Flixan Utilities

The Flixan program includes additional utilities that perform other type of functions that further refine, modify, augment and reformat the flight vehicle models. There is a utility for combining systems and matrices together using an algorithm that is not vulnerable to algebraic looping. Matlab often causes algebraic loops errors when closing a loop around a system. There are also utilities for combining transfer-functions into systems, transforming continuous systems to discrete using (z) or Tustin transformations with variable delays, utilities for transforming systems and matrices from a system files (.Qdr) to formats that can be loaded into Matlab or converting Matlab generated data to system files. There are also utilities that modify or reduce already existing systems. Modifying the inputs and outputs, or reducing the variables of a system by selecting a smaller number of inputs, states, and outputs, or modifying the system units by rescaling some of the variables. Additional outputs can also be included from the states, state derivatives, or output derivatives. These utilities are useful for separating coupled systems to longitudinal and lateral subsystems. There are also utilities for processing the input data in batch mode. Batch instructions call multiple other utilities, process the entire input file, and generate systems without any interactive assistance from the user.

Each Flixan utility reads and processes a set of instructions data which are included in the input file (.Inp), in a similar fashion as the vehicle, the actuator and other Flixan programs. An input data file typically contains multiple data-sets to be processed by different utility programs. Each data-sets is processed by the corresponding utility program which typically creates a new system in the systems file according to the instructions and the data read from the set. The input data-sets are created either by using a text editor, copied from another file and modified, or more efficiently, each utility program itself is capable of generating its own input set interactively with the user, by means of menus and dialogs, as we shall see in the examples.

Initially the analyst must generate the desired dynamic models and matrices for his analysis and must prepare the input file by setting-up and testing each data-set, one set at a time. The dynamic models created may be rigid-body or high order models with flexibility, actuators, TWD, slosh, etc. They may include flight control or sensor dynamics. They may be coupled or decoupled, with pitch and lateral separated. They may be open-loop or closed-loop depending on the analysis required. When all the elements in the input file are prepared and tested for one flight condition, the modeling becomes easier and faster for the next run or case, because the same input file can be modified and be reused for a different situation or iteration. A batch can be included which can instantly processes the entire input file.

1.0 Systems Combination Program

The systems combination program is a Flixan utility that interconnects several state-space systems together and with matrices, which are read from a systems file (.Qdr). The combined system created is in state-space form and it is saved in the same systems file. The program uses two data files: an input data file (.Inp) and the systems file. The input file contains the titles of the systems to be combined, the interconnection instructions, and the definitions of input and output variables. The interconnection instruction describe how the various subsystems are combined together and how they connect to the big system inputs and outputs. There is also an interactive Graphics/ User interface (GUI) utility included that helps the user to enter the interconnection data in the input file or to read the interconnections from the file graphically without editing the file directly. Figure (1-1) shows the interaction between the systems combination program, the GUI, the user, and the data files.

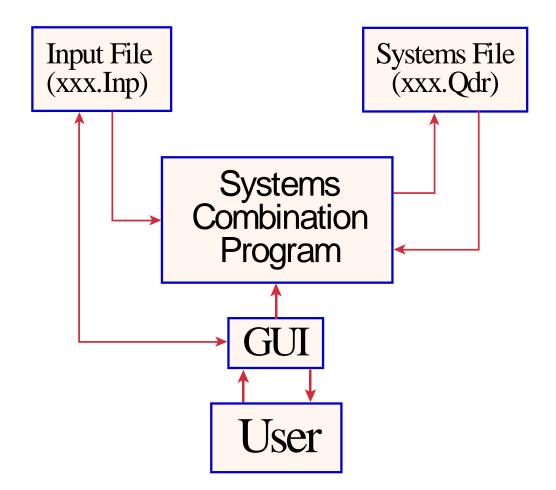
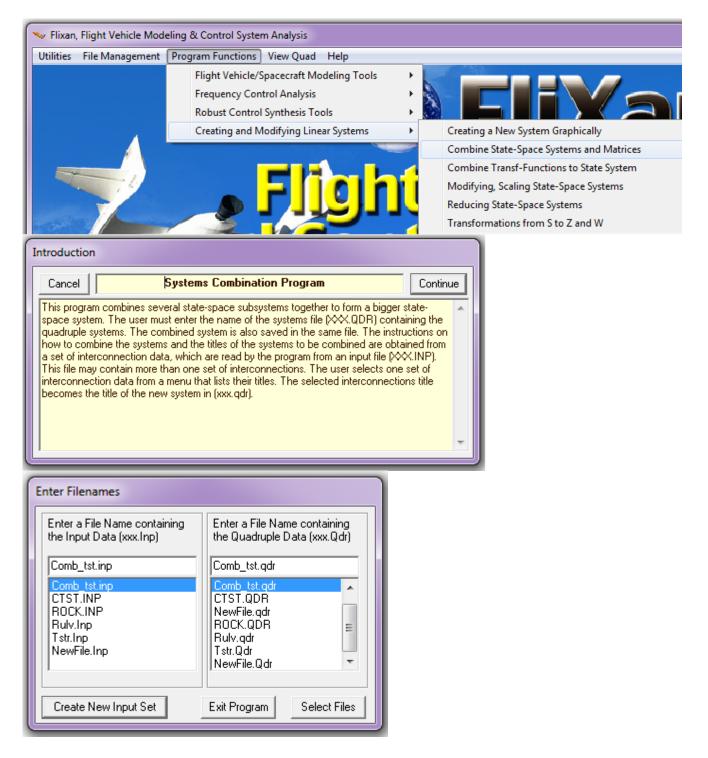


Figure (1.1) Diagram of the Systems Combination Utility Program showing its interaction with the User and the Input/ Output Files

1.1 Program and Input/ Output Files Selection

The systems combination program is selected from the Flixan main menu by clicking on the "*Program Functions*", select the "*Creating and Modifying Linear Systems*" group, and then click on "*Combine State-Space Systems and Matrices*". Then use the following file selection dialog to select the input data file and the systems file from the menus, as shown below.



Systems Interconnection data-set in the input file (.Inp)

System interconnection data-sets contain the system interconnection instructions and they are located in input files (.Inp). A typical data-set for combining two systems is shown below.

INTERCONNECTION OF SYSTEMS RULV, Pitch Closed-Loop, Simple Model ! Combine the Simple Vehicle model with the Actuator model in Closed-Loop ! Form for Time-Domain Simulation and Check the Eigenvalues Titles of Systems to be Combined Title 1 RULV, Pitch Axis, Max_Q (T=85 sec) Title 2 Main Engine Actuator SYSTEM INPUTS TO SUBSYSTEM 2 Eng. Actuator System Input 1 to Subsystem 2, Input 1, Gain=-1.8 Theta_command SYSTEM INPUTS TO SUBSYSTEM 1 Vehicl Distrb System Input 2 to Subsystem 1, Input 7, Gain= 1.0 Gust Velocity SYSTEM OUTPUTS FROM SUBSYSTEM 1 From Vehicle Via Matrix +I6 SYSTEM OUTPUTS FROM SUBSYSTEM 2 From Actuator System Output 7 from Subsystem 2, Output 1, Gain= 1.0 System Output 8 from Subsystem 2, Output 2, Gain= 1.0 Delta Engine Delta Dot Enq SUBSYSTEM NO 2 GOES TO SUBSYSTEM NO 1 Actuat to Veh Eng.Defl # 1 Subsystem 2, Output 1 to Subsystem 1, Input 1, Gain= 0.4082 Subsystem2, Output1 to Subsystem1, Input1, Galn= 0.4082Eng.Defl # 1Subsystem2, Output1 to Subsystem1, Input2, Gain= 0.4082Eng.Defl # 2Subsystem2, Output1 to Subsystem1, Input3, Gain= 0.4082Eng.Defl # 3Subsystem2, Output1 to Subsystem1, Input4, Gain= 0.4082Eng.Defl # 4Subsystem2, Output1 to Subsystem1, Input5, Gain= 0.4082Eng.Defl # 4Subsystem2, Output1 to Subsystem1, Input6, Gain= 0.4082Eng.Defl # 6 SUBSYSTEM NO 1 GOES TO SUBSYSTEM NO 2 Vehi to Actu Subsystem 1, Output 1 to Subsystem 2, Input 1, Gain= 1.8 Subsystem 1, Output 2 to Subsystem 2, Input 1, Gain= 2.3 Subsystem 1, Output 6 to Subsystem 2, Input 1, Gain=-0.008 Theta q - rate Nz Accelerat Definitions of Inputs = 2 Attitude Theta Command (radians) Wind Gust Disturbance (ft/sec) Definitions of Outputs = 8 Pitch Attitude (theta-rigid) (radians) (q -rigid) (rad/sec) Pitch Rate Angle of attack (alpha) (radians) Change in Altitude (dh) (feet) Forward Acceleration (V-dot) (ft/sec) Accelerometer # 1, (along z), (ft/sec^2) Actuator Delta_Engine (radians) Actuator Delta_Dot_Engine (rad/sec) _____

The first line in the data-set "INTERCONNECTION OF SYSTEMS", defines the type of input data and the utility program that will process it. This is because the input file typically also contains data for other Flixan programs, such as, transfer function combination data, flight vehicle modeling data, etc. The second line contains the title of the new system to be created. Every system in Flixan is identified by a title which is less than 100 characters long. The following few lines, starting with (!), are comment lines. They provide a short description of the new system for documentation purposes and they are optional. The comment lines are also copied in the systems file below the new system title. The lines below the line "Titles of Systems to be Combined", contain the titles of systems to be combined together. These systems must already exist in the systems file (.Qdr), otherwise, an error will occur. Notice that each system is assigned a reference number, (1, 2, 3, ..., max= 9). The program searches the systems file (*.Qdr), finds the subsystem titles, reads the quadruple data for each

subsystem and combines them together. The lines below the system titles define how the systems are to be connected together, and there are four types of interconnection groups.

- 1. Direct connections from the combined system inputs to the combined system outputs that define the direct feed-through matrix D.
- 2. Connections from the new system inputs to one of the subsystem inputs, followed with the detail connections to this subsystem.
- 3. Connections from one of the subsystem outputs to the combined system's outputs, followed with the detail connections from this subsystem.
- 4. Connections between one of the subsystem outputs to another subsystem inputs, followed with the detail interconnections between the two subsystems.

In the interconnections data, the sub-systems to be combined are referred to by their corresponding system numbers. Matrices can also be used in the interconnections. The matrices must already exist in the systems file and they are defined by their corresponding matrix name (not title). Identity matrices can also be used for interconnections and in this case they don't have to exist in the systems file. At the bottom of the data-set the user may include definition labels of the new system's inputs and outputs. The input and output definitions are optional. If they are not included the program creates default labels.

An experienced user can easily create by copying and pasting an interconnection data-set in the input file by using a standard text editor. There is, however, a GUI capability in the program that makes it easier for the user to create the interconnections set by using menus and dialogs. The GUI helps to enter the title, selecting the systems to be combined, defining the new system input and output labels, entering the user comments, and defining the interconnections. It also provides text editing capability to modify the input data. The GUI will also save the interconnections in the input data file, and run the program to create the combined system in file (.Qdr).

Systems File

The systems file (with an extension Qdr) contains state-space systems and matrices to be combined. The program reads the systems to be combined and the matrices from this file and when it finishes combining them together it saves the new system at the bottom of this file without destroying the already existing data. Interconnections between subsystems, inputs, and outputs are not always defined individually but they can be vectored interconnections defined by matrices. The gain matrices must already be saved in the systems file under a unique title and name. The matrix name is used in the interconnection, for example, "Via Matrix Kc". The program locates the interconnection matrix in the systems file and checks to make sure that its dimension is correct, or flags an error if it can't find it. A state-space system has the form shown in the following example.

STATE-SPACE SYSTEM ... Main Engine Actuator ! Comments for the Actuator System Number of Inputs, States, Outputs, Sample Time dT (for discrete)= 2 4 3 0.0 Quadruple Matrices: (A,B,C,D) Matrix A Size = 4×4 2-Column 4-Column 1-Column 3-Column 1-Row -0.52100776E+02 -0.11670057E+02 -0.10960186E+02 -0.20318937E+01 2-Row -0.53950001E+02 -0.14243727E+02 -0.13377304E+02 0.0000000E+00 3-Row 0.00000000E+00 0.0000000E+00 0.0000000E+00 0.10000000E+01 MATRIX B SIZE = 4 X 21-Column 2-Column 1-Row 0.40223714E+02 0.0000000E+00 2-Row 0.49094502E+02 0.0000000E+00 3-Row 0.0000000E+00 0.0000000E+00 4-Row 0.0000000E+00 0.22143490E-03 MATRIX C SIZE = 3 X 41-Column 2-Column 3-Column 4-Column 1-Row 0.00000000E+00 0.0000000E+00 0.10000000E+01 0.0000000E+00 2-Row 0.0000000E+00 0.0000000E+00 0.000000E+00 0.1000000E+01 3-Row 0.00000000E+00 0.11136935E+04 -0.27679742E+04 -0.36536758E+01 _____ MATRIX D $SIZE = 3 \times 2$ 1-Column 2-Column 1-Row 0.0000000E+00 0.0000000E+00 2-Row 0.0000000E+00 0.0000000E+00 3-Row 0.0000000E+00 0.22143490E-03 Definition of System Variables Inputs = 2 Engine Deflection Command (delta-com) (radians) 1 Load-Torque Feedback (T1) (ft-lb) 2 Outputs = 3 1 Engine Gimbal Rotation (delta) (radians) 2 Engine Gimbal Rate (delta-dot) (rad/sec) 3 Engine Gimbal Accelerat.(delta-d-dot) (rad/sec^2) States = 4 1 Differ. Pressure Feedback (DPF) (ft-lb) 2 Piston Displacement (Xr) (feet) 3 Engine Gimbal Rotation (delta-dd) (radians) 4 Engine Gimbal Rate (delta-dot) (rad/sec)

The first line indicates that the data which follow is a state-space system. The second line is the title of this system, same title as the data-set in (.Inp) file. The next lines starting with (!) are comment lines, same as the input data comments. The length of the title and length each comment line should be less than 100 characters long. The next line defines the system dimension and the sampling rate (0 for continuous system). The data at the bottom of the set below is the state-space system matrices (A, B, C, D) are definitions of the system inputs, states, and output variables, which are optional. The systems combination program will either process an already existing set of interconnection data or it can create a set of interconnection data interactively with the user, and then run it. Let us demonstrate in the following section an example of creating a systems interconnection set and then run it.

1.2 Creating a New Interconnection Set Interactively

In this example we have a systems file "*RULV.Qdr*" that contains two systems: a pitch vehicle model of a launch vehicle with 6 engines and an actuator. This example is located in folder "*C:\Flixan\Comb_Trfn\Examples*". We will combine the two systems together by generating the interconnections data-set in file "*RULV.Inp*" that will connects the two systems, as shown in Figure (1.2), and then process the set to create the closed-loop system.

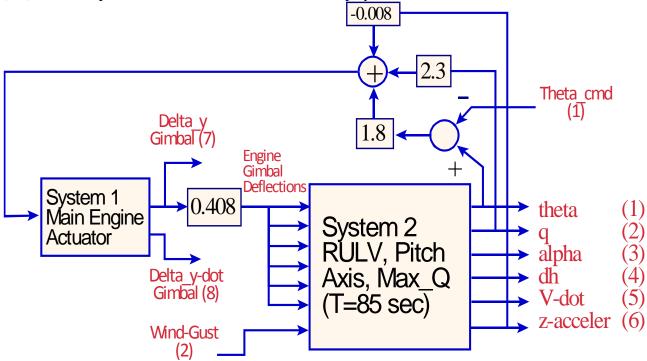
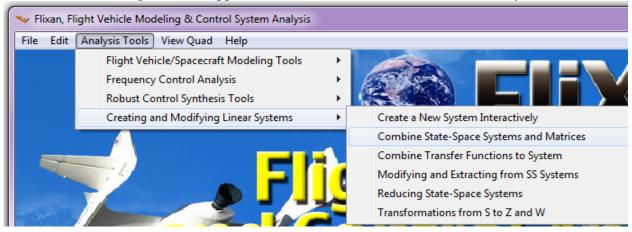


Figure (1.2) Two Subsystems in Closed-Loop Form Interconnection

So we begin the systems combination program from the Flixan main menu by clicking on "Analysis Tools", then "Creating and Modifying Linear Systems", and then on "Combine State-Space Systems and Matrices". Then from the following file selection menu select the input data file and the systems file, as shown below, and then click on "Create a New Input Set" to begin the interconnections interrogation session. In the systems dimension dialog you must enter the number of systems to be connected (2), the combined system inputs (2), and the combined system outputs (8). The systems interconnection dialog will then appear from where the user will enter the new system data.



Enter Filenames		1
Enter a File Name containing the Input Data (xxx.Inp)	Enter a File Name containing the Quadruple Data (xxx.Qdr)	
Bulv.Inp	Rulv.gdr	
NewFile.inp	NewFile.gdr	
Rulv.Inp NewFile.Inp	Rulv.gdr NewFile.Qdr	
Create New Input Set	Exit Program Select Files	
Total Number of Systems to be Comb Maximum Number of Subsystem Inpu	System Dimension	
Maximum Number of Subsystem State	es 200 Number of New Sy	vstem Inputs 2
Maximum Number of Subsystem Outp	outs 40 Number of New Sy	vstem Outputs β

<u>Title:</u> The systems interconnection GUI dialog is shown below used for entering the interconnection parameters for our example. You must first enter a title for the combined system "*RULV, Pitch Closed-Loop, Simple Model*", and click on the "Update Data" button. You must be updating the data every time you enter or modify the data in one of the tabs.

Direct Input to Output Connections Tab: The systems interconnection dialog has tabs for entering different types of data. The first tab on the left side is used for defining direct connections from the new system inputs to the new system outputs without connecting to any of the subsystems. This is used, of course, if there are any direct connections because in most cases, such as in this example, there aren't any direct connections from inputs to outputs. In essence you are defining the direct feedthrough matrix (D) of the state-space representation. The dialog includes buttons for adding a new connection, deleting, or modifying an already existing connection. If you click on "Add a Connection" a couple of menus will appear on the right. The menu on the left shows the titles of the new system inputs and the menu on the right shows the titles of the new system outputs. Default titles are used if the inputs/ outputs have not been defined. The user may select a single "from" input and a single "to" output pair for a scalar connection between one of the system inputs to one of the system outputs, one at a time, enter the gain in the field below, and click on "OK" to continue. Vectored interconnections between new system inputs and outputs can also be defined. In this case the user must select a group of inputs and a group of outputs using the "from" and "to" menus, for example, 2 inputs and 3 outputs. In this case the program expects a matrix to define the interconnection between the new system inputs and outputs. In fact, it expects the name of a (3x2) matrix that already exists in the systems file. It also expects the sign of the interconnection, for example, +Kc2 or -Kmix . It is also possible to define vector interconnections using identity matrices. The sign and size of the identity matrix must be included, for example, +I3 or -I5. In this case the identity matrix does not have to be saved in the systems file. You must make sure that you select the proper number of inputs and outputs that correspond to the size of the identity matrix or the dimensions of any other interconnection matrix, and starting from the first input and the first output. You must also remember to click on "*Update Data*" between tabs.

System Inputs to Subsystem Connections Tab: Select the second tab which is used for connecting system inputs to subsystem inputs and click on "*Add Connections*". It is similar to the first tab, except, it is more complex because there more than one set of connections to be defined from the combined system inputs to the subsystem inputs. For this reason, the system to subsystem input interconnections are defined in two levels, a top level and a detailed level. The top level interconnection defines which subsystems are connected to the combined system inputs without any specific details. The detailed level defines the actual interconnections between the combined system inputs and the subsystem's inputs. When you create a new interconnections set there aren't any connections defined yet. To begin an input to subsystem interconnection you must first click on the "*Add Connections*" button, and a menu appears on the upper-right showing the subsystems available to be connected. From the upper right menu select one of the subsystems at a time to be connected to the new system inputs. First select "*System 1, Main Engine Actuator*" and click on "*Add Connection*". A new high level connection appears in the upper-left menu "*System Inputs to Subsystem 1 [Main Engine Actuator]*". There are no details yet, the interconnection specifics will be added later.

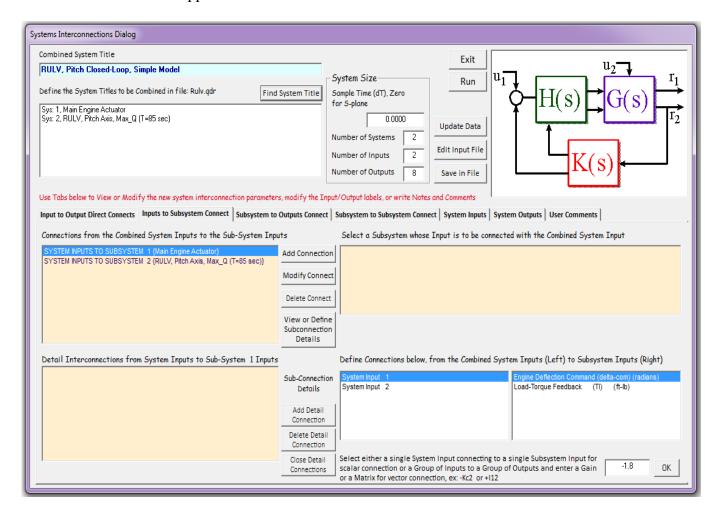
Systems Interconnections Dialog	
Combined System Title	Exit
RULV, Pitch Closed-Loop, Simple Model	System Size
Define the System Titles to be Combined in file: Rulv.qdr Find System Title	Sample Time (dT), Zero for S-plane $H(s) \rightarrow G(s)$
Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec)	\uparrow \square
	Number of Systems 2
	Number of Inputs 2 Edit Input File K(S)
	Number of Outputs 8 Save in File
Use Tabs below to View or Modify the new system interconnection parameters, modify the I	input/Output labels, or write Notes and Comments
Input to Output Direct Connects Inputs to Subsystem Connect Subsystem to Outputs Connect	ct Subsystem to Subsystem Connect System Inputs System Outputs User Comments
Connections from the Combined System Inputs to the Sub-System Inputs	
Add Connect	ion X
Modify Conn	ect
Delete Conne	Pou must select a system to connect in the upper right menu and then click on the Add Connections button
View or Defi	
Subconnecti Details	
·	OK

An additional top level connection is also defined. From the upper-right menu select "System 2, RULV, Pitch Axis, Max_Q ($T=85 \ sec$)" and click on "Add Connection". The two subsystems are now included in the upper-left display as recipients from the new system inputs. It means that both subsystems are receiving external inputs (in this case theta-command, and wind-gust). In case of error, you may also use the option buttons to modify or to delete some of the high level connections.

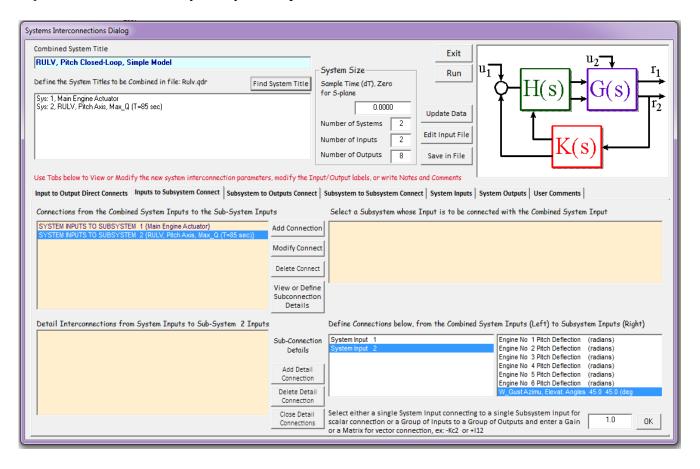
Systems Interconnections Dialog		
Combined System Title RULV, Pitch Closed-Loop, Simple Model	stem Title Sample Time (dT), Zero for 5-plane 0.0000 Number of Systems Number of Inputs Number of Outputs 8	Exit Run Update Data Edit Input File K(s)
Use Tabs below to View or Modify the new system interconnection paramete Input to Output Direct Connects Inputs to Subsystem Connect Connections from the Combined System Inputs to the Sub-System Inp SYSTEM INPUTS TO SUBSYSTEM 1 {Main Engine Actuator} SYSTEM INPUTS TO SUBSYSTEM 2 {RULV, Pitch Axis, Max_Q (T=85 sec)}	modify the Input/Output labels, or write Not utputs Connect Subsystem to Subsystem Con	nect System Inputs System Outputs User Comments se Input is to be connected with the Combined System Input uator

When the high level interconnection definitions are complete the next step is to enter the interconnection details between the combined system inputs and the individual inputs for each of the subsystems. From the upper-left menu select one of the high level connections, for example, "*System Inputs to Subsystem 1 {Main Engine Actuator}*" and click on "*View or Define Sub-Connection Details*" button to define the detail connections between the system inputs and subsystem #1. A detailed level interconnections display appears in the lower left side directly below the high level definitions menu with similar buttons on its right side as the high level menu. It is empty for now because the interconnections between the system inputs and the "*Subsystem 1 {Main Engine Actuator}*" inputs are not defined yet. They will later be included in this list. Click on "*Add Detail Connections*" to define the detail connections between the combined system inputs and subsystem #1.

