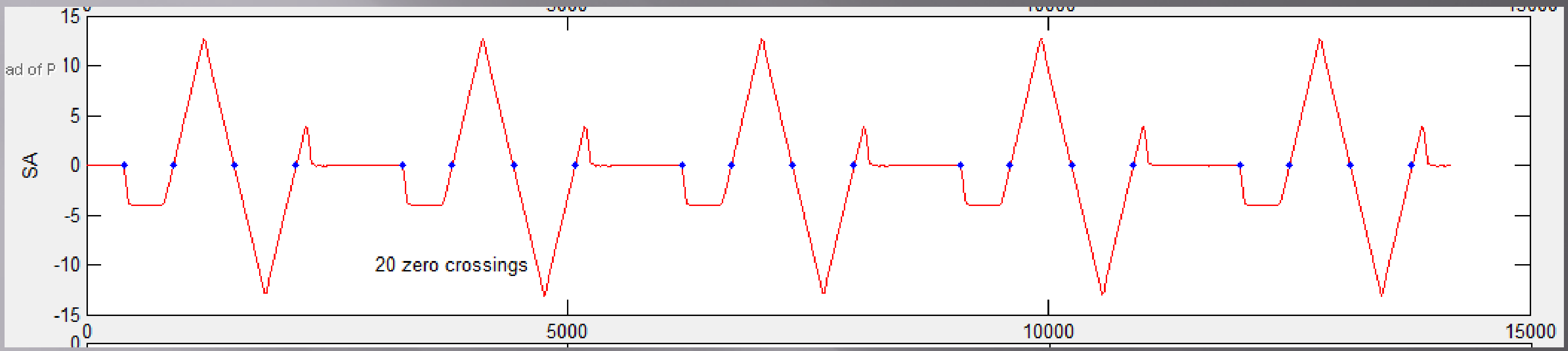
Slip Angle Sweeps

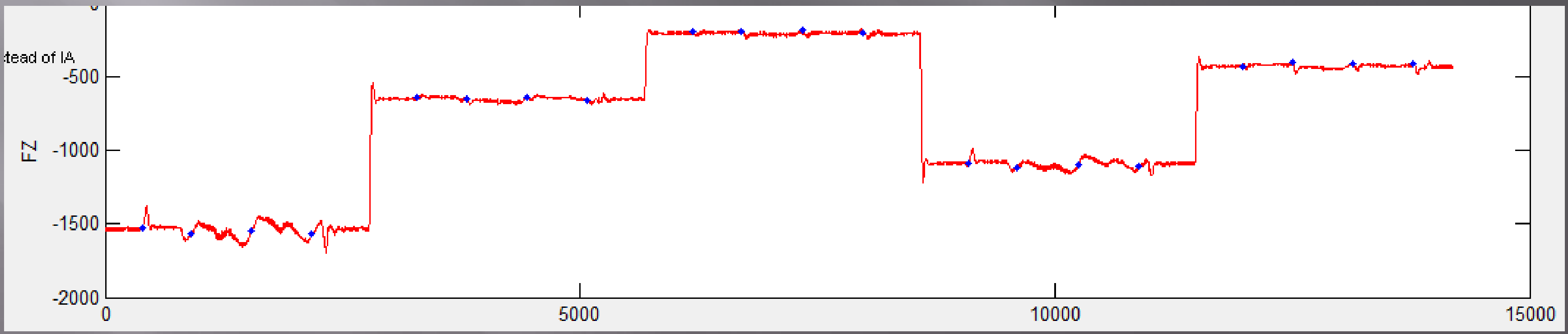
The 5 Fz Loads)

Now for the Tricky Part !

- Zoom-in on the zero camber region.
  - Use the MouseBox function to extract a Range of all data.
- Pay attention to the Fz change Sections.
- Fit a Spline to the Slip Angle channel.
  - (Spline Toolbox)
  - Use 'fnzeros' function on the resulting spline object to locate the slip zero crossings.
  - Note that there are always FOUR slip zero crossings per Fz load. So, you want to confirm that you have 20 zero crossings (5 Fz Loads x 4 Slip zero crossings per load with a Text Box message.

Like So:





Now you have Proper and complete Data Block

- You should now realize that all the Data you want to include in a Fitting Routine is between Slip Zero Crossing Locations:
- $2 \rightarrow 4 \quad Fz_1$
- $6 \rightarrow 8 \quad Fz_2$
- $10 \rightarrow 12 \quad Fz_3$
- $14 \rightarrow 16 \quad Fz_4$
- $18 \rightarrow 20 \quad Fz_5$

Now do the Fitting

- Extract Load and Slip sections.
- 5 Mean Loads or Use all the load points.
  - Whatever you prefer
  - Since you have the Spline for Slip Angle, you can subset it for increasing or decreasing slip velocity or All or Mean values of the Slip Hysteresis Loop.
  - For the Low Budget Quick Solution 4 Term Pacejka Model, I build a 2 dimensional Array with Columns for integer slip angles (min to max) and FZ Load rows for Fy, Mz and then Mx.

Now Turn The Crank

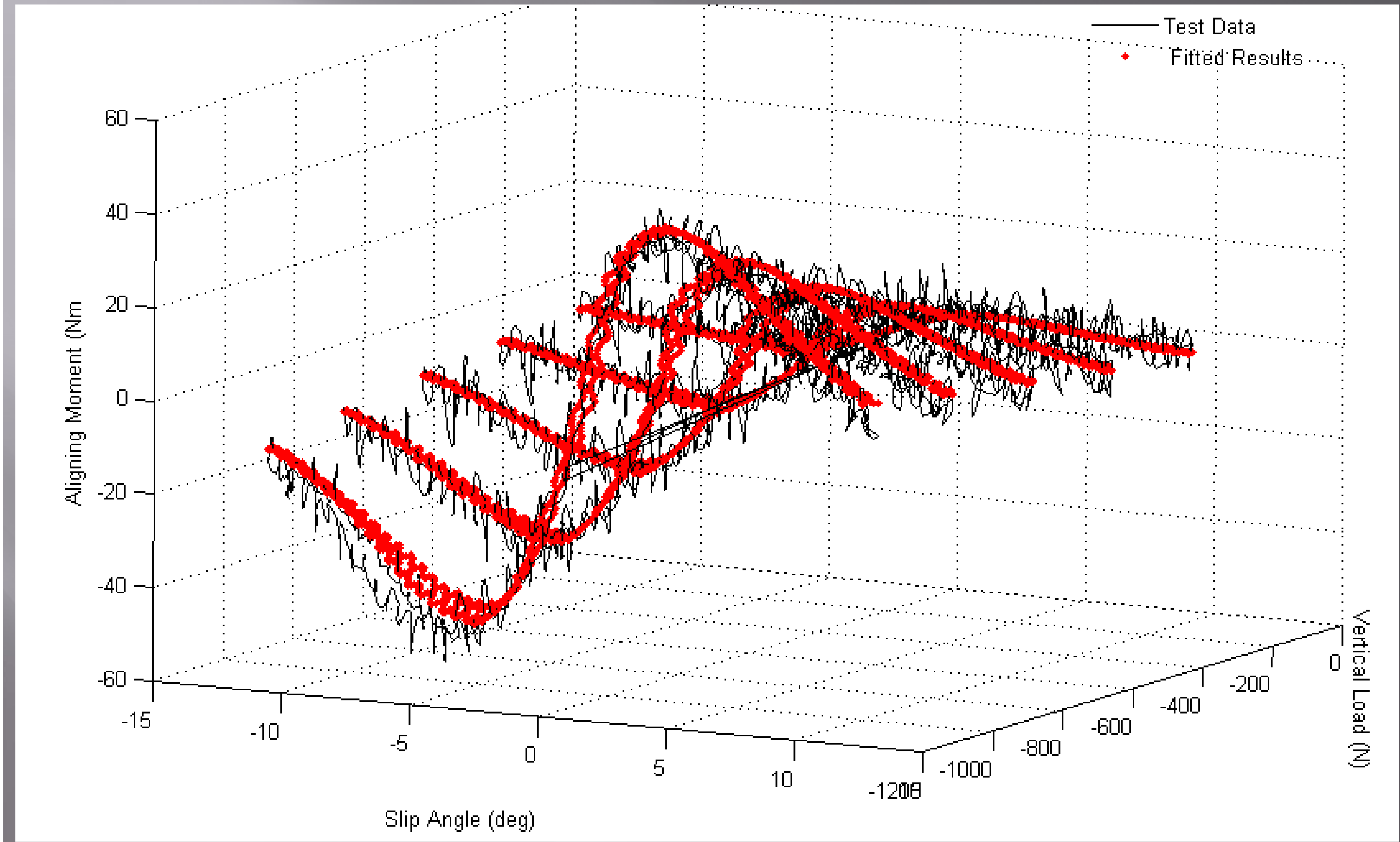
[The FY4 Array will Contain the Fitting Parameters]