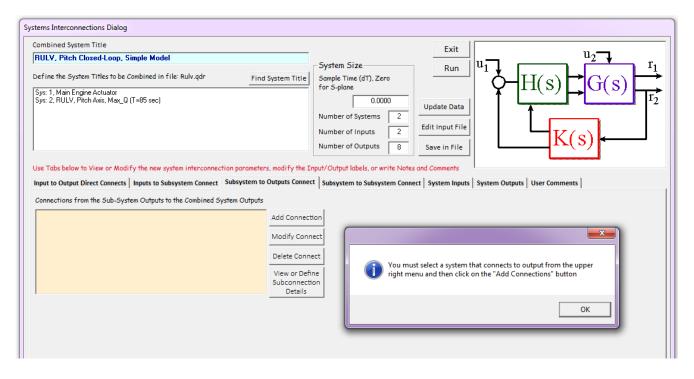
Two white menus appear at the lower right and they are used to define the "from" and "to" connection details between the system inputs and the actuator subsystem #1 inputs. The left menu shows a list of the combined system 2 inputs (generic names because they haven't been defined yet), and the right menu shows a list of the actuator subsystem #1 inputs (as defined in the systems file). The second input "Load-Torque" will not be used in this example. The user selects variables to be connected from the two menus to define the interconnections. If you select only one item from each menu the program assumes that you are defining a scalar connection from one of the system inputs to one of the subsystem inputs and it expects a gain number in the gain field below the menus, and click "OK" to continue. Otherwise, if you select more than one system inputs or more than one subsystem inputs from the menus, for example, 1 system input and 2 subsystem inputs, the program expects a matrix interconnection. In such case it would expect the name of a (2x1) matrix and assume that it has been saved in the systems file. It also expects the sign of the interconnection, for example, -Kc or +H2. In this case, however, the interconnection shown below is scalar and connects the first system input (theta_comd) to the first actuator input which is (engine deflection command), with a gain of (-1.8), see Figure (1.2). Click "OK" and the interconnection will appear in the lower-left display. Click on "Close Detail Connections", the lower menus disappear, and the dialog returns to the high level connections menu in the upper left hand corner of the tab.



Similarly, from the upper-left menu select the second high level connection between "Combined System Inputs to Subsystem Inputs", which is, "System Inputs to Subsystem 2 (Rulv ...)", and click on: "View or Define Sub-Connection Details" button to define the detail connections between the system inputs and subsystem #2. The lower-left display becomes visible again and it is empty because the connections to system #2 have not been defined yet. Click on "Add Detail Connections" to define the detail connections between the combined system inputs and subsystem #2, which is the vehicle model. It has 6 engine deflection inputs and a wind-gust disturbance. The connections between the system inputs and the subsystem #2 inputs are defined using the menus in the lower-right. In this case we must connect the 2nd system input with input #7 of subsystem #2, which is the wind-gust disturbance, see Figure (1.2). Enter a gain of 1.0, click "OK", and the interconnection will appear in the lower-left display. Click on "Close Detail Connections" and the lower menus will disappear. Click on the "Update Data" button every time you complete a tab.



Subsystem Outputs to System Output Connections: You may now select the third tab from the left which is used for defining connections between a subsystem's outputs to the combined system outputs. It is very similar to the previous tab in the sense that the interconnections are defined in two levels. The high level interconnection defining which subsystems are connected to the combined system outputs, and the detailed level defining the exact interconnections from the subsystem outputs to the combined system outputs. To introduce a new subsystem to the output connection click on "Add Connections" and a menu appears on the upper-right showing the available subsystems. From that menu select one of the subsystems to be connected at a time to the combined system outputs. In this case select "System 2, RULV, Pitch Axis, Max_Q (T=85 sec)" and click on "Add Connection" button. Both subsystems will be included in the upper-left display because they are both connecting to the new system outputs. When you finish defining the high level connections the next thing to do is to enter the interconnection details between the selected subsystem outputs and the "combined system" outputs using the lower menus.



Let us first consider the subsystem #2 to system output connections by selecting the "System Outputs from Subsystem 2 {Actuator}" connection from the upper-left menu and clicking on "View or Define Subconnection Details" button to define the interconnection details. The lower-left display (showing the detail connections) opens up directly below the high level definitions menu but it is empty for now because the interconnections are not defined yet. It uses similar buttons on its right side as the high level menu. Click on "Enter Detail Connections" to define the detail connections between subsystem #2 and the combined system outputs using the "from" and "to" white menus in the lower-right. The left menu shows a list of subsystem #2 outputs as defined in the systems file and the right menu shows a list of the combined system outputs which are default names since they haven't been defined yet. In this case we must connect all 6 vehicle model outputs to the first 6 outputs of the combined system. The last two outputs will later be connected to subsystem #1 outputs. In this case the interconnections are not defined as shown below, and click "OK". The matrix interconnection appears in the lower-left display as "Via Matrix +16". Click on "Close Detail Connections" and the lower menus disappear.

Systems Interconnections Dialog					
Combined System Title			Exit		
RULV, Pitch Closed-Loop, Simple Model	_	System Size			
Define the System Titles to be Combined in file: Rulv.qdr Find	System Title	Sample Time (dT), Zero	Run		$\frac{1}{2}$
Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec)		for 5-plane 0.0000			
		Number of Systems 2	Update Data		
		Number of Inputs 2	Edit Input File		
		Number of Outputs 8	Save in File	K(s)	←
Use Tabs below to View or Modify the new system interconnection parameter	no modificatho Topo	ut/Output labels, on write Note	c and Commonto		4
Input to Output Direct Connects Inputs to Subsystem Connect Subsystem to				System Outputs User Comments	
Connections from the Sub-System Outputs to the Combined System Outputs	·			s to the Combined System Output	· · ·
SYSTEM OUTPUTS FROM SUBSYSTEM 2 {RULV, Pitch Axis, Max_Q (T=85 sec	Add Connection	1			
	Modify Connec				
	Delete Connect	t			
	View or Define Subconnection				
	Details				
Detail Interconnections from Sub-System 2 Outputs to Combined System O	outputs	Define Connections from th Outputs below	ie Sub-system	to the Combined System Outputs	s below
	Sub-Connection			System Output 1 System Output 2	<u>^</u>
	Details	Angle of attack (alpha)	(radians)	System Output 3	=
	Connections	Forward Acceleration (V-do		System Output 4 System Output 5	_
	Delete Detail Connections	Accelerometer # 1, (along z), (ft/sec^2)	System Output 6 System Output 7	-
	Close Detail	 Select either a single Sub	system Output conn	ecting to a single System Output	
	Connections		enter Gain, or conn	ect a Group of Subsystem to	+16 ОК
L		System outputs for vector	ca connection and c		
Systems Interconnections Dialog					
Combined System Title			Exit		
		System Size			2 r ₁
Combined System Title RULV, Pitch Closed-Loop, Simple Model	System Title	Sample Time (dT), Zero	Exit Run		r_1
Combined System Title RULY, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Find Sys: 1, Main Engine Actuator Find	System Title	Sample Time (dT), Zero for S-plane		H(s)	r_1 r_2 r_3 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr	l System Title	Sample Time (dT), Zero for S-plane			r_1 r_2 r_2
Combined System Title RULY, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Find Sys: 1, Main Engine Actuator Find	I System Title	Sample Time (dT), Zero for S-plane 0.0000 Number of Systems 2	Run	H(s)	r_1 r_2 r_2
Combined System Title RULY, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Find Sys: 1, Main Engine Actuator Find	I System Title	Sample Time (dT), Zero for S-plane	Run Update Data	H(s)	r_1 r_2 r_2 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Find Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec)	I System Title	Sample Time (dT), Zero for 5-plane 0.0000 Number of Systems 2 Number of Inputs 2 Number of Outputs 8	Run Update Data Edit Input File Save in File		r_1 r_2 r_2 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec)	I System Title	Sample Time (dT), Zero for 5-plane 0.0000 Number of Systems 2 Number of Inputs 2 Number of Outputs 8 ut/Output labels, or write Note	Run Update Data Edit Input File Save in File		r_1 r_2 r_2
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We must now define the connections between the engine actuator (subsystem #1) and the combined system outputs. Using the upper-right menu select "*System #1 Main Engine Actuator*" and click on "*Add Connection*" button. The subsystem to output connection is then confirmed and included in the upper-left

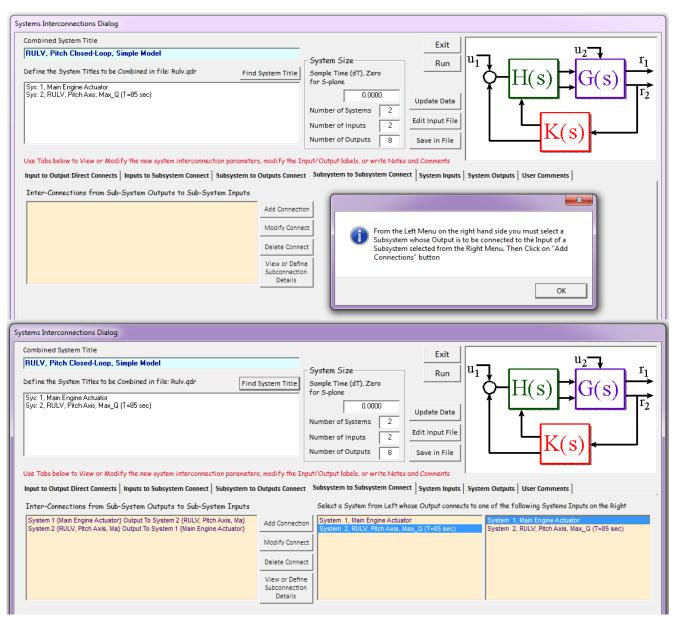
hand display as "System Outputs from Subsystem #1 (...)". To define the detail sub-connections you must select it from the upper-left hand menu and click on "View or Define Sub-Connection Details" button. The lower-left display becomes visible but it is empty because the connections have not been defined yet. Click on "Enter Detail Connections" to define the detail connections between subsystem #1 and the combined system outputs using the "from" and "to" menus in the lower-right. In this case we must connect the engine gimbal rotation to system output #7 and the gimbal rate to output #8, with a gain of 1.0, one at a time, and click "OK". The two detailed interconnections are shown in the lower-left display. Click on "Close Detail Connections" and the lower menus will disappear. Remember to click on the "Update Data" button every time you complete one of the tabs.

Systems Interconnections Dialog	
Combined System Title	Exit
RULV, Pitch Closed-Loop, Simple Model	
Define the System Titles to be Combined in file: Rulv.qdr Find System Title	System Size Sample Time (dT), Zero for S-plane
Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max. Q (T=85 sec)	for S-plane $(S) \rightarrow (S) \rightarrow (T_2)$
Sys. 2, HULY, FILCHAXS, Max_Q (1=03 SEC)	Update Data
	Number of Systems 2 Edit Input File
	Number of Outputs 8 Save in File
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Connections from the Sub-System Outputs to the Combined System Outputs	Select a Sub-System whose Output Connects to the Combined System Output
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Modify Conne	
Delete Conne	
View or Defin Subconnectio	
Details	
Systems Interconnections Dialog	
Combined System Title	Exit
RULV, Pitch Closed-Loop, Simple Model	-System Size u_1 u_1 u_1 r_1
Define the System Titles to be Combined in file: Rulv.qdr Find System Title	Sample Time (dT), Zero Run $u_1 + TT(a) \rightarrow C(a) \rightarrow 1$
Sys: 1, Main Engine Actuator	for S-plane $\Upsilon \Pi(S) \mapsto U(S) \mapsto$
Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec)	0.0000 Update Data
	Number of Systems 2
	Number of Inputs 2 Edit Input File
	Number of Outputs 8 Save in File
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Connections from the Sub-System Outputs to the Combined System Outputs	
SYSTEM OUTPUTS FROM SUBSYSTEM 1 {Main Engine Actuator}	
Modify Conne	ict
Delete Conne	ct
View or Defin	
Subconnectio Details	n
Detail Interconnections from Sub-System 1 Outputs to Combined System Outputs	
Sub-Connection	20
Details	
Enter Detail Connections	
Delete Detail	
Connections	
Close Detail Connections	

Systems Interconnections Dialog		
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RULV, Pitch Closed-Loop, Simple Model		Exit u_1 u_2 r_1
Define the System Titles to be Combined in file: Rulv.qdr	n Title 5a	System Size Run u_1 $H(S)$ $G(S)$ r_1
Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec)		1 1 1 1 1 1
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Add C SYSTEM OUTPUTS FROM SUBSYSTEM 1 {Main Engine Actuator}	Connection	
Modif	ify Connect	
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Subco	onnection Details	
Detail Interconnections from Sub-System 1 Outputs to Combined System Outputs		Define Connections from the Sub-system
		Outputs below to the Combined System Outputs below Engine Gimbal Rotation (deta) (radians) System Output 2
		Engine Gimbal Rate (delta-dot) (rad/sec) System Output 3
	ter Detail nnections	System Output 5
	ete Detail	System Output 6 System Output 7
	nnections	System Output 8
		Select either a single Subsystem Output connecting to a single System Output for Scalar connection and enter Gain, or connect a Group of Subsystem to
		for Scalar connection and enter Gain, or connect a Group of Subsystem to I.u OK System Outputs for Vectored connection and enter a Matrix. ex: -Kc2
Systems Interconnections Dialog		
Combined System Title		Exit
Combined System Title RULV, Pitch Closed-Loop, Simple Model		Exit u_1 u_2 r_1
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Find System	n Title Sa	System Size u_1 u_1 u_2 I_1 Sample Time (dT), Zero u_2 I_1
Combined System Title RULV, Pitch Closed-Loop, Simple Model	n Title Sa	System Size ample Time (dT), Zero $or S-plane$ u_1 $H(S)$ $G(S)$ r_1 r_2
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Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection parameters, modify	n Title Sa for Nu Nu fy the Input/	System Size Somple Time (dT), Zero or S-plane umber of Systems 2 tumber of Outputs 8 K(S)
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Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection parameters, modifing the to Output Direct Connects Inputs to Subsystem Connect Sys: SYSTEM OUTPUTS FROM SUBSYSTEM 2 (RULV, Pitch Axis, Max_Q (T=85 sec) SYSTEM OUTPUTS FROM SUBSYSTEM 2 (RULV, Pitch Axis, Max_Q (T=85 sec) SYSTEM OUTPUTS FROM SUBSYSTEM 2 (RULV, Pitch Axis, Max_Q (T=85 sec) SYSTEM OUTPUTS FROM SUBSYSTEM 1 (Main Engine Actuator) Modified Detail Interconnections from Sub-System 1 Outputs to Combined System Outputs Output 7 from Subsystem 1 (Main Engine Actuator) Output 1, Gaine 1.0000	Title Sa for Nu Nu Nu Sconnect S Connection ify Connect te Connect v or Define connection Details	System Size Sample Time (dT), Zero or S-plane Update Data Update Data Edit Input File Save in File Save in File Subsystem to Subsystem Connect System Inputs System Outputs User Comments Select a Sub-System whose Output Connects to the Combined System Output Select a Sub-System whose Output Connects to the Combined System Output Define Connections from the Sub-system Outputs below Engine Gimbal Rotation (deta) (radians) Engine Gimbal Rotation (deta, dry (radians) Engine Gimbal Rate (deta, dry (radians) System Output 3
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection parameters, modif Input to Output Direct Connects Inputs to Subsystem Connect Subsystem to Outputs Connections from the Sub-System Outputs to the Combined System Outputs SYSTEM OUTPUTS FROM SUBSYSTEM 2 (RULV, Pitch Axis, Max_Q (T=85 sec) SYSTEM OUTPUTS FROM SUBSYSTEM 1 (Main Engine Actuator) Detail Interconnections from Sub-System 1 Outputs to Combined System Outputs Detail Interconnections from Sub-System 1 Outputs to Combined System Outputs Dutput 7 from Subsystem 1 (Main Engine Actuator) Output 1, Gain= 1.000 Enterl	Title Safar	System Size Sample Time (dT), Zero or S-plane Update Data Update Data Update Data Update Data Edit Input File Save in File Save in File Subsystem to Subsystem Connect System Inputs User Comments Subsystem to Subsystem Connect System Inputs User Comments Select a Sub-System whose Output Connects to the Combined System Output Define Connections from the Sub-system Outputs below Engine Gimbal Rotation (delta) (radians) Engine Gimbal Rotation (delta-dot) (rad/sec) Engine Gimbal Rate (deta-dot) (rad/sec) Engine Gimbal Rate (deta-dot) (rad/sec) System Output 5 System Output 5 System Output 5
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Systems Interconnections Dialog			
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Use Tabs below to View or Modify the new system interconnection parameters, modify the I Input to Output Direct Connects Inputs to Subsystem Connect Subsystem to Outputs Connections from the Sub-System Outputs to the Combined System Outputs SYSTEM OUTPUTS FROM SUBSYSTEM 2 (RULV, Pitch Axis, Max_Q (T=85 sec) SYSTEM OUTPUTS FROM SUBSYSTEM 1 (Main Engine Actuator) Modify Connect Detail Interconnections from Sub-System 1 Outputs to Combined System Outputs Detail Interconnections from Sub-System 1 Outputs to Combined System Outputs Output 8 from Subsystem 1 (Main Engine Actuator) Output 1, Gain= 1,000 Output 8 from Subsystem 1 (Main Engine Actuator) Output 2, Gain= 1,000 Delete Details Enter Details	tion ion		tputs User Comments
Connection Close Deta Connection	1		

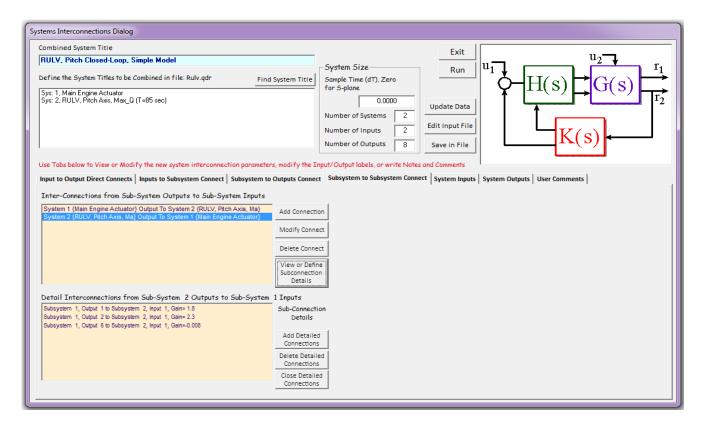
Subsystem Outputs to Subsystem Input Connections: The fourth tab from the left is used for defining scalar or matrix connections between subsystem outputs and other subsystem inputs or an algebraic feedback loop around the same subsystem. This interconnection algorithm does not cause "algebraic loop" errors like those appearing in Matlab/ Simulink. This type is very similar to the previous two tabs and the interconnections are defined in two levels. The high level interconnection defines which subsystem's output and input connect without specific details, using the two menus in the upper-right, and the lower level defines the exact interconnections between the "from" subsystem outputs and the "to" subsystem inputs using the lower level menus, as before. To introduce a new connection between subsystems click on "Add Connections" and two smaller menus appear in the upper right hand side of the tab. They are both identical and each menu contains the subsystem titles to be combined. There is a label above the two upper-right menus: "Select a System from the Left whose output connects to one of the system inputs on the Right". Select a subsystem title from each menu to indicate that some of the outputs of the subsystem from the left will be connected to some of the inputs of the subsystem on the right. First select a combination "from System #1 {Actuator} Output to System #2 {Vehicle}" and click on "Add Connection" button. Then using the same two menus select a combination "from System #2 {Vehicle} Output to System #1 {Actuator}" and click on "Add Connection" button again. This defines two top level interconnections between the two subsystems which are also included in the upper-left display. You can also modify or delete some of the existing high level connections using the appropriate buttons. When you finish defining the high level connections the next step is to enter the subsystem to subsystem interconnection details.



From the upper-left menu select one of the top level connections, for example, "System 1 [Actuator] Output to System 2 [Rulv] Input" and click on "View or Define Subconnection Details" button. The lower-left display that will include the connection details, directly below the high level definitions menu, becomes visible but it is empty because the connections have not been defined yet. Click on "Add Detail Connections" and two white menus appear in the lower right hand corner labeled "Define the Detailed Connections below from Subsystem Outputs to Subsystem Inputs" to define the exact connections between the subsystems. The left menu shows a list of subsystem #1 outputs and the right menu a list of subsystem #2 inputs for the user to select the detailed interconnections. In fact, the first output of subsystem #1 which is "engine deflection" must be connected to the first 6 inputs of the "Vehicle model" which is subsystem #2 with a gain of 0.408, one scalar connection at a time. Click "OK" after defining each connection, and the connections will gradually appear in the lower-left display, as shown below. When you have finished entering the detailed connections press the "Close Detailed Connections" button, the lower level menus close, and the dialog will return to the top level menu in the upper left hand side. From this menu you can either select another "Subsystem to

Subsystem" connection or select to another tab. You must remember to "Update Data" before changing tabs.

Systems Interconnections Dialog		
Combined System Title		E.it
RULV, Pitch Closed-Loop, Simple Model		
Define the System Titles to be Combined in file: Rulv.qdr		System Size Run U1 T1(a)
Sys: 1, Main Engine Actuator		for S-plane $\Upsilon \Pi(S) \rightarrow G(S)$
Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec)		0.0000 Update Data
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		Number of Inputs 2 K(S)
		Number of Outputs 8 Save in File
Use Tabs below to View or Modify the new system interconnection parameter		
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Inter-Connections from Sub-System Outputs to Sub-System Inputs		Select a System from Left whose Output connects to one of the following Systems Inputs on the Right
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	Modify Connect	π
	Delete Connect	t
	View or Define	
	Subconnection Details	
, Detail Interconnections from Sub-System 1 Outputs to Sub-System	2 Inputs	Define the detailed connections below, from the Subsystem Outputs to the Subsystem Inputs
	Sub-Connection	Engine Gimbal Rotation (detta) (radians) Engine No 1 Ptch Deflection (radians)
	Details	Engine Gimbal Rate (delta-dot) (rad/sec) Engine Gimbal Accelerat (delta-d-dot) (rad/sec^2) Engine No 3 Pitch Deflection (radians)
	Add Detailed Connections	Engine No 4 Pitch Deflection (radians) Engine No 5 Pitch Deflection (radians)
	Delete Detailed	Engine No. 6 Pitch Deflection (radians)
	Connections Close Detailed	
	Connections	connection or a Group of Outputs to a Group of Inputs for Vector connection 0.4082 OK
		and enter a Gain or Matrix, ex: +13 or -Km
Systems Interconnections Dialog		
Systems Interconnections Dialog Combined System Title		Evite
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Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection parameter Input to Output Direct Connects Inputs to Subsystem Connect Subsystem to Inter-Connections from Sub-System Outputs to Sub-System Inputs System 1 {Main Engine Actuator} Output To System 2 {RULV, Pitch Axis, Ma} Output To System 1 {Main Engine Actuator} Detail Interconnections from Sub-System 1 Outputs to Sub-System Subsystem 1, Output 1 to Subsystem 2, Input 1, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsy	I System Title I Add Connection Modify Connect Delete Connect Use or Define Subconnection Details 2 Inputs Sub-Connection Details Add Detailed	System Size Sample Time (dT), Zero for S-plane Update Data Number of Systems 2 Number of Systems 2 Number of Outputs 8 Save in File put/Output labels, or write Notes and Comments Subsystem to Subsystem Connect System Inputs Subsystem to Subsystem Connect System Inputs System Outputs User Comments Select a System from Left whose Output connects to one of the following Systems Inputs on the Right T t t t t t t t t t t t t t
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Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection parameter Input to Output Direct Connects Inputs to Subsystem Connect Subsystem to Inter-Connections from Sub-System Outputs to Sub-System Inputs System 1 {Main Engine Actuator} Output To System 2 {RULV, Pitch Axis, Ma} Output To System 1 {Main Engine Actuator} Detail Interconnections from Sub-System 1 Outputs to Sub-System Subsystem 1, Output 1 to Subsystem 2, Input 1, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsy	System Title rs, modify the Inpu Outputs Connection Modify Connect Delete Connection Delete Connection Details Add Detailed Connections Delete Detailed Connections Connecti	System Size Sample Time (dT), Zero for S-plane Number of Systems 2 Number of Systems 2 Number of Outputs 8 Save in File put/Output labels, or write Notes and Comments Subsystem to Subsystem Connect System Inputs System Outputs User Comments Subsystem to Subsystem Connect System Inputs System Outputs User Comments Select a System from Left whose Output connects to one of the following Systems Inputs on the Right T t t t t t t t t t t t t t
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection parameter Input to Output Direct Connects Inputs to Subsystem Connect Subsystem to Inter-Connections from Sub-System Outputs to Sub-System Inputs System 1 {Main Engine Actuator} Output To System 2 {RULV, Pitch Axis, Ma} Output To System 1 {Main Engine Actuator} Detail Interconnections from Sub-System 1 Outputs to Sub-System Subsystem 1, Output 1 to Subsystem 2, Input 1, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 3, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsystem 1, Output 1 to Subsystem 2, Input 4, Gain= 0.40820 Subsy	System Title rs, modify the Inpu Outputs Connection Modify Connect Delete Connection Delete Connection Details 2 Inputs Sub-Connection Details Add Detailed Connections Delete Detailed	System Size Sample Time (dT), Zero for S-polone Number of Systems 2 Number of Inputs 2 Number of Outputs 8 Save in File Save in File Subsystem to Subsystem Connect System Inputs System Outputs User Comments Subsystem to Subsystem Connect System Inputs System Outputs User Comments Select a System from Left whose Output connects to one of the following Systems Inputs on the Right T T T T T T T T T T T T T



Using the Top Buttons "Run", "Exit", "Update Data", "Edit Input", "Save in File"

When the system interconnections are all defined the user must press the "Update Data" button, and then "Save in File" to save the new set of interconnections in the input data file. If you made a mistake or forgot to include a detail you can always edit the input data file by clicking on "Edit Input File". A text editor comes up where the user may edit the input data file (.Inp) and save it before running it. At this point you may run the new set of system interconnections by clicking on the "Run" button. The utility will process the input data and will create a new state-space system that will be saved at the bottom of the selected systems file. The new system will have the same title and the same comments included as those in the interconnection data-set. If for some reason you do not wish to process the data and would like to exit the program without running it, use the "Exit" button to return to the Flixan main menu. The systems interconnections set will remain in the input file and you can modify it and run it at some later time.

Matrix Interconnections:

In some cases the interconnections between system inputs and outputs are not defined by scalar connections but vectored connections by means of matrices. The interconnection matrices must be saved in the systems file together with the systems to be connected. Furthermore, if all of the outputs of one system are directly connected to the inputs of another system the interconnection between the two subsystems can be defined with an identity matrix connection. In this case the identity matrix does not have to be saved in systems file but only defined in the interconnections together with its size and sign, for example, -I8. Only the gain matrices, other than identity matrices, must already exist in the systems file (*.Qdr). A typical gain matrix is shown below. It has a title in the 2nd line and a matrix name "Kmix1" in this case that must be less than 20 characters long. Comment lines beginning with "!" may be included below the title. The definitions of the matrix inputs and outputs are included below the matrix, and they are optional. The Flixan program locates the matrix in a systems file from its name. The interconnection between two subsystems in the interconnection data is defined as follows, for example:

System # 1 goes to System # 2; Via Matrix -I3 or Via Matrix +Kc1

The matrix sign, either (+ or -) must be included in front of the matrix title to indicate positive or negative connections. Matrix -I3 signifies an identity matrix of size (3x3) with a negative sign in front of it. Matrix +Kc1 means that the interconnection between subsystem #1 and subsystem #2 will be implemented via matrix Kc1 and the matrix Kc1 should be saved in file and the user must make sure that the number of output and input connections match the matrix size, otherwise, an error will occur.

```
Gain Matrix for ...
Mixing Logic for RUV Rocket Plane, Max-Q, TVC Only
! This is a TVC Matrix for a Flight Vehicle that uses 6 TVC engines
! It converts the roll, pitch, and yaw demands to pitch and yaw engine deflections
                          Size = 12 X 3
Matrix Kmix1
          1-Column
                              2-Column
                                                  3-Column
  1-Row -0.421476571158E-01 -0.696887052969E+00 -0.189849954035E-01
  2-Row -0.842953142316E-01 -0.696887052969E+00 -0.379699908071E-01
  3-Row -0.421476571158E-01 -0.696887052969E+00 -0.189849954035E-01
   4-Row 0.421476571158E-01 -0.696887052969E+00 0.189849954035E-01
  5-Row 0.842953142316E-01 -0.696887052969E+00 0.379699908071E-01
  6-Row 0.421476571158E-01 -0.696887052969E+00 0.189849954035E-01
  7-Row 0.701454508604E-01 0.560429840605E-17 -0.665455594906E+00
  8-Row -0.285868827862E-02 -0.463518776671E-18 -0.698339587537E+00
  9-Row -0.758628274177E-01 -0.653133595940E-17 -0.731223580168E+00
  10-Row -0.758628274177E-01 -0.653133595940E-17 -0.731223580168E+00
  11-Row -0.285868827862E-02 -0.463518776671E-18 -0.698339587537E+00
 12-Row 0.701454508604E-01 0.560429840605E-17 -0.665455594906E+00
 _____
Definitions of Matrix Inputs (Columns):
                                          3
P-dot Roll Acceleration About X Axis
Q-dot Pitch Acceleration About Y Axis
R-dot Yaw Acceleration About Z Axis
Definitions of Matrix Outputs (Rows):
                                         12
Output: 1 Dy(engine): 1 Pitch Deflection
Output: 2 Dy(engine): 2 Pitch Deflection
Output: 3 Dy(engine): 3 Pitch Deflection
Output: 4 Dy(engine): 4 Pitch Deflection
Output: 5 Dy(engine): 5 Pitch Deflection
Output: 6 Dy(engine): 6 Pitch Deflection
Output: 7 Dz(engine): 1 Yaw Deflection
Output: 8 Dz(engine): 2 Yaw Deflection
Output: 9 Dz(engine): 3 Yaw Deflection
Output: 10 Dz(engine):
                       4 Yaw Deflection
Output: 11 Dz(engine): 5 Yaw Deflection
Output: 12 Dz(engine): 6 Yaw Deflection
_____
```

User Comments Tab:

This tab is used for viewing system comments already entered in the systems interconnections data-set. These are comments and user notes regarding the system for documentation purposes. The comment lines begin with (!) and they are below the system title. The comments from the input data are also copied and inserted in the systems data below the title. When starting with a new system this display/ tab is also used for entering the system notes interactively.

Systems Interconnections Dialog			
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Find System Title Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection parameters, modify the I	System Size Sample Time (dT), Zero for S-plane 0.0000 Number of Systems 2 Number of Inputs 2 Number of Outputs 8 nput/Output labels, or write Notes	Exit Run Update Data Edit Input File Save in File and Comments	$H(s) \xrightarrow{u_2} r_1$ $G(s) \xrightarrow{r_2}$ $K(s) \xrightarrow{r_2}$
Input to Output Direct Connects Inputs to Subsystem Connect Subsystem to Outputs Connect User Notes that briefly describe the vehicle model (less than 2000 characters) Combine the Simple Vehicle model with the Actuator model to create a Closed-Loop system for Time-Domain Simulation and Check the Eigenvalues	t Subsystem to Subsystem Conner	ct System Inputs System Outputs	User Comments

System Input and System Output Definition Tabs:

These tabs are used for viewing the system input and output definitions. The system inputs and outputs are defined in the input file, at the bottom of the data-set, below the systems interconnections data. They are also copied to the systems file below the quadruple matrices. Initially, when we define a new set of interconnections interactively the utility assigns default titles for the system inputs and outputs, such as, "*System Input 1*". The tabs may be used to redefine the default input and output names and the user may replace them with more descriptive labels. For example, to change one of the inputs from the menu, select the default label, ex. "*System Input 2*", click on "*Edit*" button at the bottom, and the default label appears in the field below the menu. Then you can modify the default label in that field to more descriptive name, such as for example: "*Wind-Gust Disturbance in (ft/sec)*", and press the "*Edit*" button again. The default label will then be changed to the new name. You may then select other inputs and repeat. You must also remember to click "*Update Data*" before changing tabs.

Systems Interconnections Dialog	
Combined System Title	Exit
RULV, Pitch Closed-Loop, Simple Model	System Size u_1 u_1 u_2 r_1
Define the System Titles to be Combined in file: Rulv.qdr Find System Title	Sample Time (dT), Zero \longrightarrow $\Pi(\alpha) \rightarrow \Pi(\alpha)$
Sys: 1, Main Engine Actuator	
Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec)	Update Data
	Number of Systems 2 Number of Inputs 2 Edit Input File
	Number of Dutputs 8 Save in File
Use Tabs below to View or Modify the new system interconnection parameters, modify the I	
Input to Output Direct Connects Inputs to Subsystem Connect Subsystem to Outputs Connect	ct Subsystem to Subsystem Connect System Inputs System Outputs User Comments
Attitude Command (theta) in (radians) Select an Inpu	
Wind-Gust Disturbance in (ft/sec) menu and press to modify the	
title at the ba	ittom.
Repeat to char other Inputs.	ige
Wind-Gust Disturbance in (ft/sec)	Edit
L	

Systems Interconnections Dialog					
Combined System Title			Exit		
RULV, Pitch Closed-Loop, Simple Model		System Size			u_2
Define the System Titles to be Combined in file: Rulv.qdr	Find System Title S	Sample Time (dT), Zero for 5-plane	Run	1 $\overset{\bullet}{\bullet}$ H(s)	\rightarrow G(s)
Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec)		0.0000			\rightarrow r_2
	N	Number of Systems 2	Update Data		
	N	Number of Inputs 2	Edit Input File		(a).
	N	Number of Outputs 8	Save in File		(8)
Use Tabs below to View or Modify the new system interconnection para	meters modify the Taput	it/Output labels or write Note	es and Comments		
Input to Output Direct Connects Inputs to Subsystem Connect Subsyste				System Outputs User Comme	ents
System Output 1	Select an Output			•	
System Output 2	from menu and pre	ess			
System Output 3 System Output 4	Edit to modify the Output title at th				
System Output 5	bottom. Repeat to	5			
System Output 6 System Output 7	change other Outp	puts.			
System Output 8					
	· · · · · · · · · · · · · · · · · · ·				
System Output 1	Edit				
Systems Interconnections Dialog					
Systems Interconnections Dialog Combined System Title			Fxit		
		System Size	Exit		
Combined System Title		System Size Sample Time (dT), Zero	Exit Run		$u_2 \rightarrow r_1$
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator	Find System Title	Sample Time (dT), Zero for S-plane		u₁ ∳-H(s)	$\overrightarrow{G(s)}$
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr	Find System Title 5	Sample Time (dT), Zero for S-plane		H(s)	$\begin{array}{c} u_2 \\ \hline \\ G(S) \\ \hline \\ r_2 \end{array}$
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator	Find System Title 5	Sample Time (dT), Zero for S-plane 0.0000 Number of Systems 2	Run Update Data	u₁ → H(s)	$\overrightarrow{G(s)}$
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator	Find System Title S	Sample Time (dT), Zero for S-plane 0.0000 Number of Systems Number of Inputs 2	Run Update Data Edit Input File	H(s)	$G(s)$ r_1 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator	Find System Title S	Sample Time (dT), Zero for S-plane 0.0000 Number of Systems 2	Run Update Data	u₁ ←H(s) ↓ K	$\overrightarrow{G(s)}$
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator	Find System Title 5 f	Sample Time (dT), Zero for S-plane 0.0000 Number of Systems 2 Number of Inputs 2 Number of Outputs 8	Run Update Data Edit Input File Save in File	u1 -H(s)	$G(s)$ r_1 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec)	Find System Title S f	Sample Time (dT), Zero for S-plane 0.0000 Number of Systems 2 Number of Inputs 2 Number of Outputs 8 nt/Output labels, or write Note 10	Run Update Data Edit Input File Save in File	H(s)	r_1 r_2 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection para Input to Output Direct Connects Inputs to Subsystem Connect Subsystem Pitch Attittude (theta) in (rad)	Find System Title S f N N N N N N N Select an Output	Sample Time (dT), Zero for S-plane 0.0000 Number of Systems 2 Number of Inputs 2 Number of Outputs 8 ut/Output labels, or write Note Subsystem to Subsystem Context t	Run Update Data Edit Input File Save in File	H(s)	r_1 r_2 r_2 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection para Input to Output Direct Connects Inputs to Subsystem Connect Subsystem Pitch Attiittude (theta) in (rad) Pitch Rate (q) in (rad/s)	Find System Title S f N N N N N N N Select an Output from menu and pre	Sample Time (dT), Zero for S-plane 0.0000 Number of Systems 2 Number of Inputs 2 Number of Outputs 8 rt/Output labels, or write Noth Subsystem Coni t 5	Run Update Data Edit Input File Save in File	H(s)	r_1 r_2 r_2 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection para Input to Output Direct Connects Inputs to Subsystem Connect Subsystem Pitch Attittude (theta) in (rad)	Find System Title S F S S S S S S S S S S S S S	Sample Time (dT), Zero for S-plane Number of Systems Number of Inputs Number of Inputs Number of Outputs Subsystem to Subsystem Cond tess teesthe	Run Update Data Edit Input File Save in File	H(s)	r_1 G(s) r_2 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection para Input to Output Direct Connects Inputs to Subsystem Connect Subsyste Pitch Attittude (theta) in (rad) Pitch Rate (a) in (rad) Delta Altitude (dh) in (fred) Delta Altitude (dh) in (feet) Forward Acceleration (V-dot) in (ft/sec2)	Find System Title S f N N N N N N N N N N N N N N N N N N	Sample Time (dT), Zero for S-plane Number of Systems Number of Inputs Number of Outputs Number of Outputs Subsystem to Subsystem Cont ess ie the o	Run Update Data Edit Input File Save in File	H(s)	r_1 G(s) r_2 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection para Input to Output Direct Connects Inputs to Subsystem Connect Subsystem Pitch Attittude (theta) in (rad) Pitch Attid (dh) in (feet) Forward Acceleration (v-dot) in (ft/sec2) Accelerometer along Z in (ft/sec^2)	Find System Title S F S S S S S S S S S S S S S	Sample Time (dT), Zero for S-plane Number of Systems Number of Inputs Number of Outputs Number of Outputs Subsystem to Subsystem Cont ess ie the o	Run Update Data Edit Input File Save in File	H(s)	r_1 r_2 r_2 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection para Input to Output Direct Connects Inputs to Subsystem Connect Subsyste Pitch Attittude (theta) in (rad) Pitch Rate (a) in (rad) Delta Altitude (dh) in (fred) Delta Altitude (dh) in (feet) Forward Acceleration (V-dot) in (ft/sec2)	Find System Title S f N N N N N N N N N N N N N N N N N N	Sample Time (dT), Zero for S-plane Number of Systems Number of Inputs Number of Outputs Number of Outputs Subsystem to Subsystem Cont ess ie the o	Run Update Data Edit Input File Save in File	H(s)	r_1 r_2 r_2 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection para Input to Output Direct Connects Inputs to Subsystem Connect Subsystem Pitch Attittude (theta) in (rad) Pitch Attitude (dh) in (feet) Forward Acceleration (V-dot) in (ft/sec?) Accelerationeter along Z in (ft/sec?2) Pitch Engine Actuator Deflection (rad)	Find System Title S f N N N N N N N N N N N N N N N N N N	Sample Time (dT), Zero for S-plane Number of Systems Number of Inputs Number of Outputs Number of Outputs Subsystem to Subsystem Cont ess ie the o	Run Update Data Edit Input File Save in File	H(s)	r_1 r_2 r_2 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection para Input to Output Direct Connects Inputs to Subsystem Connect Subsystem Pitch Attittude (theta) in (rad) Pitch Attitude (dh) in (feet) Forward Acceleration (V-dot) in (ft/sec?) Accelerationeter along Z in (ft/sec?2) Pitch Engine Actuator Deflection (rad)	Find System Title S f N N N N N N N N N N N N N N N N Select an Outputs Connect from menu and pre Edit to modify the Output title at the bottom. Repeat to	Sample Time (dT), Zero for S-plane Number of Systems Number of Inputs Number of Outputs Number of Outputs Subsystem to Subsystem Cont ess ie the o	Run Update Data Edit Input File Save in File	H(s)	r_1 r_2 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection para Input to Output Direct Connects Inputs to Subsystem Connect Subsystem Pitch Attittude (theta) in (rad) Pitch Attitude (dh) in (feet) Forward Acceleration (V-dot) in (ft/sec?) Accelerationeter along Z in (ft/sec?2) Pitch Engine Actuator Deflection (rad)	Find System Title S f N N N N N N N N N N N N N N N N Select an Outputs Connect from menu and pre Edit to modify the Output title at the bottom. Repeat to	Sample Time (dT), Zero for S-plane Number of Systems Number of Inputs Number of Outputs Number of Outputs Subsystem to Subsystem Cont ess ie the o	Run Update Data Edit Input File Save in File	H(s)	r_1 r_2 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection para Input to Output Direct Connects Inputs to Subsystem Connect Subsystem Pitch Attittude (theta) in (rad) Pitch Attitude (dh) in (feet) Forward Acceleration (V-dot) in (ft/sec?) Accelerationeter along Z in (ft/sec?2) Pitch Engine Actuator Deflection (rad)	Find System Title S f N N N N N N N N N N N N N N N N N N	Sample Time (dT), Zero for S-plane Number of Systems Number of Inputs Number of Outputs Number of Outputs Subsystem to Subsystem Cond t ess te bo pots.	Run Update Data Edit Input File Save in File	H(s)	r_1 r_2 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection para Input to Output Direct Connects Inputs to Subsystem Connect Subsystem Pitch Attittude (theta) in (rad) Pitch Attitude (dh) in (feet) Forward Acceleration (V-dot) in (ft/sec?) Accelerationeter along Z in (ft/sec?2) Pitch Engine Actuator Deflection (rad)	Find System Title S f N N N N N N N N N N N N N N N N Select an Outputs Connect from menu and pre Edit to modify the Output title at the bottom. Repeat to	Sample Time (dT), Zero for S-plane Number of Systems Number of Inputs Number of Outputs Number of Outputs Subsystem to Subsystem Cond t ess te bo pots.	Run Update Data Edit Input File Save in File	H(s)	r_1 r_2 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection para Input to Output Direct Connects Inputs to Subsystem Connect Subsystem Pitch Attittude (theta) in (rad) Pitch Rate (a) in (rad/s) Angle of Attrack (alpha) in (rad) Delta Attitude (dhi) in (feat) Forward Acceleration (V-dot) in (ft/sec2) Accelerometer along Z in (ft/sec^2) Pitch Engine Actuator Deflection (rad) Engine Deflection Rate (rad/sec)	Find System Title S f N N N N N N N N N N N N N N N N N N	Sample Time (dT), Zero for S-plane Number of Systems Number of Inputs Number of Outputs Number of Outputs Subsystem to Subsystem Cond t ess te bo pots.	Run Update Data Edit Input File Save in File	H(s)	r_1 r_2 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection para Input to Output Direct Connects Inputs to Subsystem Connect Subsystem Pitch Attittude (theta) in (rad) Pitch Rate (a) in (rad/s) Angle of Attrack (alpha) in (rad) Delta Attitude (dhi) in (feat) Forward Acceleration (V-dot) in (ft/sec2) Accelerometer along Z in (ft/sec^2) Pitch Engine Actuator Deflection (rad) Engine Deflection Rate (rad/sec)	Find System Title S f N N N N N N N N N N N N N N N N N N	Sample Time (dT), Zero for S-plane Number of Systems Number of Inputs Number of Outputs Number of Outputs Subsystem to Subsystem Cond t ess te bo pots.	Run Update Data Edit Input File Save in File	H(s)	r_1 r_2 r_2
Combined System Title RULV, Pitch Closed-Loop, Simple Model Define the System Titles to be Combined in file: Rulv.qdr Sys: 1, Main Engine Actuator Sys: 2, RULV, Pitch Axis, Max_Q (T=85 sec) Use Tabs below to View or Modify the new system interconnection para Input to Output Direct Connects Inputs to Subsystem Connect Subsystem Pitch Attittude (theta) in (rad) Pitch Rate (a) in (rad/s) Angle of Attrack (alpha) in (rad) Delta Attriated (bit in (fest) Forward Acceleration (V-dot) in (ft/sec2) Accelerometer along Z in (ft/sec^2) Pitch Engine Actuator Deflection (rad) Engine Deflection Rate (rad/sec)	Find System Title S f N N N N N N N N N N N N N N N N N N	Sample Time (dT), Zero for S-plane Number of Systems Number of Inputs Number of Outputs Number of Outputs Subsystem to Subsystem Cond t ess te bo pots.	Run Update Data Edit Input File Save in File	H(s)	r_1 r_2 r_2

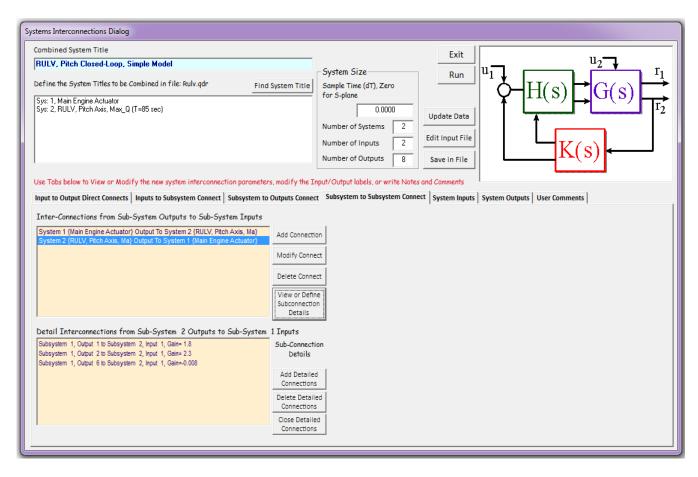
1.3 Running an Already Existing Interconnection Set

It is obviously a lot easier to modify an already existing interconnection set using a typical text editor and then process it using the interconnection utility. In this case the interconnection data are already saved in the input file "*Rulv.Inp*" and the systems to be combined are already saved in file "*Rulv.Qdr*". This example is located in folder "*C:\Flixan\Comb_Trfn\Examples*". From the Flixan main menu the user selects the systems combination utility by clicking on the "*Analysis Tools*", then "*Creating and Modifying Linear Systems*", and then clicking on "*Combine State-Space Systems and Matrices*". Using the filename selection menu, select the input and system filenames and click on "*Select Files*" to process the already existing data. In this case the input data file contains four sets of interconnection data. The following menu shows the titles of the four interconnection sets in file "*Rulv.Inp*". The user selects the second set "*RULV, Pitch Closed-Loop, Simple Model*", and clicks on "*Run Input Set*".

Enter Filenames			
Enter a File Name containing the Input Data (xxx.Inp)	Enter a File Name containing the Quadruple Data (xxx.Qdr)		
Rulv.Inp NewFile.inp	Rulv.qdr NewFile.qdr		
Rulv.Inp NewFile.Inp	Rulv.qdr NewFile.Qdr		
Create New Input Set	Exit Program Select Files		

Find a Set of Inputs							
Select a Set of Input Data for "INTERCONNECTION" from an Input File: Rulv.inp	Run Input Set						
RULV, Pitch Forward Loop, T=85, Simple Model RULV, Pitch Closed-Loop, Simple Model	Exit Program						
RULV, Pitch Closed Loop, (with TWD/ DWT/ Slosh) RULV, Pitch Open-Loop System, (with TWD/ DWT/ Slosh/ Flex)	Create New						

The following dialog shows the interconnection details of the closed-loop system already described in Figure (1.2). The interconnections are obtained from the input data set. The combined system's title is shown at the top and the two systems to be combined are shown in the white display below. This system has 2 inputs and 8 outputs. The sampling time is zero for continuous system. The interconnection details, input/ output definitions and user comments are shown by selecting in the corresponding tabs. To process the data and to generate the new system you must click on "*Run*". The dialog also provides the capability to edit the input file before processing it by clicking on "*Edit Input File*". The "*Exit*" button will return to the Flixan main menu without running the program.



This example can also be processed in batch mode by running the batch set which is located on the top of the input file "*Rulv.Inp*". More system combination examples are located in folder: "*C*:*Flixan*\ *Comb_Trfn**Examples*".