- inx=1:length(sa); % 1 thru whatever
- xdata=[sa(inx) fz(inx)]; % Independent variables array
- ydata= fy(inx); % Dependent variable. Fy in this case
- figure('Name','Lateral Force Data Fitting'); hold on
- plot3(xdata(:,1),xdata(:,2),ydata,'k-') % plot raw data points
- f0=[1.33 .05 .1335 1.00]; % Initial guess for starting points
- options = optimset('MaxFunEvals',1000000000, 'TolFun',.00000001,'Display','off'); % Go with throttle up !
- [FY4,f_resnorm,f_residual]=lsqcurvefit('Pacejka4_Model',f0,
- xdata,ydata,[],[],options); % Behold the power of cheese !

Here's the Pacejka4 Function

- function fy = Pacejka4_Model(P,X)
- % x1 = X(:,1); %Slip
- % x2 = X(:,2); % Fz
- % D1 = P(1);
- % D2 = P(2);
- % B   = P(3);
- % C   = P(4);
- D   = (P(1) + P(2)/1000.*X(:,2)).*X(:,2);   % peak value (normalized
- fy = D.*sin(P(4).*atan(P(3).* X(:,1)));   % or Mz or Mx

After the Fitting is Done
Overlay the Math Version onto the raw data.
(Mz Shown Here)



Go ahead, Load the Information into an Excel Database

```
function load_Pacejka4_database_Callback(hObject, eventdata, handles)
options.Resize='on';
% options.WindowStyle='normal';
prompt={'Source','Tire_ID','Filename','Test_ID','Test_Speed','Pressure','Camber'}
size_wind = [1 55; 1 55; 1 15; 1 15;1 15; 1 15; 1 15;]; % Windows size
defaultanswer={handles.source,handles.tireid,handles.FileName,handles.testid,...
        num2str(handles.speed),num2str(mean(handles.pressure)),num2str(round(handles.camber))}
answer = inputdlg(prompt,'Load TTC Tire Test Pacejka4 Database',size_wind,defaultanswer,options);

record={char(answer(1)),char(answer(2)),char(answer(3)),char(answer(4)),char(answer(5)),char(answer(6)),char(answer(7)),...
  handles.fy_d1, handles.fy_d2, handles.fy_b, handles.fy_c, ...
  handles.mz_d1, handles.mz_d2, handles.mz_b, handles.mz_c,...
  handles.mx_d1, handles.mx_d2, handles.mx_b, handles.mx_c,...
  handles.loads(1),handles.loads(2),handles.loads(3),handles.loads(4),handles.loads(5)} ;

file='C:\Documents and Settings\BillCobb\My Documents\FSAE\TTC_Library.xls'
[numeric,txt]=xlsread(file);
newline=size(txt);
newline=newline(1)+1  % add a line don't clobber the last record
xlswrite(file, record,'Pacejka4',['a' num2str(newline)])

msgbox('TTC Excel Pacejka4 Database loaded.')
```

Other Tire models are done exactly the same way.

- For the 4D Spline and the MF5.2 Models, you Select all the INCL (Camber) sections.
  - That's 20 slip zeros per INCL x 3 INCLS == 60 zeros.
- Be careful to watch Speed and Pressure Sections in the .mat segment.
- Same processing for Spring Rate, Pneumatic Scrub, Lateral Spring Rate, etc.

Finis

- **acta est fabula plaudite !**