1.4 Processing Interconnection Sets in Batch Mode

In this example we have an input file " $Comb_tst.Inp$ " consisting entirely of system and transferfunction interconnections, and it is located in directory " $C:\Flixan\Comb_Trfn\Examples$ ". This input file, shown below, includes many data-sets, and it is a lot easier and faster to process it in batch mode. It also includes a batch set on the top that can process the entire file. There are user notes in the batch below the title that describe the processes. The generated systems are saved in file " $Comb_tst.Qdr$ ". BATCH MODE INSTRUCTIONS Systems Interconnection Testing Batch

! A Batch Set used for generating and connecting systems together for demo purposes. ! It first retains two matrices in the systems file that will be used later in the connections. ! Then it generates two second order systems from Transf-Functions. Then a second order with ! 1 sec delay. Then it combines the two 2nd order systems together to create a 4th order system. ! Then it combines two identical 4th order systems in series to create an 8th order system. ! Then it combines four of these 8th order systems in parallel to create a 32nd order system. ! Then it creates a 14th order system by combining 3 of the above systems (2nd, 4th, and 8th). ! Then we create a system by combining two different 2nd order Transf-Functions in parallel. ! We also create a big system of 116 states, 5 inputs and 5 outputs by combining seven of the ! above systems together. We also combine the 14th order with the 8th order systems via gain ! matrix connections to create a 22nd order system. We finally create a 5th order system using ! transf-functions and combine the 5th order with a 4th order and also an 8th order systems to ! create another system. Retain Matrix : (3x2) Gain Connection matrix : (2x2) Gain Connection matrix Retain Matrix Transf-Functions : (s^2 +2s +16)/(s^2 +5s +25) Transf-Functions : $4/(s^2 + 2s + 4)$ Transf-Functions : $4/(s^2 + 2s + 4) * exp(-sT)$ System Connection: Fourth Order System System Connection: Eighth Order System System Connection: 32nd Order System Connection: Fourteenth Order System (3 Systems Combined) System Connection: Two Second Order Transfer Functions Connected in Parallel System Connection: Two Systems in Series (12th Order) System Connection: A Big System System Connection: Two Systems Connected with a Gain Matrix Transf-Functions : $4/(s^2 + 2s + 4) \exp(-sT)$ (b) Transf-Functions : Fifth Order System of 3 Transfer Functions System Connection: Another System Combination _____ ------SYSTEM OF TRANSFER FUNCTIONS ... $(s^{2} + 2s + 16)/(s^{2} + 5s + 25)$! A simple 2nd order numerator 2nd order denominator transfer function Continuous TF. Block # 1 Second order, (2 zeros/2 poles) Order of Numer, Denom= 2 2 Numer 1.00000 2.00000 16.0000 Denom 1.00000 5.00000 25.0000 _____ Block #, from Input #, Gain 1 1 1.00000 Outpt #, from Block #, Gain 1 1 1.00000 Definitions of Inputs = 1 Transf. Function (s² +2s +16)/(s² +5s +25) Input #1 Definitions of Outputs = 1 Transf. Function (s² +2s +16)/(s² +5s +25) Output #1 _____ SYSTEM OF TRANSFER FUNCTIONS ... $4/(s^2 + 2s + 4)$! Another second order denominator transfer function Continuous TF. Block # 1 Low Pass Filter (2 rad/sec bandwidth) Order of Numer, Denom= 0 2 0.0 4.0 Numer 0.0 Denom 1.00000 2.00000 4.00000 _____ -----Block #, from Input #, Gain 1 1 1.00000 Outpt #, from Block #, Gain 1 1 1.00000 Definitions of Inputs = 1 Transf. Function $4/(s^2 + 2s + 4)$ Input # 1 Definitions of Outputs = 1 Transf. Function $4/(s^2 + 2s + 4)$ Output # 1

SYSTEM OF TRANSFER FUNCTIONS ... $4/(s^2 + 2s + 4) * exp(-sT)$! Another second order denominator transfer function Continuous TF. Block # 1 Low Pass Filter (2 rad/sec bandwidth) Order of Numer, Denom= 0 2 Numer 0.0 0.0 Denom 1.00000 2.00000 4.0 4.00000 TF. Block # 2 Delay (sec)= 1.00000 Order of Numer, Denom= 1 1 _____ ------_____ Block #, from Input #, Gain 1 1 1.00000 Block #, from Block #, Gain 2 1 1.00000 Outpt #, from Block #, Gain 1 2 1.00000 Outpt #, from Input #, Gain 1 1 0.10000 Definitions of Inputs = 1 Low Pass Filter Input 1 Definitions of Outputs = 1 Delay Output 1 _____ INTERCONNECTION OF SYSTEMS Fourth Order System ! Combine the two transfer functions in parallel in a single fourth order system Titles of Systems to be Combined (Found in File Comb tst.Odr) Title 1 (s² +2s +16)/(s² +5s +25) Title 2 $4/(s^2 + 2s + 4)$ SYSTEM INPUTS DIRECT TO SYSTEM OUTPUTS System Input 2 to System Outpt 1, Gain=0.156250 System Input 2 to System Outpt 2, Gain=0.500000 SYSTEM INPUTS TO SUBSYSTEM 1 System Input 1 to Subsystem 1, Input 1, Gain= 1.00000 SYSTEM INPUTS TO SUBSYSTEM 2 System Input 2 to Subsystem 2, Input 1, Gain= 1.00000 SYSTEM OUTPUTS FROM SUBSYSTEM 1 System Output 1 from Subsystem 1, Output 1, Gain= 1.56250 SYSTEM OUTPUTS FROM SUBSYSTEM 2 System Output 2 from Subsystem 2, Output 1, Gain=0.500000 Definitions of Inputs = 2 Transfer Function 1 Input 1 Transfer Function 2 Input 2 Definitions of Outputs = 2 Transfer Function 1 Output 1 Transfer Function 2 Output 2 _____ _____ INTERCONNECTION OF SYSTEMS Eighth Order System ! Combine the fourth order system with an identical 4th order in series to create ! an 8th order system Titles of Systems to be Combined (Found in File CMBT.QDR) Title 1 Fourth Order System Title 2 Fourth Order System SYSTEM INPUTS TO SUBSYSTEM 1 Via Matrix +I2 SYSTEM OUTPUTS FROM SUBSYSTEM 2 Via Matrix +I2 SUBSYSTEM NO 1 GOES TO SUBSYSTEM NO 2 Via Matrix +I2 Definitions of Inputs = 2 System 1 Input 1 System 1 Input 2 Definitions of Outputs = 2 System 2 Output 1 System 2 Output 2 _____

INTERCONNECTION OF SYSTEMS 32nd Order ! This Interconnection set combines four identical Eighth order systems ! in parallel to create a 32nd order system. Titles of Systems to be Combined (Found in File CMBT.QDR) Title 1 Eighth Order System Title 2 Eighth Order System Title 3 Eighth Order System Title 4 Eighth Order System SYSTEM INPUTS TO SUBSYSTEM 1 Via Matrix +I2 SYSTEM INPUTS TO SUBSYSTEM 2 System Input 3 to Subsystem 2, Input 1, Gain= 1.00000 System Input 4 to Subsystem 2, Input 2, Gain= 1.00000 SYSTEM INPUTS TO SUBSYSTEM 3 System Input 5 to Subsystem 3, Input 1, Gain= 1.00000 System Input 6 to Subsystem 3, Input 2, Gain= 1.00000 SYSTEM INPUTS TO SUBSYSTEM 4 System Input 7 to Subsystem 4, Input 1, Gain= 1.00000 System Input 8 to Subsystem 4, Input 2, Gain= 1.00000 SYSTEM OUTPUTS FROM SUBSYSTEM 1 Via Matrix +I2 SYSTEM OUTPUTS FROM SUBSYSTEM 2 System Output 3 from Subsystem 2, Output 1, Gain= 1.00000 System Output 4 from Subsystem 2, Output 2, Gain= 1.00000 SYSTEM OUTPUTS FROM SUBSYSTEM 3 System Output 5 from Subsystem 3, Output 1, Gain= 1.00000 System Output 6 from Subsystem 3, Output 2, Gain= 1.00000 SYSTEM OUTPUTS FROM SUBSYSTEM 4 System Output 7 from Subsystem 4, Output 1, Gain= 1.00000 System Output 8 from Subsystem 4, Output 2, Gain= 1.00000 Definitions of Inputs = 8 System 1 Input 1 System 1 Input 2 System 2 Input 3 System 2 Input 4 System 3 Input 5 System 3 Input 6 System 4 Input 7 System 4 Input 8 Definitions of Outputs = 8 System 1 Output 1 System 1 Output 2 System 2 Output 3 System 2 Output 4 System 3 Output 5 System 3 Output 6 System 4 Output 7 System 4 Output 8 _____

```
INTERCONNECTION OF SYSTEMS .....
Fourteenth Order System (3 Systems Combined)
! Combine a second order system with a fourth order system and an eighth order system to create a
! fourteenth order system
Titles of Systems to be Combined
Title 1 (s<sup>2</sup> +2s +16)/(s<sup>2</sup> +5s +25)
Title 2 Fourth Order System
Title 3 Eighth Order System
SYSTEM INPUTS DIRECT TO SYSTEM OUTPUTS
System Input 1 to System Outpt 1, Gain= 0.10000
System Input 3 to System Outpt 2, Gain= 0.20000
SYSTEM INPUTS TO SUBSYSTEM 1 (s^2 +2s +16)/(s^2 +5s +25)
System Input 1 to Subsystem 1, Input 1, Gain= 1.0000
.....
SYSTEM INPUTS TO SUBSYSTEM 2 Fourth Order System
System Input 2 to Subsystem 2, Input 1, Gain= 2.0000
System Input 3 to Subsystem 2, Input 2, Gain= 3.0000
SYSTEM OUTPUTS FROM SUBSYSTEM 3 Eighth Order System
Via Matrix -I2
                            Size ( 2 x 2)
 . . . . . . . . . . . . . . . .
             SUBSYSTEM NO 1 GOES TO SUBSYSTEM NO 3
Subsystem 1, Output 1 to Subsystem 3, Input 1, Gain= 1.0000
Subsystem 1, Output 1 to Subsystem 3, Input 2, Gain= 0.50000
SUBSYSTEM NO 2 GOES TO SUBSYSTEM NO 3
Subsystem 2, Output 1 to Subsystem 3, Input 2, Gain= 1.0000
Subsystem 2, Output 2 to Subsystem 3, Input 1, Gain= 0.60000
Definitions of Inputs = 3
New System Input 1
New System Input 2
New System Input 3
Definitions of Outputs =
                    2
New System Output 1
New System Output 2
_____
INTERCONNECTION OF SYSTEMS .....
Two Second Order Transfer Functions Connected in Parallel
! A simple 2nd order numerator 2nd order denominator transfer function
Titles of Systems to be Combined
Title 1 (s<sup>2</sup> +2s +16)/(s<sup>2</sup> +5s +25)
Title 2 4/(s^2 +2s +4)
SYSTEM INPUTS DIRECT TO SYSTEM OUTPUTS
System Input 1 to System Outpt 1, Gain= 0.10000
System Input 2 to System Outpt 2, Gain= 0.20000
SYSTEM INPUTS TO SUBSYSTEM 1 (s^2 +2s +16)/(s^2 +5s +25)
System Input 1 to Subsystem 1, Input 1, Gain= 1.0000
SYSTEM INPUTS TO SUBSYSTEM 2
                        4/(s^2 +2s +4)
System Input 2 to Subsystem 2, Input 1, Gain= 1.0000
SYSTEM OUTPUTS FROM SUBSYSTEM 1 (s<sup>2</sup> +2s +16)/(s<sup>2</sup> +5s +25)
System Output 1 from Subsystem 1, Output 1, Gain= 1.0000
SYSTEM OUTPUTS FROM SUBSYSTEM 2 4/(s^2 +2s +4)
System Output 2 from Subsystem 2, Output 1, Gain= 1.0000
Definitions of Inputs = 2
System Input
           1
System Input
           2
Definitions of Outputs =
                   2
System Output 1
System Output 2
              _____
```

INTERCONNECTION OF SYSTEMS Two Systems in Series (12th Order) ! Connect the Fourth Order System in Series with the Eighth Order System Titles of Systems to be Combined Title 1 Fourth Order System Title 2 Eighth Order System SYSTEM INPUTS TO SUBSYSTEM 1 Fourth Order System Via Matrix +I2 Size (2 x 2) SYSTEM OUTPUTS FROM SUBSYSTEM 2 Eighth Order System Via Matrix -I2 Size (2 x 2) SUBSYSTEM NO 1 GOES TO SUBSYSTEM NO 2 Via Matrix +I2 Size (2 x 2) Definitions of Inputs = 2 Fourth Order, Input 1 Fourth Order, Input 2 Definitions of Outputs = 2 Eighth Order, Output 1 Eighth Order, Output 2 _____ INTERCONNECTION OF SYSTEMS A Big System ! Randomly Connect seven Systems together Titles of Systems to be Combined Title 1 Fourth Order System Title 2 Eighth Order System Title 3 Fourteenth Order System (3 Systems Combined) Title 4 Two Systems in Series (12th Order) Title 5 32nd Order Title 6 32nd Order Title 7 Fourteenth Order System (3 Systems Combined) SYSTEM INPUTS DIRECT TO SYSTEM OUTPUTS System Input 1 to System Outpt 3, Gain= 2.0000 System Input 2 to System Outpt 1, Gain= 1.0000 SYSTEM INPUTS TO SUBSYSTEM 1 FOURTH ORDER SYSTEM System Input 5 to Subsystem 1, Input 2, Gain= 1.0000 System Input 3 to Subsystem 1, Input 1, Gain= 2.0000 System Input 1 to Subsystem 1, Input 2, Gain= 1.0000 SYSTEM INPUTS TO SUBSYSTEM 7 Fourteenth Order System (3 Systems Combined) Via Matrix +I2 Size (2 x 2) SYSTEM INPUTS TO SUBSYSTEM 2 EIGHTH ORDER SYSTEM System Input 2 to Subsystem 2, Input 1, Gain= 2.0000 System Input 3 to Subsystem 2, Input 2, Gain= 2.0000 System Input 5 to Subsystem 2, Input 2, Gain= 2.0000 TWO SYSTEMS IN SERIES (12TH ORDER) SYSTEM INPUTS TO SUBSYSTEM 4 System Input 4 to Subsystem 4, Input 1, Gain= 2.0000 System Input 5 to Subsystem 4, Input 2, Gain= 2.0000 System Input 2 to Subsystem 4, Input 1, Gain= 2.0000 SYSTEM INPUTS TO SUBSYSTEM 5 32ND ORDER System Input 1 to Subsystem 5, Input 4, Gain= 2.0000 System Input 5 to Subsystem 5, Input 8, Gain= 2.0000 System Input 3 to Subsystem 5, Input 2, Gain= 2.0000 SYSTEM INPUTS TO SUBSYSTEM 6 32ND ORDER System Input 2 to Subsystem 6, Input 6, Gain= System Input 3 to Subsystem 6, Input 7, Gain= 1.0000 2.0000 System Input 4 to Subsystem 6, Input 3, Gain= 3.0000 SYSTEM OUTPUTS FROM SUBSYSTEM 3 FOURTEENTH ORDER SYSTEM (3 SYSTEMS COMBINED) System Output 5 from Subsystem 3, Output 2, Gain= 2.0000 System Output 2 from Subsystem 3, Output 1, Gain= 1.0000 System Output 4 from Subsystem 3, Output 2, Gain= 5.0000 System Output 1 from Subsystem 3, Output 1, Gain= 2.0000

SYSTEM OUTPUTS FROM SUBSYSTEM 5 32ND ORDER System Output 3 from Subsystem 5, Output 6, Gain= 1.0000 System Output 5 from Subsystem 5, Output 8, Gain= 1.0000 System Output 4 from Subsystem 5, Output 3, Gain= 1.0000 SYSTEM OUTPUTS FROM SUBSYSTEM 6 32ND ORDER System Output 1 from Subsystem 6, Output 7, Gain= System Output 2 from Subsystem 6, Output 5, Gain= 1.0000 1.0000 System Output 5 from Subsystem 6, Output 2, Gain= 1.0000 SUBSYSTEM NO 1 GOES TO SUBSYSTEM NO 3 Subsystem 1, Output 1 to Subsystem 3, Input 1, Gain= 1.0000 Subsystem 1, Output 2 to Subsystem 3, Input 3, Gain= 1.0000 SUBSYSTEM NO 7 GOES TO SUBSYSTEM NO 5 Subsystem 7, Output 1 to Subsystem 5, Input 1, Gain= 1.0000 Subsystem 7, Output 2 to Subsystem 5, Input 2, Gain= -1.0000 SUBSYSTEM NO 2 GOES TO SUBSYSTEM NO 5 Subsystem 2, Output 1 to Subsystem 5, Input 2, Gain= 2.0000 Subsystem 2, Output 2 to Subsystem 5, Input 7, Gain= 3.0000 SUBSYSTEM NO 2 GOES TO SUBSYSTEM NO 6 Subsystem 2, Output 1 to Subsystem 6, Input 4, Gain= 1.0000 Subsystem 2, Output 2 to Subsystem 6, Input 8, Gain= 2.0000 SUBSYSTEM NO 3 GOES TO SUBSYSTEM NO 2 Via Matrix -I2 Size (2 x 2) SUBSYSTEM NO 5 GOES TO SUBSYSTEM NO 1 Via Matrix +I2 Size (2 x 2) Definitions of Inputs = 5 Big System Input 1 Big System Input 2 Big System Input 3 Big System Input 4 Big System Input 5 Definitions of Outputs = 5 Big System Output 1 Big System Output 2 Big System Output 3 Big System Output 4 Big System Output 5 _____ INTERCONNECTION OF SYSTEMS Two Systems Connected with a Gain Matrix ! Combine an eighth order system in series with a fourteenth order system and synthesize ! twenty second order system Titles of Systems to be Combined Title 1 Eighth Order System Title 2 Fourteenth Order System (3 Systems Combined) SYSTEM INPUTS DIRECT TO SYSTEM OUTPUTS Via Matrix +K2 Size (2 x 2) SYSTEM INPUTS TO SUBSYSTEM 1 Fourth Order System Size (2 x 2) Via Matrix -I2 SYSTEM OUTPUTS FROM SUBSYSTEM 2 Fourteenth Order System (3 Systems Combined) Via Matrix -K2 Size (2 x 2) SUBSYSTEM NO 1 GOES TO SUBSYSTEM NO 2 Via Matrix -Kg Size (3 x 2) Definitions of Inputs = 2 System Input 1 System Input 2 System Input Definitions of Outputs = 2 System Output 1 System Output 2 _____ _____

SYSTEM OF TRANSFER FUNCTIONS ... $4/(s^2 + 2s + 4) * exp(-sT)$ (b) ! This is a second order low pass filter with a cut-off frequency of 2 (rad/sec) in series with a ! one second Pade delay approximation. Continuous TF. Block # 1 Low Pass Filter (2 rad/sec bandwidth) Order of Numer, Denom= 0 2 Numer 0.0 0.0 4.0 Denom 1.00000 2.00000 4.00000 TF. Block # 2 Delay (sec)= 1.00000 Order of Numer, Denom= 1 1 Outpt #, from Input #, Gain 1 1 0.100000 {Combined System Outp} from {Low Pass Filter Inpu} Block #, from Input #, Gain {TF: 1, Low Pass Fil} from {Low Pass Filter Inpu} 1 1 1.000000 Outpt #, from Block #, Gain 1 2 1.000000 {Combined System Outp} from {TF: 2, Delay (sec)=} Block #, from Block #, Gain 2 1 1.000000 {TF: 2, Delay (sec)=} from {TF: 1, Low Pass Fil} Definitions of Inputs = 1 Low Pass Filter Input Definitions of Outputs = 1 Combined System Output _____ SYSTEM OF TRANSFER FUNCTIONS ... Fifth Order System of 3 Transfer Functions ! This System consists of three transfer functions in feedback configuration Continuous TF. Block # 1 Second Order (a) Order of Numer, Denom= 2 2 Numer 1.0 1.0 3.0 Denom 1.0 2.0 5.0 TF. Block # 2 Second Order (b) Order of Numer, Denom= 2 2 Numer 1.0 0.5 2.0 Denom 1.0 4.0 6.0 TF. Block # 3 First Order Order of Numer, Denom= 1 1 Numer 1.0 1.0 Denom 1.0 4.0 Block #, from Input #, Gain 1 1 1.000000 {TF: 1, Second Order} from {Combined System Inpu} 2 2 1.000000 {TF: 2, Second Order} from {Combined System Inpu} Outpt #, from Block #, Gain 1 2 1.000000 {Combined System Outp} from {TF: 2, Second Order} 2 3 1.000000 {Combined System Outp} from {TF: 3, First Order } Block #, from Block #, Gain 2 1 1.000000 {TF: 2, Second Order} from {TF: 1, Second Order} {TF: 3, First Order } from {TF: 2, Second Order} {TF: 1, Second Order} from {TF: 3, First Order } 3 2 1.000000 1 3 -4.000000 Definitions of Inputs = 2 Combined System Input 1 Combined System Input 2 Definitions of Outputs = Combined System Output 1 Combined System Output 2 _____

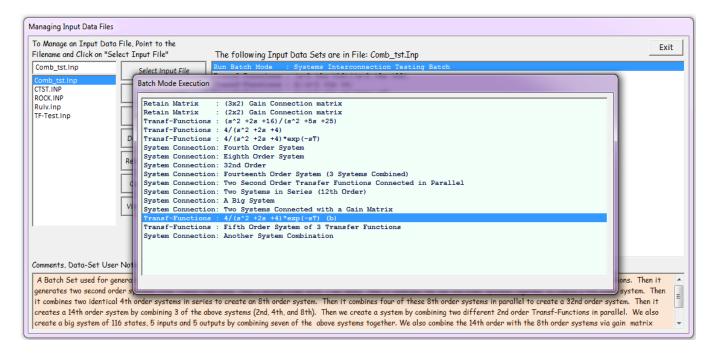
```
INTERCONNECTION OF SYSTEMS .....
Another System Combination
! Combine three systems together from above
Titles of Systems to be Combined
Title 1 Fourth Order System
Title 2 Eighth Order System
Title 3 Fifth Order System of 3 Transfer Functions
SYSTEM INPUTS DIRECT TO SYSTEM OUTPUTS
System Input 1 to System Outpt 2, Gain= 0.10000
System Input 2 to System Outpt 1, Gain= 0.20000
SYSTEM INPUTS TO SUBSYSTEM 1 Fourth Order System
System Input 1 to Subsystem 1, Input 2, Gain= 1.0000
System Input 2 to Subsystem 1, Input 1, Gain= 1.3400
SYSTEM INPUTS TO SUBSYSTEM 2 Eighth Order System
Via Matrix +I2
                             Size ( 2 x 2)
SYSTEM OUTPUTS FROM SUBSYSTEM 2 Eighth Order System
System Output 2 from Subsystem 2, Output 1, Gain= 2.0000
System Output 1 from Subsystem 2, Output 2, Gain= 1.5670
.....
SUBSYSTEM NO 1 GOES TO SUBSYSTEM NO 2
Subsystem 1, Output 1 to Subsystem 2, Input 1, Gain=
                                             2.0000
Subsystem 1, Output 1 to Subsystem 2, Input 2, Gain= 2.3456
Subsystem 1, Output 2 to Subsystem 2, Input 2, Gain= 1.2345
SUBSYSTEM NO 2 GOES TO SUBSYSTEM NO 3
Via Matrix -I2
                              Size ( 2 x 2)
SUBSYSTEM NO 3 GOES TO SUBSYSTEM NO 1
                              Size ( 2 x 2)
Via Matrix -I2
Definitions of Inputs = 2
Combined System Input 1
Combined System Input 2
Definitions of Outputs =
Combined System Output 1
Combined System Output 2
```

Let us now process this file by running the batch set which is located on the top of the input file. First select the directory, and from the Flixan main menu select "*File Management*", then "*Manage Input Files*", and then "*Edit/ Process Input Data Files*", as shown.

(🐦 Flixan, Flight Vehicle Modeling & Control System Analysis						
l	Utilities	ilities File Management Program Functions View Quad Help					uad Help
l			Managing Inp	ut Files (.Inp)	•		Edit / Process Batch Data Sets
l			Managing Sys	tem Files (.Qdr)	►		Edit / Process Input Data Files

The input data file manager dialog comes up that has two menus. From the left menu select the input file "*Comb_tst.Inp*" and click on "Select Input File". The menu on the right side shows the titles of the data-sets located in this file, also the program that will process each set. They are mainly system and transfer-function interconnection sets. Select the first title which is the batch set and it will process the remaining data-sets in batch (non-interactively). Click on "*Process Input Data*", and the batch set will process the input file and save the systems in file "*Comb_tst.Qdr*".

Managing Input Data Files						
To Manage an Input Data Filename and Click on "Se		The following Input Data Sets are in File: Comb_tst.Inp	Exit			
Comb_tst.Inp Comb_tst.Inp	Select Input File	Run Batch Mode : Systems Interconnection Testing Batch Transf-Functions : (s^2 +2s +16)/(s^2 +5s +25) Transf-Functions : 4/(s^2 +2s +4)				
CTST.INP ROCK.INP Rulv.Inp	Edit Input File	Transf-Functions : 4/(s^2 +2s +4)*exp(-sT) System Connection: Fourth Order System				
TF-Test.Inp	Process Input Data	System Connection: Eighth Order System System Connection: 32nd Order System Connection: Fourteenth Order System (3 Systems Combined)				
	Delete Data Sets in File	System Connection: Two Second Order Transfer Functions Connected in Parallel System Connection: Two Systems in Series (12th Order) System Connection: A Big System				
	Relocate Data Set in File	System Connection: Two Systems Connected with a Gain Matrix Transf-Functions : 4/(s'2 +2s +4)*exp(-sT) (b) Transf-Functions : Fifth Order System of 3 Transfer Functions	×			
	Copy Set to Another File View Data-Set Comments	System Connection: Another System Combination The systems filename: Comb_tst.Qdr already exists. Do you want to create it agai	in?			
Comments, Data-Set Use	n Notae	Yes N	•			
		ems together for demo purposes. It first retains two matrices in the systems file that will be used later in the connections. Then i				
generates two second or it combines two identica creates a 14th order sys	A barch set used for generating and connecting systems togener tor demo purposes. If this i returns two matrices in the systems the fund with de used rater in the connections. Then it generates two second order systems from Transf-Functions. Then a second order with 1 sec delay. Then it combines the two 2nd order systems together to create a 4th order system. Then it combines two identical 4th order systems in series to create an 8th order system. Then it combines four of these 8th order systems in parallel to create a 32nd order system. Then it creates a 14th order system by combining 3 of the above systems (2nd, 4th, and 8th). Then we create a system by combining two different 2nd order Transf-Functions in parallel. We also create a big system of 116 states, 5 inputs and 5 outputs by combining seven of the above systems together. We also combine the 14th order with the 8th order systems via gain matrix					



A display pops up temporarily while the batch is executing that shows the batch commands, as shown above. The currently executing command is highlighted for debugging purposes in case of errors. Notice that the batch includes two commands to retain and copy two matrices from the original file to the new file because the matrices are used in the interconnections. Otherwise, the old data in the systems file are erased and replaced with new data.

2.0 Transfer Functions Combination Program

The transfer functions combination program is a Flixan utility that can be used to combine several transfer function blocks together in a state-space system form. The combined state-space system is saved in a systems file. The program uses two data files, an input data file (.Inp) and a systems file (.Qdr). The input data file includes the transfer functions to be combined, the transfer function interconnections, and the definitions of the combined system's input and output variables. The interconnection instructions describe how the transfer functions are to be connected together by the program, and to the system inputs and outputs. The combined TF system is saved in the systems file. There is also an interactive Graphics/ User interface (GUI) utility included that helps the user to enter the transfer-function interconnection data in the input file or to read the interconnections from the file graphically without editing the file directly. Figure (2.1) shows the interaction between the transfer functions combination program, the GUI, the user, and the data files.

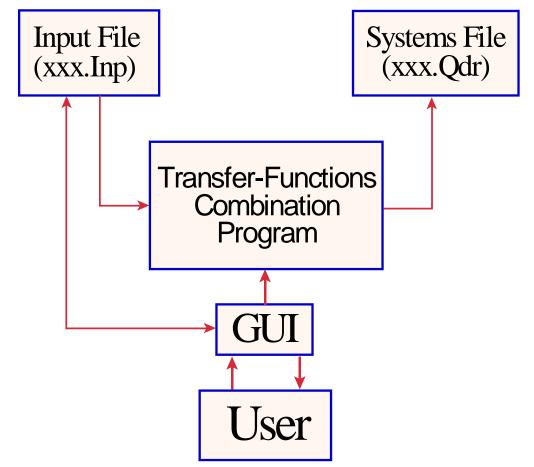
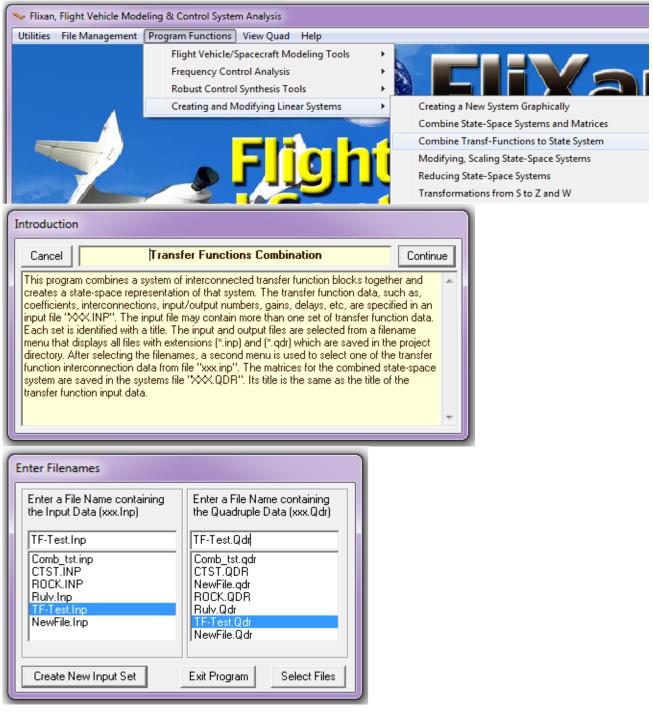


Figure (2.1) Diagram of the Transfer-Functions Interconnection Utility Program showing its interaction with the User and the Input/ Output Files

2.1 Program and Input/ Output Files Selection

The transfer functions combination program can be selected from the Flixan main menu by clicking on the "*Program Functions*", select the "*Creating and Modifying Linear Systems*" group, and then click on "*Combine Transfer-Functions to State Systems*". Then use the following file selection dialog to select the input data file and the systems file from the menus, as shown below. The two files are selected from a filenames selection menu.



Transfer Functions Interconnection data-set in the input file (.Inp)

TF interconnection data-sets contain the transfer functions interconnection instructions and they are located in input files (.Inp). A typical data-set for interconnecting three transfer function blocks together is shown below.

```
SYSTEM OF TRANSFER FUNCTIONS ...
3 Blocks Interconnection Test
! Comment lines for the new system
! This system is obtained by combining 3 TF blocks
Cont inuous
TF. Block # 1 (s2+3s=2)/(s2+2s+0.75)
                                                          Order of Numer, Denom= 2 2
Numer1.000003.000002.00000Denom1.000002.000000.750000
TF. Block # 2 1/(s+5)
                                                          Order of Numer, Denom= 0 1
Numer 0.00000 1.00000
Denom 1.00000 5.00000
TF. Block # 3 (s3+5s2+6.75s+2.25)/(s3+3.4s2+3.2s+0.8)
                                                          Order of Numer, Denom= 3 3

        Numer
        1.00000
        5.00000
        6.75000
        2.25000

        Denom
        1.00000
        3.40000
        3.20000
        0.800000

_____
                                           Block #, from Input #, Gain
         2 1.00000
1 1.00000
     1
     2
                1
                 3
     3
                         1.00000
 Block #, from Block #, Gain
    2
                         0.37500
         1
Outpt #, from Block #, Gain
     1
           2
3
1
                         5.00000
     2
                         0.35555
    2
                          0.133333
Outpt #, from Input #, Gain
          1 0.001
1 0.355555
     1
    2
Definitions of Inputs =
System Input 1 to Block 2
System Input 2 to Block 1
System Input 3 to Block 3
Definitions of Outputs =
                        2
System Output 1 from Block 2
System Output 2 from Blocks 1 and 3
                                 _____
   _____
```

At the top of the data-set there is a line describing the type of data following in order to identify the program that will process the data. In this case it is a system of transfer-functions interconnection. This is because the input file does not only contain transfer functions combination data for this program but it may also contain data-set for other Flixan programs (such as, for example, systems combination data, flight vehicle modeling, actuator, etc). In the second line we have the title for the new system to be created. It will not be a transfer function but it will be in state-space form. The next few lines below the title beginning with (!) are comment lines for documentation purposes which describe the new system title.

The next line defines if the transfer functions and subsequently the new system to be created are "Continuous" (s-plane), or "Discrete" (z-plane). If the TF are discrete the sampling period is also included in (seconds). For example, "Discrete, dT = 0.04". The following lines define the transfer function blocks. Each block is assigned a TF block number and a short description title. The numerator and denominator orders of each TF are shown at the right end of the line. Below each TF title, in the

next two lines, the numerator and denominator coefficients are included in descending order. The order of each transfer function should not exceed 5. To include higher order TFs you must combine smaller blocks in series. The lines below the transfer functions define the interconnections. That is, how the TF blocks are connected together and with the system inputs and outputs. Similar to the systems interconnection utility there are four types of interconnection instructions.

- 1. Direct connections from the system inputs to the system outputs which define the direct feedthrough matrix D, (*Output #, from Input #, Gain*), followed with the detailed direct connections and gains between system inputs to system outputs.
- 2. Connections between the system inputs to TF blocks, (*Block #, from Input #, Gain*), followed with detailed connections and gains between inputs and blocks.
- 3. Connections between transfer function outputs and the system outputs, (*Output #, from Block #, Gain*), followed with detailed connections and gains between TF blocks and outputs.
- 4. Connections between the TF blocks, (*Block #, from Block #, Gain*), followed with detailed connections and gains.

In the TF interconnections data, the blocks to be combined are referred to by their block numbers. At the bottom of the data set the user may include definition labels of the new system's inputs and outputs. The input and output definitions are optional. If they are not included the program assigns default labels, such as, "*System Input 1*", etc. An experienced user can easily create by copying and pasting a TF interconnections data-set in the input file by using a standard text editor. There is, however, a GUI capability in the program that makes it easier for the user to generate the interconnections set by using menus and dialogs. The GUI helps entering the title, selecting and defining the transfer-functions to be combined, entering the TF interconnections, the new system input and output labels, and the user comments. It also provides text editing capability to modify the input data. The GUI will also save the TF interconnections in the input data file, and run the TF program to create the combined system in file (.Qdr).

Systems File

The systems file (with an extension Qdr) contains state-space systems and matrices generated by Flixan. The program reads the transfer function interconnection data, combines them together, saves the combined system at the bottom of the systems file without destroying the already existing data. The system title is the same as in the TF interconnections data in the input file. The lines below the title starting with (!) are comments copied from the TF set. The length of the title and length each comment line should be less than 100 characters long. The following line defines the system dimension and sample rate (0 if continuous).

2.2 Creating a New Transfer-Functions Interconnection Set Interactively

If the transfer function interconnection data have not been created yet in the input file the program will obtain the interconnections from the user interactively using a GUI dialog. In the example that follows we will use the TF program to combine a system of transfer-function blocks together and to create a TF interconnections set in file "*TF-Test.Inp*". Then we will process this data-set using the transfer-functions interconnection program to generate a state-space system that will be saved in systems file "*TF-Test.Qdr*". This TF system is a Shuttle lateral flight control system, shown in Figure (2.2), and the example files are located in folder "*C:\Flixan\Comb_Trfn\Examples*".

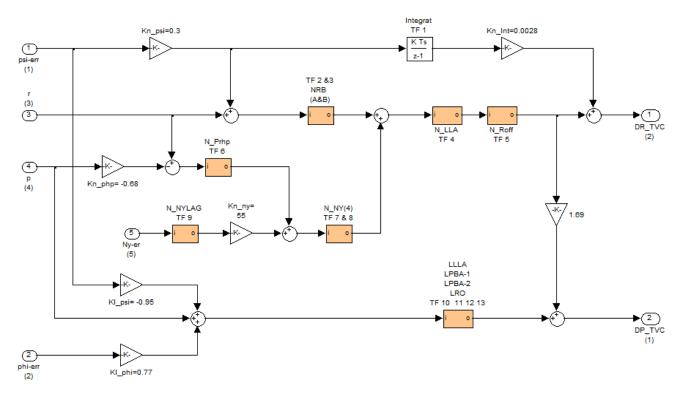
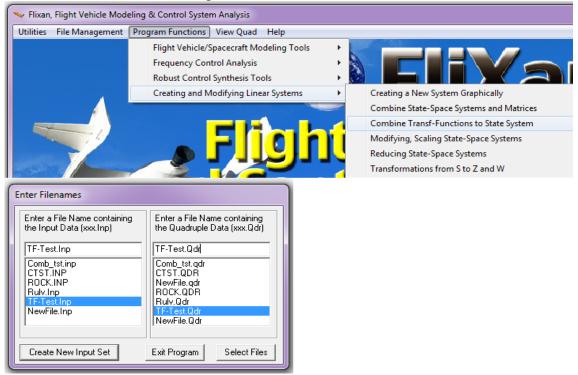
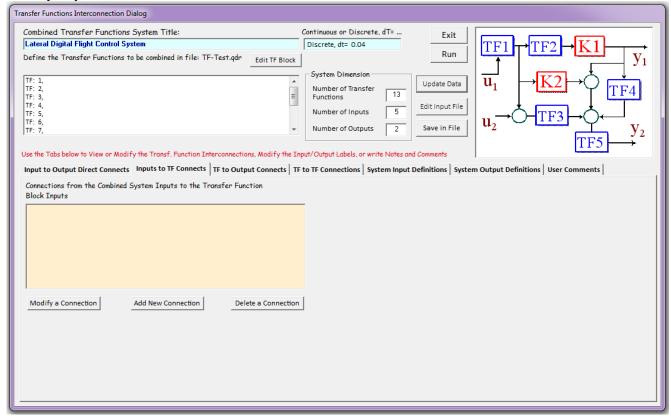


Figure (2.2) Shuttle Ascent Lateral Flight Control System

So let us begin the transfer-functions combination program starting from the Flixan main menu, click on "*Program Functions*", select "*Creating and Modifying Linear Systems*", and then "*Combine Transfer-Functions to State Systems*". From the following file selection menu select an input data file and the systems file, as shown below, and then click on "*Create a New Input Set*" to begin the interactive TF interconnections process.



The transfer functions interconnection GUI dialog will then appear where the user will enter the TF data for this example. You must first enter a title for the combined system "*Lateral Digital Flight Control System*", the number of transfer functions to be combined (13), the sampling time (sec) if the transfer-functions are defined in the z-plane, in this case enter: "*Discrete, dT*= 0.04", otherwise "*Continuous*" if the transfer-functions are in the s-plane. Then enter the number of inputs (2) and the number of outputs (2) in the new system. Each TF is automatically assigned a number used for interconnection referencing. After entering the top level data click on the "*Update Data*" button to update the data internally. You must update the data every time you change tabs. Do not save the data in file yet, you must save it at the end.



The dialog has several tabs for entering the four different groups of interconnection data between inputs, outputs, and transfer-functions, already discussed, definitions of the new system inputs and outputs, and user notes/ comments about this TF system. The TF interconnections are not shown in block diagram form like in Simulink. It is assumed that the user has already a block diagram drawing of the combined system to implement. The TF block diagram is defined by individual connections between the TF, the inputs, and outputs. The connections are defined using the first four tabs by the "from" and "to" numbers of the: TF, inputs, and outputs, and by the "Gain" in between, as already seen in the input data-set. Once the interconnection set is "saved in file" the user may either process the data set by clicking on "Run", or modify some of the info and save it under a different title in the same input data file and run the modified version. It is also possible to edit the data directly from the GUI dialog by clicking on "*Edit Input File*". A text editor comes up where the user can edit the input data file (.Inp) and save it before running it.

Defining the TF blocks: The next thing to do is to enter the data for the 13 TF blocks defined above. The transfer function blocks are listed in the white menu below the title and they are initially blank. When starting with a new system this window is empty and the user must define the transfer function data and titles. Up to 40 transfer functions blocks may be included in that list and each transfer function must be 5th order or less. At this point the dialog expects us to define the 13 TF coefficients and to identify each one with a short label. Let us select the first TF from the menu and click on "*Edit TF Block*" to define the transfer function title and its coefficients. The TF may also be defined as a Pade delay approximation by entering the delay time in (sec) and the order of the Pade approximation. In this case we enter an integrator for the first TF and click OK. We also enter a short title "yaw Integrator". Similarly we define the remaining of the TF blocks, one at a time. The last one shown is TF:13, "*LRO (roll axis roll-off)*". The transfer-function titles are gradually appearing in the white menu as they get updated. We may now begin entering the interconnections. Click on the "Update Data" button before entering the tabs.

Combined Transfer Functions Syste	m Title:	Continuous or Discrete, dT=	Exit	
Lateral Digital Flight Control System		Discrete, dt= 0.04	TF1 T	$F2 \rightarrow K1 \rightarrow K1$
Define the Transfer Functions to be co	mbined in file: TF-Test.qdr Edi	t TF Block	Run	y_1
TF: 1, TF: 2, TF: 3, TF: 5, TF: 6, TF: 7,	ransf Function Interconnections . Mr	System Dimension Number of Transfer Functions 13 Number of Inputs 5 Number of Outputs 2 Ddify the Input/Output Labels, or write Notes of	Update Data Edit Input File Save in File Comments	$\begin{array}{c} K2 \rightarrow & \downarrow \\ TF3 \rightarrow & \downarrow \\ TF5 \rightarrow & y_2 \\ TF5 \rightarrow & y_2 \end{array}$
	s to TF Connects TF to Output Co	nnects TF to TF Connections System Inpu		s User Comments
Block Inputs		Edit Transfer Function Da Yaw Integrator Numerator Coefficients in D 0.04 0.0 Denominator Coefficients in 1.0 -1.0 Connection	Descending Order Numerator Order	OK Delay aplace it n a Delay Block

ransfer Functions Interconnection Dialog	
Combined Transfer Functions System Title:	Continuous or Discrete, dT= Exit
Lateral Digital Flight Control System	Discrete, dt= 0.04 $TF1 \rightarrow TF2 \rightarrow K1 \rightarrow K1$
Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 7, NNY-(A) TF: 8, NNY-(B)	System Dimension Update Data Update Data u_1 $K2 \rightarrow TETA$
TF: 9, NYLAG TF: 10, LLLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) TF: 13, TF: 13, TF: 13, TF: 13, TF: 13, TF: 10, TF: 10, TF	Functions 13 Number of Inputs 5 Number of Outputs 2 Save in File u_2 $TF3$ y_2
Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the In Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TF Connections from the Combined System Inputs to the Transfer Function Block Inputs	$TF5 \rightarrow$
Modify a Connection Add New Connection Delete a Connection	Edit Transfer Function Data LRO (roll roll-off) OK Numerator Coefficients in Descending Order Numerator Order 0.357357 0.150150 0.033033 2 Delay Denominator Coefficients in Descending Order Denominator Order 1.00000 -0.810811 0.351351 2 Block

Direct Connections from System Inputs to System Outputs: The first tab on the left is for defining direct connections from the system inputs to the system outputs without connecting to the TF blocks. It defines the direct feed-through matrix (D) in the state-space representation. In this example we do not have any direct connections between the system inputs and outputs. However, the tab includes a menu on the left side that has a title "Direct Connections from the Combined System Inputs to the Combined System Outputs". The buttons below the menu are used for adding a new connection, deleting, or modifying an already existing connection. If you click on the "Add a Connection" button a couple of white menus appear on the right used for defining the interconnection. The menu on the left shows the titles of the combined system inputs and the menu on the right shows the combined system outputs. Default names are used, such as "System Input 1", if descriptive names have not yet been defined. Connections must be defined one at a time by selecting one item from each menu, entering the gain, and clicking "OK". No matrix interconnections. The two white menus on the right disappear, and interconnection defined appears in the left menu, one at a time, for example, "Input 1 goes to Output 2, Gain=5.2". We may now go to the second tab.

Connections from System Inputs to Transfer Function Blocks: The second tab is for defining connections from the system inputs to the TF block inputs, and it is very similar to the first tab. There is a menu on the left that has a title "*Connections from the Combined System Inputs to the Transfer Function Inputs*". The interconnections are eventually included in this menu, for example, "*Input 1 [Command] goes to T.F. #2 [Integrator], Gain=3.2*", but initially when there are no connections defined this menu is blank. There are buttons below the menu for adding a new connection, deleting, or modifying an already existing connection. You may click on "*Add a Connection*" and a couple of menus appear on the right having a title "*Define Connections from the Combined System Inputs to Transfer Function Inputs*". The menu on the left shows the titles of the combined system inputs, and the menu on the right shows the titles and numbers of the transfer function blocks. The TF data and

titles are already defined. You can only select one item from each menu which defines a scalar connection between one of the system inputs to one of the transfer functions. Begin by selecting "System Input 1" from the left menu and "TF: 1, Yaw Integrator" from the right menu. Enter a gain of 0.3 below, and click on "OK" to submit it. The two white menus on the right disappear and the interconnection that you defined appears in the left menu as follows: "Input 1 [system input 1] goes to T.F. #1 (yaw integrator), Gain=0.3". Click on "Add a Connection" button again to define more connections between system inputs and TF blocks, as shown below. The menu on the left gradually begins to fill with input to TF connections as shown. When you finish with the connections click on the "Update Data" button and go to the next tab.

Combined Transfer Functions System Title:		
comprise indicitors system titles	Continuous or Discrete, dT= Exit	
Lateral Digital Flight Control System	Discrete, dt= 0.04	TF1 \rightarrow TF2 \rightarrow K1 \rightarrow
Define the Transfer Functions to be combined in file: TF-Test.qdr	Run	
TF: 6, NPRHP	System Dimension	$\overline{u_1} \rightarrow \overline{K2} \rightarrow \mathring{O}$
TF: 7, NNY-(A)	Number of Transfer Update Data	$\mathbf{u}_1 \mathbf{u}_2 \mathbf{v}_{\mathrm{TF4}}$
TF: 8, NNY-(B) TF: 9, NYLAG	rancaona	
TF: 10, LLLA	Number of Inputs 5	
TF: 11, LPBA-(1)	Number of Outputs 2 Save in File	\mathbf{u}_{1}
TF: 12, LPBA-(2)	Number of Outputs 2 Save in File	
the description of the second state of the sec		TF5 →
Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir		
Input to Output Direct Connects Inputs to TF Connects TF to Output Connects		n Output Definitions User Comments
Connections from the Combined System Inputs to the Transfer Function Block Inputs	Define connections from combined system Inputs	Connecting to the Transfer Function Inputs
	System Input 1	TF: 1, Yaw Integrator
	System Input 2 System Input 3	TF: 2, NRB- (A) TF: 3, NRB-(B)
	System Input 4	TF: 4, NLLA
	System Input 5	TF: 5, NROFF (yaw roll-off)
		TF: 6, NPRHP
	1	TF: 7, NNY-(A)
	Select a "From" System Input and a Transfer	Function that it goes to. Enter 0.3 OK
, 	also the scalar connection gain	
Modify a Connection Add New Connection Delete a Connection	<u>ו</u>	
ansfer Functions Interconnection Dialog		
Combined Transfer Functions System Title:	Continuous or Discrete, dT= Exit	
Lateral Digital Flight Control System	Discrete, dt= 0.04	$TF1 \rightarrow TF2 \rightarrow K1 \rightarrow F1$
Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block	Run	
Edit IF Block		
TF: 6, NPRHP	System Dimension	$\overline{\mathbf{u}} \rightarrow \overline{\mathbf{K}} 2 \rightarrow 0$
TF: 7, NNY-(A)	Number of Transfer Update Data	$ \mathbf{u}_1 \mathbf{u}_2 \mathbf{v}_1 \mathbf{T}_{F4} $
TF: 8, NNY-(B) TF: 9, NYLAG	Functions Edit Input File	
TF: 10, LLLA	Number of Inputs 5	
TF: 11, LPBA-(1) TF: 12, LPBA-(2)	Number of Outputs 2 Save in File	
11.12, C ON (2)		
	nput/Output Labels, or write Notes and Comments	$TF5 \longrightarrow$
Jse the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir		n Output Definitions User Comments
Jse the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir		n Output Definitions User Comments Connecting to the Transfer Function Inputs
Jse the Tabs below to View or Modify the Transf. Function Interconnections, Modify the In Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TF Connections from the Combined System Inputs to the Transfer Function Block Inputs	F to TF Connections System Input Definitions System Define connections from combined system Inputs	Connecting to the Transfer Function Inputs
Jse the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TF Connections from the Combined System Inputs to the Transfer Function Block Inputs Input: 1 (System Input 1) goes to T.F.# 1 (Yaw Integrator), Gain= 0.3000000 Input: 1 (System Input 1) goes to T.F.# 2 (NRB- (A)), Gain= 0.3000000	F to TF Connections System Input Definitions System Define connections from combined system Inputs System Input 1 System Input 2	Connecting to the Transfer Function Inputs TF: 5, NROFF (yaw roll-off) TF: 6, NPRHP
Ise the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TF Connections from the Combined System Inputs to the Transfer Function Block Inputs Input: 1 (System Input: 1) goes to T.F.# 1 (Yaw Integrator), Gain= 0.3000000 Input: 1 (System Input: 1) goes to T.F.# 2 (NRB-(A)), Gain= 0.3000000 Input: 1 (System Input: 1) goes to T.F.# 2 (NRB-(A)), Gain= 0.3000000 Input: 3 (System Input: 3) goes to T.F.# 2 (NRB-(A)), Gain= 0.000000	F to TF Connections System Input Definitions System Define connections from combined system Inputs System Input 1 System Input 2 System Input 3	Connecting to the Transfer Function Inputs TF: 5, NROFF (yaw roll-off) TF: 6, NRRHP TF: 7, NRV-(A)
Inputs to TF connects TF to Output Connects Input: 1 {Syste	F to TF Connections System Input Definitions System Define connections from combined system Inputs System Input 1 System Input 2	Connecting to the Transfer Function Inputs TF: 5, NROFF (yaw roll-off) TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NVAG
Jse the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TF Connections from the Combined System Inputs to the Transfer Function Block Inputs I (System Input 1) goes to T.F.# 1 {Yaw Integrator }, Gain= 0.3000000 Input: 1 (System Input 1) goes to T.F.# 2 {INBE- (A) }, Gain= 0.3000000 Input: 3 (System Input 3) goes to T.F.# 2 {INBE- (A) }, Gain= 1.000000 Input: 3 (System Input 3) goes to T.F.# 6 {INPRHP }, Gain= 1.000000 Input: 4 (System Input 4) goes to T.F.# 0 { {INRHP }, Gain= -0.6800000 Input: 4 (System Input 4) goes to T.F.# 10 { LLL A }, Gain= -0.0500000	F to TF Connections System Input Definitions System Define connections from combined system Inputs System Input 1 System Input 2 System Input 3 System Input 4	Connecting to the Transfer Function Inputs TF: 5, NROFF (yaw roll-off) TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLLA
Jse the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TF Connections from the Combined System Inputs to the Transfer Function Block Inputs Input 1 (System Input 1) goes to TF# 2 (NRB- (A)), Gain= 0.3000000 Input: 3 (System Input 3) goes to TF# 2 (NRB- (A)), Gain= 1.000000 Input: 3 (System Input 3) goes to TF# 2 (NRB- (A)), Gain= 1.000000 Input: 3 (System Input 3) goes to TF# 6 (NRRHP), Gain= -0.6800000	F to TF Connections System Input Definitions System Define connections from combined system Inputs System Input 1 System Input 2 System Input 3 System Input 4	Connecting to the Transfer Function Inputs TTF: 5, NROFF (yaw roll-off) TF: 6, NPRHP TTF: 7, NNY-(A) TTF: 9, NNY-(B) TTF: 9, NNY-(B) E
Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF Connections from the Combined System Inputs to the Transfer Function Block Inputs [Input: 1 {System Input 1 } goes to T.F.# 1 {Yaw Integrator }, Gain= 0.3000000 Input: 1 {System Input 1 } goes to T.F.# 2 {NRB-(A) }, Gain= 0.3000000 Input: 3 {System Input 3 } goes to T.F.# 2 {NRB-(A) }, Gain= 1.000000 Input: 3 {System Input 3 } goes to T.F.# 6 {NPRHP }, Gain= 1.000000 Input: 4 {System Input 4 } goes to T.F.# 0 {NPRHP }, Gain= -0.6800000 Input: 4 {System Input 4 } goes to T.F.# 10 {LLA }, Gain= -0.0500000	F to TF Connections System Input Definitions System Define connections from combined system Inputs System Input 1 System Input 2 System Input 3 System Input 4 System Input 5 Select a "From" System Input and a Transfer	Connecting to the Transfer Function Inputs TF: 5, NROFF (yaw roll-off) TF: 6, NRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLLA TF: 11, LPBA-(1)
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Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TF Connections from the Combined System Inputs to the Transfer Function Block Inputs Input: {System Input 1 } goes to TF# 1 {Yaw Integrator }, Gain= 0.3000000 Input: {System Input 1 } goes to TF# 2 { NRB- (A) }, Gain= 0.3000000 Input: 3 {System Input 3 } goes to TF# 2 { NRB- (A) }, Gain= 1.000000 Input: 3 {System Input 3 } goes to TF# 6 { NPRHP }, Gain= -0.6800000 Input: 4 {System Input 4 } goes to TF# 10 { LLLA }, Gain= 0.500000 Input: 2 { System Input 2 } goes to TF# 10 { LLLA }, Gain= 0.7700000	F to TF Connections System Input Definitions System Define connections from combined system Inputs System Input 1 System Input 2 System Input 3 System Input 4 System Input 5 Select a "From" System Input and a Transfer also the scalar connection gain	Connecting to the Transfer Function Inputs TF: 5, NROFF (yaw roll-off) TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLA TF: 11, LPBA-(1)
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Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TF Connections from the Combined System Inputs to the Transfer Function Block Inputs Input: 1 (System Input 1) goes to TF# 1 (Yaw Integrator), Gain= 0.3000000 Input: 1 (System Input 1) goes to TF# 2 (NRB- (A)), Gain= 0.3000000 Input: 3 (System Input 3) goes to TF# 2 (NRB- (A)), Gain= 0.3000000 Input: 3 (System Input 3) goes to TF# 2 (NRB- (A)), Gain= 0.000000 Input: 3 (System Input 3) goes to TF# 2 (NRB- (A)), Gain= 0.6800000 Input: 4 (System Input 4) goes to TF# 5 (NRPHP), Gain=-0.6800000 Input: 1 (System Input 4) goes to TF# 10 (LLLA), Gain= 0.7700000	F to TF Connections System Input Definitions System Define connections from combined system Inputs System Input 1 System Input 2 System Input 3 System Input 4 System Input 5 Select a "From" System Input and a Transfer also the scalar connection gain	Connecting to the Transfer Function Inputs TF: 5, NROFF (yaw roll-off) TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLA TF: 11, LPBA-(1)
Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TF Connections from the Combined System Inputs to the Transfer Function Block Inputs Input: 1 {System Input 1 } goes to TF# 1 {Yaw Integrator }, Gain= 0.3000000 Input: 1 {System Input 1 } goes to TF# 2 { NRB- (A) }, Gain= 0.3000000 Input: 3 {System Input 3 } goes to TF# 2 { NRB- (A) }, Gain= 1.000000 Input: 3 {System Input 3 } goes to TF# 6 { NPRHP }, Gain= -0.6800000 Input: 4 {System Input 1 } goes to TF# 10 { LLLA }, Gain= 0.7700000 Input: 2 {System Input 2 } goes to TF# 10 { LLLA }, Gain= 0.7700000	F to TF Connections System Input Definitions System Define connections from combined system Inputs System Input 1 System Input 2 System Input 3 System Input 4 System Input 5 Select a "From" System Input and a Transfer also the scalar connection gain	Connecting to the Transfer Function Inputs TF: 5, NROFF (yaw roll-off) TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLLA TF: 11, LPBA-(1)
Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TF Connections from the Combined System Inputs to the Transfer Function Block Inputs Input: 1 {System Input 1 } goes to TF# 1 {Yaw Integrator }, Gain= 0.3000000 Input: 1 {System Input 1 } goes to TF# 2 { NRB- (A) }, Gain= 0.3000000 Input: 3 {System Input 3 } goes to TF# 2 { NRB- (A) }, Gain= 1.000000 Input: 3 {System Input 3 } goes to TF# 6 { NPRHP }, Gain= -0.6800000 Input: 4 {System Input 1 } goes to TF# 10 { LLLA }, Gain= 0.7700000 Input: 2 {System Input 2 } goes to TF# 10 { LLLA }, Gain= 0.7700000	F to TF Connections System Input Definitions System Define connections from combined system Inputs System Input 1 System Input 2 System Input 3 System Input 4 System Input 5 Select a "From" System Input and a Transfer also the scalar connection gain	Connecting to the Transfer Function Inputs TF: 5, NROFF (yaw roll-off) TF: 6, NRNH TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLLA TF: 11, LPBA-(1)
Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TF Connections from the Combined System Inputs to the Transfer Function Block Inputs I Input: 1 (System Input 1) goes to TF# 1 (Yaw Integrator), Gain= 0.3000000 Input: 1 (System Input 1) goes to TF# 2 (NRB- (A)), Gain= 0.3000000 Input: 3 (System Input 3) goes to TF# 2 (NRB- (A)), Gain= 1.000000 Input: 3 (System Input 3) goes to TF# 2 (NRB- (A)), Gain= 0.6800000 Input: 4 (System Input 4) goes to TF# 10 (LLLA), Gain= -0.6800000 Input: 2 (System Input 2) goes to TF# 10 (LLLA), Gain= 0.7700000	F to TF Connections System Input Definitions System Define connections from combined system Inputs System Input 1 System Input 2 System Input 3 System Input 4 System Input 5 Select a "From" System Input and a Transfer also the scalar connection gain	Connecting to the Transfer Function Inputs TF: 5, NROFF (yaw roll-off) TF: 6, NRNH TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLLA TF: 11, LPBA-(1)
Jse the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TF Connections from the Combined System Inputs to the Transfer Function Block Inputs Input: 1 {System Input 1 } goes to TF# 1 {Yaw Integrator }, Gain= 0.3000000 Input: 1 {System Input 1 } goes to TF# 2 { NRB- (A) }, Gain= 0.3000000 Input: 3 {System Input 3 } goes to TF# 2 { NRB- (A) }, Gain= 1.000000 Input: 3 {System Input 3 } goes to TF# 2 { NRB- (A) }, Gain= -0.6800000 Input: 4 {System Input 4 } goes to TF# 10 { LLLA } }, Gain= -0.9500000 Input: 2 {System Input 2 } goes to TF# 10 { LLLA } }, Gain= 0.7700000	F to TF Connections System Input Definitions System Define connections from combined system Inputs System Input 1 System Input 2 System Input 3 System Input 4 System Input 5 Select a "From" System Input and a Transfer also the scalar connection gain	Connecting to the Transfer Function Inputs TF: 5, NROFF (yaw roll-off) TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLA TF: 11, LPBA-(1)

System Inputs to Transfer-Function Connections

Connections from Transfer Function Blocks to System Outputs: The third tab is for defining connections from TF block outputs to the combined system outputs and it is very similar to the previous tabs. There is a menu on the left that has a title "Connections from Transfer Function Outputs" to the Combined System Outputs". The interconnections are eventually included in this menu, for example, "T.F. #2 {low-pass} goes to Output #3 {Gimbal Command}, Gain=5.2", but initially when there are no connections defined this menu is blank. There are buttons below the menu for adding new connections, and for deleting, or modifying already existing connections. You may click on "Add a Connection" and a couple of white menus appear on the right having a title "Define Connections from Transfer Function Outputs to the Combined System Outputs". The menu on the left shows the titles and numbers of the "from" transfer function blocks and the menu on the right shows the titles and numbers of the system outputs. The TF data and titles are already defined. You can only select one item from each menu which defines a scalar connection between one of the transfer functions to one of the system outputs. Begin by selecting "TF: 1, Yaw Integrator" from the left menu and "System Output 2" from the right menu. Enter a gain of 0.00028 below, and click on "OK" to accept it. The two white menus on the right disappear and the interconnection that you defined appears in the left menu as follows: "T.F. #1 {vaw integrator} goes to Output #2 {system output 2}, Gain=0.28e-3". Click on "Add a Connection" button again to define more connections between TF blocks and system outputs, as shown below. You may also use the "Modify a Connection" or "Delete a Connection" buttons in case of errors. The menu on the left gradually begins to fill with TF to output connections, as shown below. When you finish with the connections click on the "Update Data" button and go to the next tab.

Connections between Transfer Function Blocks: The fourth tab is also similar to the previous tabs and it is used for defining connections from TF block outputs to other TF blocks, or a feedback loop around the same TF block. There is a menu on the left side with a title "Connections from Transfer Function Outputs to Transfer Function Inputs". The interconnections between TF's are eventually included in this menu, for example, "T.F. #1 {low-pass} goes to T.F. #2 {Integrator}, Gain=1.5", but initially when there are no connections defined, this menu is blank. There are buttons below the menu for adding new connections, and for deleting, or modifying an already existing connection. You may click on "Add a Connection" and a couple of white menus appear on the right having a title "Define Connections from Transfer Function Outputs Connecting to Transfer Function Inputs". Both menus show the titles and numbers of the transfer function blocks as they are already defined. You can only select one item from each menu which defines a scalar connection between the two transfer functions. Begin by selecting "TF: 2, NRB-(A)" from the left menu and "TF: 3, NRB-(B)" from the right menu, enter a gain of 1.0 below, and click on "OK" to accept it. The two white menus on the right disappear and the interconnection that you defined appears in the left menu as follows: "T.F. #2 {NRBB-(A)} goes to T.F. #3 (NRBB-(B)), Gain=1.0". Click on "Add a Connection" again to define more connections between the TF blocks, as shown below. You may also use the "Modify a Connection" or "Delete a Connection" buttons in case of an error. The menu on the left gradually begins to fill with TF to TF connections, as shown below. When you finish with this type of interconnections click on the "Update Data" button and go to the next tab.

Transfer Functions Interconnection Dialog	
Combined Transfer Functions System Title:	Continuous or Discrete, dT= Exit
Lateral Digital Flight Control System	Discrete, dt= 0.04 TF1 \rightarrow TF2 \rightarrow K1 \rightarrow
Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block	
	System Dimension
TF: 6, NPRHP TF: 7, NNY-(A)	Number of Transfer Update Data $u_1 \rightarrow K2 \rightarrow \uparrow TF4$
TF: 8, NNY-(B)	Functions
TF: 9, NYLAG TF: 10, LLLA	
TF: 11, LPBA-(1) TF: 12, LPBA-(2)	Number of Outputs 2 Save in File U2 V 115 Y2
11.12, CFUR(2)	$[TF5] \rightarrow] 2$
Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir	
	to TF Connections System Input Definitions System Output Definitions User Comments
Connections from Transfer Function Block Outputs to the Combined	
System Outputs	Define connections from Transfer Function Outputs Connecting to the Conbined System Outputs
T.F. # 1 { Yaw Integrator } goes to Outp: 2 { System Output 2 }, Gain= 0.2800000E-03	TF: 1, Yaw Integrator
	TF: 2, NRB- (A) TF: 3, NRB-(B)
	TF: 4, NLLA
	TF: 5, NROFF (yaw roll-off) TF: 6, NPRHP
	TF: 7, NNY-(A)
	Select a "From" Transfer Function Block and a System Output that it 1.0 OK
Modify a Connection Add New Connection Delete a Connection	-
Transfer Functions Interconnection Dialog	
·	Continuous or Discrete, dT=
Transfer Functions Interconnection Dialog Combined Transfer Functions System Title: Lateral Digital Flight Control System	Continuous or Discrete, $dT= \dots$ Exit
Combined Transfer Functions System Title: Lateral Digital Flight Control System	Discrete, dt= 0.04 $TF1 \rightarrow TF2 \rightarrow K1 \rightarrow K1$
Combined Transfer Functions System Title: Lateral Digital Flight Control System	Discrete, dt= 0.04 Run $TF1 \rightarrow TF2 \rightarrow K1$ y_1
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator	Discrete, dt= 0.04 System Dimension Undate Data Unda
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block	Discrete, dt= 0.04 Run System Dimension $TF1 \rightarrow TF2 \rightarrow K1 \rightarrow Y_1$
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB- (A) TF: 3, NRB- (B) TF: 4, NLLA	Discrete, dt= 0.04 System Dimension Number of Transfer Functions $\begin{array}{c} LKT\\ Run\\ Update Data\\ Edit Input Elle\\ Filt Input Elle\\ \end{array}$
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) E	Discrete, dt= 0.04 System Dimension Number of Transfer Functions 13 Number of Inputs 5 LAR Run TF1 TF2 K1 Y1 Update Data Edit Input File Update Data Edit Input File U TF3
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLLA TF: 5, NROFF (yaw roll-off)	Discrete, dt= 0.04 System Dimension Number of Transfer Functions 13 Number of Inputs 5 Number of Outputs 2 Save in File LAR Run Update Data Edit Input File Save in File
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLLA TF: 5, NROFF (yaw roll-off) TF: 6, NPRP TF: 7, NNY-(A)	Discrete, dt= 0.04 System Dimension Number of Transfer Functions 13 Number of Outputs 5 Number of Outputs 2 Number of Outputs 2
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 5, NROFF (year roll-off) TF: 7, NNY-(A) Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Int	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs 5 Number of Outputs 2 Save in File put/Output Labels, or write Notes and Comments
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 5, NROFF (year roll-off) TF: 7, NNY-(A) Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Int	Discrete, dt= 0.04 System Dimension Number of Transfer Functions 13 Number of Outputs 5 Number of Outputs 2 Number of Outputs 2
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLA TF: 5, NROFF (yaw roll-off) TF: 6, NRPHP TF: 7, NNY-(A) Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TF Connections from Transfer Function Block Outputs to the Combined	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs 5 Number of Outputs 2 Save in File put/Output Labels, or write Notes and Comments
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB- (A) TF: 3, NRB-(B) TF: 5, NROFF (year roll-off) TF: 7, NNY-(A) Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Input to Output Direct Connects Tr Connections from Transfer Function Block Outputs to the Combined System Outputs	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs Submer of Outputs Save in File TF1 Connections from Transfer Function Define connections from Transfer Function Outputs Connecting to the Conbined System Outputs Connecting to the Conbined System Outputs
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLA TF: 5, NROFF (yaw roll-off) TF: 6, NPRHP TF: 7, NNY-(A) Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TF Connections from Transfer Function Block Outputs to the Combined System Outputs TF: # 1 (Yaw Integrator 3 goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 0.2800000E-0:	Discrete, dt= 0.04 System Dimension Vumber of Transfer Functions Number of Inputs Save in File Save in File TF 7, NNY-(A) TF: 7, NNY-(A)
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB- (A) TF: 3, NRB-(B) TF: 5, NROFF (year roll-off) TF: 7, NNY-(A) Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Input to Output Direct Connects Tr Connections from Transfer Function Block Outputs to the Combined System Outputs	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs Save in File TF 7, NNY-(A) TF: 7, NNY-(B) TF: 8, NNY-B) TF: 7, NNY-(B) TF: 7, NNY-
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLLA TF: 5, NROFF (yaw roll-off) TF: 6, NRPHP TF: 7, NNY-(A) Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TE Connections from Transfer Function Block Outputs to the Combined System Outputs TF: # 1 (Yaw Integrator) goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 0.2800000E-0: TF. # 5 (NROFF (yaw roll-off) goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 1.00000	Discrete, dt= 0.04 Run System Dimension update Data Number of Transfer 13 Edit Input File Edit Input File Number of Inputs 5 Number of Outputs 2 Save in File Save in File put/Output Labels, or write Notes and Comments User Comments E to TF Connections System Input Definitions User Comments Define connections from Transfer Function Connecting to the Conbined System Outputs Outputs TF: 7, NNY-(A) TF: 9, NYLAG TF: 9, NYLAG Part FCS Demand to TVC
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLLA TF: 5, NROFF (yaw roll-off) TF: 6, NRPHP TF: 7, NNY-(A) Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TE Connections from Transfer Function Block Outputs to the Combined System Outputs TF: # 1 (Yaw Integrator) goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 0.2800000E-0: TF. # 5 (NROFF (yaw roll-off) goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 1.00000	Discrete, dt= 0.04 Run System Dimension Update Data Number of Transfer 13 Number of Inputs 5 Save in File Save in File Number of Outputs 2 Save in File Save in File Define connections System Output Definitions Update Data Update Data Dumber of Outputs 2 Save in File Save in File Define connections System Output Definitions Update Data Update Data Define connections from Transfer Function Connecting to the Conbined System Outputs Outputs TE: 7, NNY-(A) TE: 10, LLLA TE: 11, LPBA-(1) TE: 11, LPBA-(1) TE: 12, LPBA-(2)
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLLA TF: 5, NROFF (yaw roll-off) TF: 6, NRPHP TF: 7, NNY-(A) Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TE Connections from Transfer Function Block Outputs to the Combined System Outputs TF: # 1 (Yaw Integrator) goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 0.2800000E-0: TF. # 5 (NROFF (yaw roll-off) goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 1.00000	Discrete, dt= 0.04 Run System Dimension Update Data Number of Transfer 13 Edit Input File Edit Input File Number of Inputs 5 Number of Outputs 2 Save in File Save in File put/Output Labels, or write Notes and Comments User Comments E to TF Connections System Input Definitions User Comments Define connections from Transfer Function Connecting to the Conbined System Outputs Outputs TF: 7, NNY-(A) TF: 9, NYLAG TF: 10, LLLA TF: 10, LLLA TF: 10, LLLA TF: 10, LLLA TF: 10, LLLA TF: 10, LLLA
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLLA TF: 5, NROFF (yaw roll-off) TF: 6, NRPHP TF: 7, NNY-(A) Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TE Connections from Transfer Function Block Outputs to the Combined System Outputs TF: # 1 (Yaw Integrator) goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 0.2800000E-0: TF. # 5 (NROFF (yaw roll-off) goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 1.00000	Discrete, dt= 0.04 Run System Dimension Update Data Number of Transfer 13 Number of Inputs 5 Edit Input File Edit Input File Number of Outputs 2 Save in File Save in File put/Output Labels, or write Notes and Comments Update Definitions System Input Definitions System Output Definitions Define connections from Transfer Function Connecting to the Conbined System Outputs Outputs TT: 7, NIY-(A) TT: 7, NIY-(A) Red FCS Demand to TVC TT: 10, LLA FT: 10, LLA TT: 11, LPBA-(1) FT: 12, LPGA-(2) TT: 13, LRO (roll roll-off) Ft to for the for th
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLLA TF: 5, NROFF (yaw roll-off) TF: 6, NRPHP TF: 7, NNY-(A) Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TE Connections from Transfer Function Block Outputs to the Combined System Outputs TF: # 1 (Yaw Integrator) goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 0.2800000E-0: TF. # 5 (NROFF (yaw roll-off) goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 1.00000	Discrete, dt= 0.04 Run System Dimension Update Data Number of Transfer 13 Number of Inputs 5 Save in File Save in File Number of Outputs 2 Save in File Save in File Define connections System Output Definitions User Comments Define connections from Transfer Function Connecting to the Corbined System Outputs Outputs TIT: 7, NNY-(A) TIT: 8, NNY-(B) TIT: 10, LLLA TIT: 11, LPBA-(1) TIT: 11, LPBA-(1)
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLLA TF: 5, NROFF (yaw roll-off) TF: 6, NRPHP TF: 7, NNY-(A) Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Inputs to TF Connects TF to Output Connects TE Connections from Transfer Function Block Outputs to the Combined System Outputs TF: # 1 (Yaw Integrator) goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 0.2800000E-0: TF. # 5 (NROFF (yaw roll-off) goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 1.00000	Discrete, dt= 0.04 Run System Dimension Run Number of Transfer 13 Functions Edit Input File Number of Inputs 5 Number of Outputs 2 Save in File Save in File Number of Outputs 2 Save in File TF 3, NNY-(A) TF: 7, NNY-(A) Connections TF: 8, NNY-(B) Connections TF: 9, NYLAG TF: 10, LLLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) TF: 12, LPBA-(2) TF: 13, LRO (roll roll-off) Select from one of the Transfer-Function Blocks and the System 1.0 Output that it connects to, Enter also the Gain 1.0
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLA TF: 5, NROFF (yaw roll-off) TF: 7, NNY-(A) Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Input to Output Direct Connects TF: 1 (Yaw Integrator -) goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 0.2800000E-0: TF: # 1 (Yaw roll-off) goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 1.00000 TF: # 5 (NROFF (yaw roll-off) goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 1.00000	Discrete, dt= 0.04 Run System Dimension Run Number of Transfer 13 Functions Edit Input File Number of Inputs 5 Number of Outputs 2 Save in File Save in File Number of Outputs 2 Save in File TF 3, NNY-(A) TF: 7, NNY-(A) Connections TF: 8, NNY-(B) Connections TF: 9, NYLAG TF: 10, LLLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) TF: 12, LPBA-(2) TF: 13, LRO (roll roll-off) Select from one of the Transfer-Function Blocks and the System 1.0 Output that it connects to, Enter also the Gain 1.0
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Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLA TF: 5, NROFF (yaw roll-off) TF: 7, NNY-(A) Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the Ir Input to Output Direct Connects Input to Output Direct Connects TF: 1 (Yaw Integrator -) goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 0.2800000E-0: TF: # 1 (Yaw roll-off) goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 1.00000 TF: # 5 (NROFF (yaw roll-off) goes to Outp: 2 (Yaw FCS Demand to TV), Gain= 1.00000	Discrete, dt= 0.04 Run System Dimension Update Data Number of Transfer 13 Functions Edit Input File Number of Inputs 5 Number of Outputs 2 Save in File action of the transfer Put/Output Labels, or write Notes and Comments Et ot TF Connections System Input Definitions Define connections from Transfer Function Connecting to the Conbined System Outputs Outputs TF: 7, NNY-(A) TF: 10, NULA TF: 11, LPBA-(1) TF: 12, LPBA-(2) TF: 12, LPBA-(2) TF: 13, LRO (roll roll-off) TF: 14, LRO input that it connects to, Enter also the Gain
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Transfer-Function to System Output Connections

nsfer Functions Interconnection Dialog	
Combined Transfer Functions System Title:	Continuous or Discrete, dT= Exit
Lateral Digital Flight Control System	Discrete, dt= 0.04 TF1 \rightarrow TF2 \rightarrow K1
Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block	
TF: 6. NPRHP	System Dimension
TF: 7, NNY-(A)	Number of Transfer
TF: 8, NNY-(B) TF: 9, NYLAG	Functions
TF: 10, LLLA	Number of Inputs 5 Edit Input File $7 \rightarrow 7$ TF3 $\rightarrow 7$
TF: 11, LPBA-(1)	
TF: 12, LPBA-(2)	
	$TF5 \longrightarrow$
se the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I	Input/Ourput Labels, or write Notes and Comments
Connections from Transfer Function Block Outputs to Transfer Function	Define connections from Transfer Function Outputs Connecting to Transfer Function Inputs Connecting to Transfer Function Inputs
Block Inputs	
T.F.# 2 { NRB- (A) } goes to T.F. # 3 { NRB-(B) }, Gain= 1.000000 T.F.# 3 { NRB-(B) } goes to T.F. # 4 { NLLA }, Gain= 1.000000	TF: 3, NRB-(B) TF: 4, NLLA
T.F.# 3 { NRB-(B) } goes to T.F. # 4 { NLLA }, Gain= 1.000000 T.F.# 7 { NNY-(A) } goes to T.F. # 8 { NNY-(B) }, Gain= 1.000000	TF: 5. NROFF (vaw roll-off) TF: 3. NRB-(B)
T.F.# 8 { NNY-(B) } goes to T.F. # 4 { NLLA }, Gain= 1.000000	TF: 6, NPRHP
T.F.# 4 { NLLA } goes to T.F. # 5 { NROFF (yaw roll-off), Gain= 1.000000 T.F.# 6 { NPRHP } goes to T.F. # 7 { NNY-(A) }, Gain= 1.000000	TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 6, NPRHP
, j	TF: 9, NYLAG
	Colort a "Enough Toportion Constitution of a Toporto Constitution of the Constitutiono
	Select a "From" Transfer Function, and a Transfer Function that it connects 55.0 OK to. Enter also the connection gain
Modify a Connection Add New Connection Delete a Connection	-
erfor Europtions Interconnection Dialog	
nsfer Functions Interconnection Dialog	
·	Continuous on Disconta dT-
Combined Transfer Functions System Title:	Continuous or Discrete, dT= Exit
Combined Transfer Functions System Title: Lateral Digital Flight Control System	Discrete, dt= 0.04 $TF1 \rightarrow TF2 \rightarrow K1$
Combined Transfer Functions System Title: Lateral Digital Flight Control System	Discrete, dt= 0.04 TF1 → TF2 → K1
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block	Discrete, dt= 0.04
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr [Edit TF Block TF: 1, Yaw Integrator	Discrete, dt= 0.04 System Dimension Update Data Update Data Update Data
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) FT: 3, NRB-(B)	Discrete, dt= 0.04 System Dimension Update Data Update Data Update Data
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLA	Discrete, dt= 0.04 System Dimension Number of Transfer Functions $\begin{bmatrix} LXII \\ Run \\ Update Data \\ Filt Input File \\ File \\ TF1 \\ Update Data \\ TF1 \\ TF2 \\ K2 \\ TF4 \\ T$
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NNB-(A) TF: 3, NNB+(B) TF: 5, NNDF(yaw roll-off)	Discrete, dt= 0.04 Run System Dimension Number of Transfer Functions 13 Number of Inputs 5 Edit Input File Update Data Edit Input File Update Data
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 3, NRB-(B) TF: 4, NLLA F: 5, NRDF(yaw roll-off) TF: 6, NRNPF	Discrete, dt= 0.04 Run System Dimension Number of Transfer Functions 13 Number of Inputs 5 Edit Input File Update Data Edit Input File Update Data
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 3, NRB-(B) TF: 4, NLLA F: 5, NRDF(yaw roll-off) TF: 6, NRNPF	Discrete, dt= 0.04 Run System Dimension Number of Transfer Functions 13 Number of Inputs 5 Number of Outputs 2 Save in File Functions 2 Save in File
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLLA TF: 5, NROFF (yaw roll-off) TF: 6, NRPHP TF: 7, NNY-(A)	Discrete, dt= 0.04 Run System Dimension Number of Transfer Functions Number of Inputs Number of Outputs 2 Save in File Save in File Number of Outputs 2 Save in File
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, N8H (A) TF: 3, N8H (B) TF: 4, NLLA FF: 5, NROFF (yaw roll-off) TF: 6, NRNPH FF: 7, NNY-(A) se the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I nput to Output Direct Connects Inputs to TF Connects TF to Output Connects	Discrete, dt= 0.04 Run System Dimension Number of Transfer Functions Number of Inputs Number of Outputs 2 Save in File Save in File Number of Outputs 2 Save in File
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLL TF: 5, NROFF (yaw roll-off) TF: 6, NRPHP TF: 7, NNY-(A) Se the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I nput to Output Direct Connects Inputs to TF Connects TF to Output Connects Connections from Transfer Function Block Outputs to Transfer Function	Discrete, dt= 0.04 Run System Dimension Number of Transfer Functions Number of linputs Number of Outputs 2 Save in File Liti Input File Save in File Liti Input File Save in File Liti Input File Save in File Liti Input Save
Connections from Transfer Function Block Outputs to Transfer Function Block Outputs TF.# 2 {NRB- (A) } goes to TF.# 3 {NRB-(B) } TF. 4 3 {NRB-(B) } TF. 5 NRB-(B) } TRB-(B) } TRB-	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Outputs 5 Number of Outputs 2 Enput/Output Labels, or write Notes and Comments TF to TF Connections from Transfer Function Outputs TF: 7, NNY-(A)
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLLA TF: 5, NRPF(9) TF: 6, NRPFP TF: 7, NNY-(A) set the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I nput to Output Direct Connects Inputs to TF Connects TF to Output Connects TF: 7, NNY-(A) TF: 7, NNY-(A) goes to TF.# 3 (NRB-(B)), Gain= 1.000000 TF.# 3 (NRB-(B)), Gain= 1.000000	Discrete, dt= 0.04 Run System Dimension Number of Transfer Functions Number of Outputs 5 Number of Outputs 2 Save in File Tr to TF Connections from Transfer Function Outputs TF: 7, NNY-(A) TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 8, NNY-(B)
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLLA TF: 5, NRPHP TF: 6, NRPHP TF: 6, NRPHP TF: 7, NNY-(A) se the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I nput to Output Direct Connects Inputs to TF Connects TF to Output Connects T Connections from Transfer Function Block Outputs to Transfer Function Block Inputs TF:# 2 (NRB-(A) 3 goes to TF.# 3 (NRB-(B)), Gain= 1.000000 TF.# 7 (NNY-(A) 3 goes to TF.# 4 (NULA), Gain= 1.000000 TF.# 7 (NNY-(A) 3 goes to TF.# 4 (NULA), Gain= 1.000000	Discrete, dt= 0.04 Run System Dimension Number of Transfer Functions Number of Outputs 5 Number of Outputs 2 Save in File Linput/Output Labels, or write Notes and Comments TF to TF Connections System Input Definitions System Output Definitions User Comments Define connections from Transfer Function Outputs TF: 7, NNY-(A) TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NNY-(B) TF: 9, NNY-(A) TF: 9, NNY-(A) TF: 9, NNY-(A) TF: 9, NNY-(A) TF: 9, NNY-(B) TF: 9, NNY-(A) TF: 9, NNY-(B) TF: 9, NNY-(B) TF: 9, NNY-(A) TF: 9, NNY-(A) TF: 9, NNY-(B) TF: 9, NNY-(B) TF: 9, NNY-(B) TF: 9, NNY-(B) TF: 9, NNY-(A) TF: 9, NNY-(B) TF: 9, NNY-(A) TF: 9, NNY-(A)
Combined Transfer Functions System Title: Lateral Digital Flight Control System befine the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator FF: 2, NRB- (A) FF: 3, NRB-(B) FF: 4, NLLA FF: 6, NRPH P FF: 7, NNY-(A) Eethe Tabs below to View or Modify the Transf. Function Interconnections, Modify the I nput to Output Direct Connects Inputs to TF Connects TF: # 3 (NRB-(B) Sections from Transfer Function Block Outputs to Transfer Function Block Inputs TF# 3 (NRB-(B) goes to TF.# 3 (NRB-(B) J goes to TF.# 4 {NLLA , Gain= 1.000000 TF# 4 {NLLA , Gain= 1.000000 TF# 4 {NLA , Gain= 1.000000	Discrete, dt= 0.04 Run System Dimension Number of Transfer Functions Number of Outputs Save in File Laput/Output Labels, or write Notes and Comments TF to TF Connections System Input Definitions Define connections from Transfer Function Outputs TF: 7, NNY-(A) TF: 7, NNY-(A) TF: 7, NNY-(A) TF: 9, NYLAG TF: 0, NNY-(B) TF: 0, NNY-(B) TF: 0, NNY-(C) TF: 0, NNY-(C)
Combined Transfer Functions System Title: Lateral Digital Flight Control System refine the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block FF: 1, Yaw Integrator FF: 3, NRB-(A) FF: 4, NuLA FF: 5, NRB-(B) FF: 6, NRH(B) FF: 7, NNY-(A) se the Tabs below to View or Modify the Transf. Function Interconnections. Modify the I nput to Output Direct Connects Inputs to TF Connects TF# 2 (NRB-(A) 17# 3 (NRB-(B) TF# 3 (NRB-(A) 17# 3 (NRB-(A) 17# 3 (NRB-(B) 17# 3 (NRB-(A) 19 goes to TF.# 3 (NRB-(B) 17# 7 (NNY-(A) 19 goes to TF.# 4 (NLLA 19 goes to TF.# 4 (NLLA) 17# 8 (NNY-(B)) 17# 8 (NNY-(B)) 17# 8 (NNY-(B)) 17# 8 (NNY-(B)) 17# 6 (NNY-(B)) 17# 7 (NNY-(A)) 19 goes to TF.# 5 (NROFF (yaw roll-off), Gain= 1.000000 17# 6 (NNY-(B))), Gain= 1.000000 17#	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Outputs 5 Number of Outputs 2 Edit Input File Save in File Save in File TF to TF Connections from Transfer Function Outputs TF: 7, NNY-(A) TF: 9, NNY-(B) TF: 9, NNY-(B) TF: 10, LLLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) TF: 12, LPBA-(2) TF: 10, LLLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) TF: 2, NNY-(A) TF: 12, LPBA-(2) TF: 10, LLLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) TF: 10, LLLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) TF: 10, LLLA
Combined Transfer Functions System Title: Lateral Digital Flight Control System befine the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block [F: 1, Yaw Integrator [F: 2, NRB-(A) [F: 5, NRB-(B) [F: 6, NRPF] [F: 6, NRPF] [F: 7, NNY-(A) se the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I nput to Output Direct Connects Inputs to TF Connects TF to Output Connects T Sonnections from Transfer Function Block Outputs to Transfer Function Block Inputs TF# 2 {NRB-(A) goes to TF.# 3 {NRB-(B) , Gain= 1.000000 TF.# 3 {NRB-(B) , Gain= 1.000000 TF# 3 {NRB-(B) goes to TF.# 3 {NRB-(B) , Gain= 1.000000 TF.# 4 {NLLA , Gain= 1.000000 TF# 4 {NLLA goes to TF.# 3 {NRB-(B) , Gain= 1.000000 TF.# 4 {NLLA } goes to TF.# 3 {NRB-(B) , Gain= 1.000000 TF# 8 {NNY-(A) goes to TF.# 7 {NNY-(A) } Gain= 1.000000 TF.# 4 {NLLA } Gain= 1.000000	Discrete, dt= 0.04 Run System Dimension Number of Transfer Functions Number of Outputs Save in File Laput/Output Labels, or write Notes and Comments TF to TF Connections System Input Definitions Define connections from Transfer Function Outputs TF: 7, NNY-(A) TF: 7, NNY-(A) TF: 7, NNY-(A) TF: 9, NYLAG TF: 9, NYLAG TF: 10, LLLA TF: 10, LLLA TF: 10, LLLA TF: 11, LPBA-(1)
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, NaB (A) TF: 3, NBB-(B) TF: 4, NLA TF: 5, NROFF (yaw roll-off) TF: 5, NROFF (yaw roll-off) TF: 5, NROFF (yaw roll-off) TF: 7, NNY-(A) se the Tabs below to View or Modify the Transf. Function Interconnections. Modify the I nput to Output Direct Connects Inputs to TF Connects TF to Output Connects TF.# 2 (NRB-(A) TF.# 2 (NRB-(A)) goes to TF.# 3 (NRB-(B)), Gain= 1.000000 TF.# 3 (NRB-(B)) goes to TF.# 4 (NLLA), Gain= 1.000000 TF.# 4 (NLLA) goes to TF.# 4 (NLLA), Gain= 1.000000 TF.# 4 (NLLA) goes to TF.# 7 (NYY-(A)) Set TF.# 4 (NLLA), Gain= 1.000000 TF.# 4 (NLLA) goes to TF.# 7 (NYY-(A)), Gain= 1.000000 TF.# 4 (NLLA) goes to TF.# 7 (NYY-(A)), Gain= 1.000000 TF.# 4 (NLLA) goes to TF.# 7 (NYY-(A)), Gain= 1.000000 TF.# 4 (NLLA) goes to TF.# 7 (NYY-(A)), Gain= 1.000000 TF.# 4 (NLLA) goes to TF.# 7 (NYY-(A)), Gain= 1.000000 TF.# 4 (NLLA) goes to TF.# 7 (NYY-(A)), Gain= 1.000000 TF.# 4 (NLLA), Gain= 1.000000 TF.# 4 (NLA), G	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Outputs 5 Number of Outputs 2 Save in File Save in File Save in File Save in File Save in File Save in File TF to TF Connections from Transfer Function Outputs TF: 7, NNY-(A) TF: 3, NY-(A) TF: 10, LLLA TF: 11, LPBA-(1) TF: 13, LRO (roll roll-off) TF: 13, LRO (roll roll-off) Connections from Transfer TF: 11, LPBA-(2) TF: 13, LRO (roll roll-off) Connections from Transfer Connections from Transfer TF: 11, LPBA-(1) TF: 12, LPBA-(2) TF: 13, LRO (roll roll-off) Connections from Transfer TF: 13, LRO (roll roll-off) Connections from Transfer Connections from Transfer TF: 13, LRO (roll roll-off) Connections from Transfer Connections from Transfer TF: 13, LRO (roll roll-off) Connections from Transfer TF: 13, LRO (roll roll-off) Connections from Transfer Connections from Transfer Connections from Transfer Connections from Transfer Connections from Transfer TF: 13, LRO (roll roll-off) Connections from Transfer Connections from Transfer Conne
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLL FF: 5, NRB-(F (yaw roll-off) TF: 6, NRPHP TF: 7, NNY-(A) se the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I nput to Output Direct Connects Inputs to TF connects TF# 3 (NRB-(B) 100000 TF# 3 (NRB-(B) 100000 TF# 3 (NRB-(B) 100000 TF# 4 (NLLA 100000 TF# 4 (NLL 100000 TF# 4 (NLA	Discrete, dt= 0.04 Run Number of Transfer Functions Number of linputs Number of Outputs Save in File Linput/Output Labels, or write Notes and Comments TF to TF Connections from Transfer Function Outputs Define connections from Transfer Function Outputs TF: 7, NNY-(A) TF: 11, LPBA-(1) TF: 12, LPBA-(2) TF: 13, LRO (roll roll-off) Select from one of the Transfer-Functions and the Transfer-Function LO OK
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLLA FF: 5, NRB-(F) TF: 6, NRPHP TF: 7, NNY-(A) se the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I Input to Output Direct Connects Inputs to TF Connects TF to Output Connects Connections from Transfer Function Block Outputs to Transfer Function Block Inputs TF# 3 (NRB-(B) 3 goes to TF.# 3 (NRB-(B) 3, Gain= 1.000000 TF# 7 (NNY-(A) 3 goes to TF.# 4 (NLLA 3, Gain= 1.000000 TF# 4 (NL-A 3) goes to TF.# 4 (NLLA 4), Gain= 1.000000 TF# 4 (NL-A 3) goes to TF.# 7 (NNY-(A) 4), Gain= 1.000000 TF# 4 (NL-A 4) 3 goes to TF.# 7 (NNY-(A) 4), Gain= 1.000000 TF.# 6 (NPRHP 4) 3 goes to TF.# 7 (NNY-(A) 4), Gain= 1.000000 TF.# 10 (LLA 4) 3 goes to TF.# 11 (LPBA-(1) 4), Gain= 1.000000 TF.# 11 (LPBA-(1) 4), TF.# 12 (LPBA-(2) 4), Gain= 1.000000 TF.# 11 (LPBA-(1) 4), TF.# 12 (LPBA-(2) 4), Gain= 1.000000 TF.# 11 (LPBA-(1) 4), TF.# 12 (LPBA-(2) 4), Gain= 1.000000 TF.# 11 (LPBA-(1) 4), TF.# 12 (LPBA-(2) 4), TF.#	Discrete, dt= 0.04 EXIT Run Run System Dimension Update Data Functions 13 Number of Transfer 13 Number of Inputs 5 Number of Outputs 2 Save in File ave in File Input/Output Labels, or write Notes and Comments Update Data TF to TF Connections System Input Definitions System Input Definitions System Output Definitions User Comments Define connections from Transfer Function Connecting to Transfer Function Inputs Outputs TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 10, LLLA TF: 10, LLLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB-(A) TF: 3, NRB-(B) TF: 4, NLLA FF: 5, NRB+(B) TF: 6, NRB+(B) TF: 7, NNY-(A) Se the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I Input to Output Direct Connects Inputs to TF Connects TF to Output Connects Connections from Transfer Function Block Outputs to Transfer Function Block Inputs TF# 3 (NRB-(B) 3 goes to TF.# 3 (NRB-(B)), Gain= 1.000000 TF# 3 (NRB-(B) 3 goes to TF.# 4 { NLLA }, Gain= 1.000000 TF# 4 (NLLA) goes to TF.# 4 { NLLA }, Gain= 1.000000 TF# 4 (NLLA) goes to TF.# 7 (NNY-(A)), Gain= 1.000000 TF# 4 (NLLA) goes to TF.# 7 (NNY-(A)), Gain= 1.000000 TF# 4 (NLLA) goes to TF.# 7 (NNY-(A)), Gain= 1.000000 TF# 9 (NTLAB) goes to TF.# 7 (NNY-(A)), Gain= 1.0	Discrete, dt= 0.04 EXIT Run Run System Dimension Update Data Functions 13 Number of Transfer 13 Number of Inputs 5 Number of Outputs 2 Save in File ave in File Input/Output Labels, or write Notes and Comments Update Data TF to TF Connections System Input Definitions System Input Definitions System Output Definitions User Comments Define connections from Transfer Function Connecting to Transfer Function Inputs Outputs TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 10, LLLA TF: 10, LLLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 3, NR6-(B) TF: 5, NR6-(B) TF: 6, NR0-FE (yaw roll-off) TF: 6, NR0-FE (yaw roll-off) TF: 7, NNY-(A) Ise the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I Input to Output Direct Connects Inputs to TF Connects TF# 3 (NR8-(B) TF# 3 (NR8-(B) TF# 5, NR0-FE (yaw roll-off) TF: 6, NPRHP TF: 7, NNY-(A) Ise the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I Input to Output Direct Connects Inputs to TF connects TF# 3 (NR8-(B)] goes to TF.# 3 (NR8-(B)], Gain= 1.000000 TF# 3 (NR8-(B)] goes to TF.# 4 (NLLA] Gain= 1.000000 TF# 3 (NR8-(B)] goes to TF.# 4 (NLLA] Gain= 1.000000 TF# 4 (NV-(A)] goes to TF.# 4 (NLLA] Gain= 1.000000 TF# 4 (NV-(A)] goes to TF.# 7 (NY-(A)] Gain= 1.000000 TF# 4 (NV-(A)] goes to TF.# 7 (NY-(A)] Gain= 1.000	Discrete, dt= 0.04 EXIT Run Run System Dimension Update Data Functions 13 Number of Transfer 13 Number of Inputs 5 Number of Outputs 2 Save in File update Data Input/Output Labels, or write Notes and Comments Update Data TF to TF Connections System Input Definitions System Output Definitions Update Data Define connections from Transfer Function Connecting to Transfer Function Inputs Outputs TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 8, NNY-(B) TF: 10, LLLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 11, LPBA-(1) TF: 11, LPBA-(2) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 13, LPBA-(1) TF: 13, LPBA-(1) Select from one of the Transfer-Functions and the Transfer-Function 1.0 OK
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 3, NR6-(B) TF: 5, NR6-(B) TF: 6, NR0-FE (yaw roll-off) TF: 6, NR0-FE (yaw roll-off) TF: 7, NNY-(A) Ise the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I Input to Output Direct Connects Inputs to TF Connects TF# 3 (NR8-(B) TF# 3 (NR8-(B) TF# 5, NR0-FE (yaw roll-off) TF: 6, NPRHP TF: 7, NNY-(A) Ise the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I Input to Output Direct Connects Inputs to TF connects TF# 3 (NR8-(B)] goes to TF.# 3 (NR8-(B)], Gain= 1.000000 TF# 3 (NR8-(B)] goes to TF.# 4 (NLLA] Gain= 1.000000 TF# 3 (NR8-(B)] goes to TF.# 4 (NLLA] Gain= 1.000000 TF# 4 (NV-(A)] goes to TF.# 4 (NLLA] Gain= 1.000000 TF# 4 (NV-(A)] goes to TF.# 7 (NY-(A)] Gain= 1.000000 TF# 4 (NV-(A)] goes to TF.# 7 (NY-(A)] Gain= 1.000	Discrete, dt= 0.04 EXIT Run Run System Dimension Update Data Functions 13 Number of Transfer 13 Number of Inputs 5 Number of Outputs 2 Save in File update Data Input/Output Labels, or write Notes and Comments Update Data TF to TF Connections System Input Definitions System Output Definitions Update Data Define connections from Transfer Function Connecting to Transfer Function Inputs Outputs TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 8, NNY-(B) TF: 10, LLLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 11, LPBA-(1) TF: 11, LPBA-(2) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 13, LPBA-(1) TF: 13, LPBA-(1) Select from one of the Transfer-Functions and the Transfer-Function 1.0 OK
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 3, NR6-(B) TF: 5, NR6-(B) TF: 6, NR0-FE (yaw roll-off) TF: 6, NR0-FE (yaw roll-off) TF: 7, NNY-(A) Ise the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I Input to Output Direct Connects Inputs to TF Connects TF# 3 (NR8-(B) TF# 3 (NR8-(B) TF# 5, NR0-FE (yaw roll-off) TF: 6, NPRHP TF: 7, NNY-(A) Ise the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I Input to Output Direct Connects Inputs to TF connects TF# 3 (NR8-(B)] goes to TF.# 3 (NR8-(B)], Gain= 1.000000 TF# 3 (NR8-(B)] goes to TF.# 4 (NLLA] Gain= 1.000000 TF# 3 (NR8-(B)] goes to TF.# 4 (NLLA] Gain= 1.000000 TF# 4 (NV-(A)] goes to TF.# 4 (NLLA] Gain= 1.000000 TF# 4 (NV-(A)] goes to TF.# 7 (NY-(A)] Gain= 1.000000 TF# 4 (NV-(A)] goes to TF.# 7 (NY-(A)] Gain= 1.000	Discrete, dt= 0.04 EXIT Run Run System Dimension Update Data Functions 13 Number of Transfer 13 Number of Inputs 5 Number of Outputs 2 Save in File update Data Input/Output Labels, or write Notes and Comments Update Data TF to TF Connections System Input Definitions System Output Definitions Update Data Define connections from Transfer Function Connecting to Transfer Function Inputs Outputs TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 8, NNY-(B) TF: 10, LLLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 11, LPBA-(1) TF: 11, LPBA-(2) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 13, LPBA-(1) TF: 13, LPBA-(1) Select from one of the Transfer-Functions and the Transfer-Function 1.0 OK
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NR8-(A) TF: 3, NR8-(B) TF: 4, NLA TF: 5, NR8-(B) TF: 6, NR9-HP TF: 7, NNY-(A) TF: 5, NR9-HP TF: 7, NNY-(A) TF: 5, NR8-(B) TF: 4, NLA See the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I Input to Output Direct Connects Inputs to TF Connects TF to Output Connects Connections from Transfer Function Block Outputs to Transfer Function Block Inputs TF: # 3 (NR8-(B) 3 goes to TF: # 3 (NR8-(B) 3, Gain= 1.000000 TF:# 3 (NR9-(B) 3 goes to TF: # 4 (NLLA 3, Gain= 1.000000 TF:# 4 (NV-(A) 3 goes to TF: # 4 (NLLA 4, 3, Gain= 1.000000 TF:# 4 (NV-(A) 3 goes to TF: # 7 (NYY-(A) 4, 3, Gain= 1.000000 TF:# 4 (NV-(A) 4, 3 goes to TF: # 7 (NYY-(A) 4, 3, Gain= 1.000000 TF:# 4 (NV-(A) 4, 3 goes to TF: # 7 (NYY-(A) 4, 3, Gain= 1.000000 TF:# 4 (NV-(A) 4, 3 goes to TF: # 7 (NYY-(A) 4, 3, Gain= 1.000000 TF:# 4 (NV-(A) 4, 3 goes to TF: # 7 (NYY-(A) 4, 4, 4, 7 Gain= 1.000000 TF:# 4 (NV-(A) 4, 3 goes to TF: # 7 (NYY-(A) 4, 4, 4, 7 Gain= 1.000000 TF:# 4 (NV-(A) 4, 3 goes to TF: # 7 (NYY-(A) 4, 4, 4, 7 Gain= 1.000000 TF:# 4 (NV-(A) 4, 3 goes to TF: # 7 (NYY-(A) 4, 4, 4, 7 Gain= 1.000000 TF:# 4 (NV-(A) 4, 3 goes to TF: # 7 (NYY-(A) 4, 4, 4, 7 Gain= 1.000000 TF:# 4 (NV-(A) 4, 3 goes to TF: # 7 (NYY-(A) 4, 4, 4, 7 Gain= 1.000000 TF:# 10 (LLLA 4, 3 goes to TF: # 11 (LPBA-(1) 4, 4, 7 Gain= 1.000000 TF:# 11 (LPBA-(1) 4, 3 goes to TF: # 12 (LPBA-(2) 4, 4, 7 Gain= 1.000000 TF:# 10 (LLLA 4, 3 goes to TF: # 12 (LPBA-(2) 4, 5 Gain= 1.000000 TF:# 10 (LLA 4, 3 goes to TF: # 12 (LPBA-(2) 4, 5 Gain= 1.000000 TF:# 10 (LLA 4, 3 goes to TF: # 12 (LPBA-(2) 4, 5 Gain= 1.000000 TF:# 10 (LLA 4, 3 goes to TF: # 12 (LPBA-(2) 4, 5 Gain= 1.000000 TF:# 10 (LLA 4, 3 goes to TF: # 12 (LPBA-(2) 4, 5 Gain= 1.000000 TF:# 10 (LLA 4, 3 goes to TF: # 12 (LPBA-(2) 4, 5 Gain= 1.000000 TF:# 10 (LLA 4, 3 goes to TF: # 12 (LPBA-(2) 4, 5 Gain= 1.000000 TF:# 10 (L	Discrete, dt= 0.04 EXIT Run Run System Dimension Update Data Functions 13 Number of Transfer 13 Number of Inputs 5 Number of Outputs 2 Save in File ave in File Input/Output Labels, or write Notes and Comments Update Data TF to TF Connections System Input Definitions System Input Definitions System Output Definitions User Comments Define connections from Transfer Function Connecting to Transfer Function Inputs Outputs TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 10, LLLA TF: 10, LLLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NR8-(A) TF: 3, NR8-(B) TF: 4, NLA TF: 5, NR8-(B) TF: 6, NR9-HP TF: 7, NNY-(A) TF: 5, NR9-HP TF: 7, NNY-(A) TF: 5, NR8-(B) TF: 4, NLA See the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I Input to Output Direct Connects Inputs to TF Connects TF to Output Connects Connections from Transfer Function Block Outputs to Transfer Function Block Inputs TF: # 3 (NR8-(B) 3 goes to TF: # 3 (NR8-(B) 3, Gain= 1.000000 TF:# 3 (NR9-(B) 3 goes to TF: # 4 (NLLA 3, Gain= 1.000000 TF:# 4 (NV-(A) 3 goes to TF: # 4 (NLLA 4, 3, Gain= 1.000000 TF:# 4 (NV-(A) 3 goes to TF: # 7 (NYY-(A) 4, 3, Gain= 1.000000 TF:# 4 (NV-(A) 4, 3 goes to TF: # 7 (NYY-(A) 4, 3, Gain= 1.000000 TF:# 4 (NV-(A) 4, 3 goes to TF: # 7 (NYY-(A) 4, 3, Gain= 1.000000 TF:# 4 (NV-(A) 4, 3 goes to TF: # 7 (NYY-(A) 4, 3, Gain= 1.000000 TF:# 4 (NV-(A) 4, 3 goes to TF: # 7 (NYY-(A) 4, 4, 4, 7 Gain= 1.000000 TF:# 4 (NV-(A) 4, 3 goes to TF: # 7 (NYY-(A) 4, 4, 4, 7 Gain= 1.000000 TF:# 4 (NV-(A) 4, 3 goes to TF: # 7 (NYY-(A) 4, 4, 4, 7 Gain= 1.000000 TF:# 4 (NV-(A) 4, 3 goes to TF: # 7 (NYY-(A) 4, 4, 4, 7 Gain= 1.000000 TF:# 4 (NV-(A) 4, 3 goes to TF: # 7 (NYY-(A) 4, 4, 4, 7 Gain= 1.000000 TF:# 4 (NV-(A) 4, 3 goes to TF: # 7 (NYY-(A) 4, 4, 4, 7 Gain= 1.000000 TF:# 10 (LLLA 4, 3 goes to TF: # 11 (LPBA-(1) 4, 4, 7 Gain= 1.000000 TF:# 11 (LPBA-(1) 4, 3 goes to TF: # 12 (LPBA-(2) 4, 4, 7 Gain= 1.000000 TF:# 10 (LLLA 4, 3 goes to TF: # 12 (LPBA-(2) 4, 5 Gain= 1.000000 TF:# 10 (LLA 4, 3 goes to TF: # 12 (LPBA-(2) 4, 5 Gain= 1.000000 TF:# 10 (LLA 4, 3 goes to TF: # 12 (LPBA-(2) 4, 5 Gain= 1.000000 TF:# 10 (LLA 4, 3 goes to TF: # 12 (LPBA-(2) 4, 5 Gain= 1.000000 TF:# 10 (LLA 4, 3 goes to TF: # 12 (LPBA-(2) 4, 5 Gain= 1.000000 TF:# 10 (LLA 4, 3 goes to TF: # 12 (LPBA-(2) 4, 5 Gain= 1.000000 TF:# 10 (LLA 4, 3 goes to TF: # 12 (LPBA-(2) 4, 5 Gain= 1.000000 TF:# 10 (L	Discrete, dt= 0.04 EXIT Run Run System Dimension Update Data Functions 13 Number of Transfer 13 Number of Inputs 5 Number of Outputs 2 Save in File ave in File Input/Output Labels, or write Notes and Comments Update Data TF to TF Connections System Input Definitions System Input Definitions System Output Definitions User Comments Define connections from Transfer Function Connecting to Transfer Function Inputs Outputs TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 10, LLLA TF: 10, LLLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator TF: 2, NRB- (A) TF: 3, NRB-(B) TF: 4, NLLA Sethe Tabs below to View or Modify the Transf. Function Interconnections, Modify the I TF: 5, NRNFF (yaw roll-off) TF: 6, NRPHP TF: 7, NNY-(A) Set the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I Input to Output Direct Connects Inputs to TF Connects TF# 3 (NRB-(B) goes to TF.# 3 (NRB-(B) , Gain= 1.000000 TF# 3 (NRB-(B) goes to TF.# 4 (NLLA , Gain= 1.000000 TF# 3 (NRH-(B) goes to TF.# 4 (NLLA , Gain= 1.000000 TF# 3 (NRH-(B) goes to TF.# 4 (NLLA , Gain= 1.000000 TF# 3 (NRH-(B) goes to TF.# 4 (NLLA , Gain= 1.000000 TF# 4 (NLLA) goes to TF.# 7 (NNY-(A) , Gain= 1.000000 TF# 4 (NLA) goes to TF.# 7 (NNY-(A) , Gain= 1.000000 TF# 4 (NLA) goes to TF.# 7 (NNY-(A) , Gain= 1.000000 TF# 4 (NLA) goes to TF.# 7 (NNY-(A) , G	Discrete, dt= 0.04 EXIT Run Run System Dimension Update Data Functions 13 Number of Transfer 13 Number of Inputs 5 Number of Outputs 2 Save in File ave in File Input/Output Labels, or write Notes and Comments Update Data TF to TF Connections System Input Definitions System Input Definitions System Output Definitions User Comments Define connections from Transfer Function Connecting to Transfer Function Inputs Outputs TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 10, LLLA TF: 10, LLLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 10, LLA TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1
Combined Transfer Functions System Title: Lateral Digital Flight Control System befine the Transfer Functions to be combined in file: TF-Test.qdr Edit TF Block TF: 1, Yaw Integrator FF: 2, NRB- (A) FF: 3, NRB-(B) FF: 4, NLLA FF: 5, NROFF (yaw roll-off) FF: 6, NRPHP FF: 7, NNY-(A) se the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I nput to Output Direct Connects Inputs to TF Connects TF# 3 (NRB-(B) Gaine 1.000000 TF# 3 (NRB-(B) J goes to TF.# 3 (NRB-(B) J goes to TF.# 3 (NRB-(B) J goes to TF.# 4 (NLLA J goes to TF.# 4 (NLLA J goes to TF.# 4 (NLLA J goes to TF.# 4 (NLA J goes to TF.# 7 (NY-(A) J goes t	Discrete, dt= 0.04 EXIT Run Run System Dimension Update Data Functions 13 Number of Transfer 13 Number of Inputs 5 Number of Outputs 2 Save in File update Data Input/Output Labels, or write Notes and Comments Update Data TF to TF Connections System Input Definitions System Input Definitions System Output Definitions Update Data Define connections from Transfer Function Connecting to Transfer Function Inputs Outputs TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 10, LLLA TF: 10, LLLA TF: 11, LPBA-(1) TF: 10, LLA TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 11, LPBA-(1) TF: 12, LPBA-(2) TF: 13, LPD (role-off) TF: 10, LLA TF: 13, LPBA-(1) TF: 13, LPBA-(1) TF: 10, LLA TF: 13, LPBA-(1) TF: 13, LPBA-(1) TF: 10, LLA T

Transfer-Function to Transfer-Function Connections

User Comments Tab:

This tab is used for viewing the system comments already entered in the transfer-function interconnections data-set. These are comments and user notes regarding the TF system for documentation purposes. The comment lines begin with (!) and they are below the system title. The comments from the input data are also copied and inserted in the systems data below the title. When starting with a new TF system this display/ tab is also used for entering the new system notes interactively.

Transfer Functions Interconnection Dialog	
Combined Transfer Functions System Title:	Continuous or Discrete, dT= Exit
Lateral Digital Flight Control System	Discrete, dt= 0.04 $TF1 \rightarrow TF2 \rightarrow K1 \rightarrow F1$
Define the Transfer Functions to be combined in file: TF-Test.qdr	
TF: 1, Yaw Integrator TF: 2, NRB - (A) TF: 3, NRB-(B) TF: 4, NLLA TF: 5, NROFF (yaw roll-off) TF: 7, NNY-(A) Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the	System Dimension Number of Transfer Functions Number of Outputs 5 Number of Outputs 2 Trput/Output Labels, or write Notes and Comments TF to TF Connections System Input Definitions System Output Definitions User Comments

System Input and System Output Definition Tabs:

These tabs are used for viewing the system input and output definitions. The system inputs and outputs are defined at the bottom of the TF data-set, in the input file below the TF interconnections data, and they are also copied to the systems file below the quadruple matrices. Initially, when we define a new TF interconnection system interactively the utility assigns default titles for the system inputs and outputs, such as, "*System Output 1*". The tabs may be used to redefine the default input and output names and the user may replace them with more descriptive labels. For example, to change one of the outputs from the menu, select the default label, ex. "*System Output 2*", click on "Edit" button at the bottom, and the default label appears in the field below the menu. Then you can modify the default label in that field to more descriptive name, such as for example: "*Pitch Rate in (deg)*", and press the "*Edit*" button again. The default label will then be changed to the new name. You may then select other variables and repeat. You must also remember to click "*Update Data*" before changing tabs.

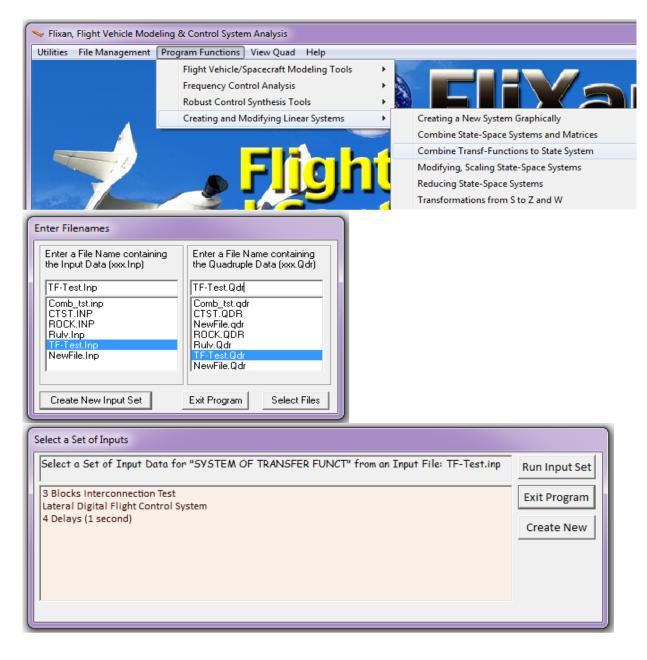
Using the Top Buttons "Run", "Exit", "Update Data", "Edit Input", "Save in File"

When the TF interconnections are all defined the user must press the "Update Data" button, and then "Save in File" to save the new set of TF interconnections in the input data file. If you made a mistake or forgot to include a detail you can always edit the input data file by clicking on "Edit Input File". A text editor comes up where the user may edit the input data file (.Inp) and save it before running it. At this point you may run the new set of system interconnections by clicking on the "Run" button. The utility will process the TF data and it will create a new state-space system that will be saved at the bottom of the selected systems file. The new system will have the same title and the same comments included as those in the TF interconnection data-set. If for some reason you do not wish to process the data and would like to exit the program without running it, use the "Exit" button to return to the Flixan main menu. The TF interconnections set will remain in the input file and you can modify it and run it at some later time.

Transfer Functions Interconnection Dialog					
Combined Transfer Functions System Title:		Continuous or Discrete, dT=			
Lateral Digital Flight Control System		Discrete, dt= 0.04	Exit	TE1 TE2	
Define the Transfer Functions to be combined in file: TF-Test.gdr		pisciete, de 0.04	Run	$TF1 \rightarrow TF2 \rightarrow$	
berne me transfer functions to be combined in the transfigur	Edit TF Block				y 1
TF: 6, NPRHP	*	System Dimension		$\overline{u_1} \rightarrow \overline{K2}$	→☆ – ↓
TF: 7, NNY-(A)		Number of Transfer	Update Data		Υ TF4
TF: 8, NNY-(B) TF: 9, NYLAG			Edit Input File		
TF: 10, LLLA	=	Number of Inputs 5	Laicinpactile	$- \rightarrow \bigcirc TE3$	→Č←
TF: 11, LPBA-(1) TF: 12, LPBA-(2)	-	Number of Outputs 2	Save in File	$ \mathbf{u}_2 \cup \mathbf{u}_2 $	y_2
11.12, LEDR(2)					$TF5 \longrightarrow J^2$
Use the Tabs below to View or Modify the Transf. Function Interconnectio	one Modify the Tor	out/Outout Labels, or write Nates	and Comments		115 -
					1
Input to Output Direct Connects Inputs to TF Connects TF to Outp	out Connects TF	to TF Connections System inp	ut Definitions Syste	m Output Definitions User Cor	mments
Yaw Attitude Error	Select an Inpu	it from			
Roll Attitude Error	menu and press				
Yaw Rate Error	to modify the I				
Roll Rate Error	title at the bo				
Lateral Accelerometer	Repeat to chan	ige			
	other Inputs.				
,					
Lateral Accelerometer	E	dit			
	<u>.</u>				
Transfer Functions Interconnection Dialog					
Transfer Functions Interconnection Dialog Combined Transfer Functions System Title:		Continuous or Discrete, dT=	Fxit		
-		Continuous or Discrete, dT= Discrete, dt= 0.04	Exit		
Combined Transfer Functions System Title: Lateral Digital Flight Control System			Exit	TF1 TF2→	<u>K1</u>
Combined Transfer Functions System Title:	Edit TF Block	Discrete, dt= 0.04		TF1 ↑ TF2→	
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr	Edit TF Block		Run		
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A)		System Dimension		$\begin{array}{c} \hline TF1 \rightarrow TF2 \rightarrow \\ \hline u_1 \rightarrow K2 \rightarrow \end{array}$	
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B)	Edit TF Block	Discrete, dt= 0.04	Run Update Data		$\begin{array}{c} K1 \\ \downarrow \\ \downarrow \\ \downarrow \\ TF4 \end{array}$
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A)	Edit TF Block	System Dimension	Run		
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLLA TF: 11, LPBA-(1)	Edit TF Block	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs	Run Update Data Edit Input File		→ → → → → → → → → → → → ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLLA	Edit TF Block	Discrete, dt= 0.04 System Dimension Number of Transfer Functions 13	Run Update Data	$u_1 \rightarrow K2$	\rightarrow TF4 \rightarrow y_2
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLLA TF: 11, LPBA-(1) TF: 12, LPBA-(2)	Edit TF Block	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs 5 Number of Outputs 2	Run Update Data Edit Input File Save in File	$u_1 \rightarrow K2$	→ → → → → → → → → → → → ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYAG TF: 10, LUA TF: 11, LPBA-(1) TF: 12, LPBA-(2) Use the Tabs below to View or Modify the Transf. Function Interconnection	Edit TF Block	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs 5 Number of Outputs 2 put/Output Labels, or write Notes	Run Update Data Edit Input File Save in File and Comments	$u_1 \rightarrow K2$ $u_2 \rightarrow O-TF3$	$\xrightarrow{+} TF4$ $\xrightarrow{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline$
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLLA TF: 11, LPBA-(1) TF: 12, LPBA-(2)	Edit TF Block	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs 5 Number of Outputs 2 put/Output Labels, or write Notes	Run Update Data Edit Input File Save in File and Comments	$u_1 \rightarrow K2$ $u_2 \rightarrow O-TF3$	$\xrightarrow{+} TF4$ $\xrightarrow{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline$
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) Use the Tabs below to View or Modify the Transf. Function Interconnection Input to Output Direct Connects Inputs to TF Connects TF to Output	Edit TF Block	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs Number of Outputs Number of Outputs 2 put/Output Labels, or write Notes to TF Connections	Run Update Data Edit Input File Save in File and Comments	$u_1 \rightarrow K2$ $u_2 \rightarrow O-TF3$	$\xrightarrow{+} TF4$ $\xrightarrow{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline$
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) Use the Tabs below to View or Modify the Transf. Function Interconnection Input to Output Direct Connects Inputs to TF Connects TF to Output Roll FCS Demond to TVC	Edit TF Block E E E E E E E E E E E E E E E E E E E	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs Sumber of Outputs Quit/Output Labels, or write Notes to TF Connections System Inp	Run Update Data Edit Input File Save in File and Comments	$u_1 \rightarrow K2$ $u_2 \rightarrow O-TF3$	$\xrightarrow{+} TF4$ $\xrightarrow{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline$
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) Use the Tabs below to View or Modify the Transf. Function Interconnection Input to Output Direct Connects Inputs to TF Connects TF to Output	Edit TF Block	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs 5 Number of Outputs 2 put/Output Labels, or write Notes to TF Connections System Inp put press	Run Update Data Edit Input File Save in File and Comments	$u_1 \rightarrow K2$ $u_2 \rightarrow O-TF3$	$\xrightarrow{+} TF4$ $\xrightarrow{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline$
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) Use the Tabs below to View or Modify the Transf. Function Interconnection Input to Output Direct Connects Inputs to TF Connects TF to Output Roll FCS Demond to TVC	Edit TF Block E E E Sons, Modify the Inpout Connects TF Select an Outy from menu and Edit to modify	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs Sumber of Outputs Number of Outputs Put/Output Labels, or write Notes to TF Connections System Inp put press	Run Update Data Edit Input File Save in File and Comments	$u_1 \rightarrow K2$ $u_2 \rightarrow O-TF3$	$\xrightarrow{+} TF4$ $\xrightarrow{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline$
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) Use the Tabs below to View or Modify the Transf. Function Interconnection Input to Output Direct Connects Inputs to TF Connects TF to Output Roll FCS Demond to TVC	Edit TF Block E E E T Sons. Modify the Inp out Connects TF Select an Outp from menu and Edit to modify Output title a	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs Number of Outputs 2 put/Output Labels, or write Notes to TF Connections System Inp press the t the	Run Update Data Edit Input File Save in File and Comments	$u_1 \rightarrow K2$ $u_2 \rightarrow O-TF3$	$\xrightarrow{+} TF4$ $\xrightarrow{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline$
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) Use the Tabs below to View or Modify the Transf. Function Interconnection Input to Output Direct Connects Inputs to TF Connects TF to Output Roll FCS Demond to TVC	Edit TF Block E E E Sons, Modify the Inpout Connects TF Select an Outy from menu and Edit to modify	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs Sumber of Outputs Quit/Output Labels, or write Notes to TF Connections System Inp put press the to	Run Update Data Edit Input File Save in File and Comments	$u_1 \rightarrow K2$ $u_2 \rightarrow O-TF3$	$\xrightarrow{+} TF4$ $\xrightarrow{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline$
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) Use the Tabs below to View or Modify the Transf. Function Interconnection Input to Output Direct Connects Inputs to TF Connects TF to Output Roll FCS Demond to TVC	Edit TF Block E E Sons. Modify the Inp out Connects TF Select an Outp from menu and Edit to modify Output title a bottom. Repeat	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs Sumber of Outputs Quit/Output Labels, or write Notes to TF Connections System Inp put press the to	Run Update Data Edit Input File Save in File and Comments	$u_1 \rightarrow K2$ $u_2 \rightarrow O-TF3$	$\xrightarrow{+} TF4$ $\xrightarrow{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline$
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Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) Use the Tabs below to View or Modify the Transf. Function Interconnection Input to Output Direct Connects Inputs to TF Connects TF to Output Roll FCS Demond to TVC	Edit TF Block E E Sons. Modify the Inp out Connects TF Select an Outp from menu and Edit to modify Output title a bottom. Repeat	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs Sumber of Outputs Quit/Output Labels, or write Notes to TF Connections System Inp put press the to	Run Update Data Edit Input File Save in File and Comments	$u_1 \rightarrow K2$ $u_2 \rightarrow O-TF3$	$\xrightarrow{+} TF4$ $\xrightarrow{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline$
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Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) Use the Tabs below to View or Modify the Transf. Function Interconnectio Input to Output Direct Connects Inputs to TF Connects TF to Outp Roll FCS Demand to TVC Yaw FCS Demand to TVC	Edit TF Block	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs 5 Number of Outputs 2 put/Output Labels, or write Notes to TF Connections System Inp put puts the t the to Dutputs.	Run Update Data Edit Input File Save in File and Comments	$u_1 \rightarrow K2$ $u_2 \rightarrow O-TF3$	$\xrightarrow{+} TF4$ $\xrightarrow{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline$
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Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) Use the Tabs below to View or Modify the Transf. Function Interconnectio Input to Output Direct Connects Inputs to TF Connects TF to Outp Roll FCS Demand to TVC Yaw FCS Demand to TVC	Edit TF Block	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs 5 Number of Outputs 2 put/Output Labels, or write Notes to TF Connections System Inp put puts the t the to Dutputs.	Run Update Data Edit Input File Save in File and Comments	$u_1 \rightarrow K2$ $u_2 \rightarrow O-TF3$	$\xrightarrow{+} TF4$ $\xrightarrow{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline$
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) Use the Tabs below to View or Modify the Transf. Function Interconnectio Input to Output Direct Connects Inputs to TF Connects TF to Outp Roll FCS Demand to TVC Yaw FCS Demand to TVC	Edit TF Block	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs 5 Number of Outputs 2 put/Output Labels, or write Notes to TF Connections System Inp put puts the t the to Dutputs.	Run Update Data Edit Input File Save in File and Comments	$u_1 \rightarrow K2$ $u_2 \rightarrow O-TF3$	$\xrightarrow{+} TF4$ $\xrightarrow{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline$
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) Use the Tabs below to View or Modify the Transf. Function Interconnectio Input to Output Direct Connects Inputs to TF Connects TF to Outp Roll FCS Demand to TVC Yaw FCS Demand to TVC	Edit TF Block	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs 5 Number of Outputs 2 put/Output Labels, or write Notes to TF Connections System Inp put puts the t the to Dutputs.	Run Update Data Edit Input File Save in File and Comments	$u_1 \rightarrow K2$ $u_2 \rightarrow O-TF3$	$\xrightarrow{+} TF4$ $\xrightarrow{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline$
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) Use the Tabs below to View or Modify the Transf. Function Interconnectio Input to Output Direct Connects Inputs to TF Connects TF to Outp Roll FCS Demand to TVC Yaw FCS Demand to TVC	Edit TF Block	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs 5 Number of Outputs 2 put/Output Labels, or write Notes to TF Connections System Inp put puts the t the to Dutputs.	Run Update Data Edit Input File Save in File and Comments	$u_1 \rightarrow K2$ $u_2 \rightarrow O-TF3$	$\xrightarrow{+} TF4$ $\xrightarrow{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline$
Combined Transfer Functions System Title: Lateral Digital Flight Control System Define the Transfer Functions to be combined in file: TF-Test.qdr TF: 6, NPRHP TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLLA TF: 11, LPBA-(1) TF: 12, LPBA-(2) Use the Tabs below to View or Modify the Transf. Function Interconnectio Input to Output Direct Connects Inputs to TF Connects TF to Outp Roll FCS Demand to TVC Yaw FCS Demand to TVC	Edit TF Block	Discrete, dt= 0.04 System Dimension Number of Transfer Functions Number of Inputs 5 Number of Outputs 2 put/Output Labels, or write Notes to TF Connections System Inp put puts the t the to Dutputs.	Run Update Data Edit Input File Save in File and Comments	$u_1 \rightarrow K2$ $u_2 \rightarrow O-TF3$	$\xrightarrow{+} TF4$ $\xrightarrow{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline{+} \overline$

2.3 Running an Already Existing TF Interconnection Set

It is obviously a lot easier to modify an already existing TF interconnection set using a typical text editor and then process it using the interconnection utility. In this case the transfer-function data are already saved in the input file "*TF-Test.Inp*" and the new system will be saved in file "*TF-Test.Qdr*". This example is located in folder "*C:\Flixan\Comb_Trfn\Examples*". The transfer-functions interconnection program is selected from the Flixan main menu by clicking on the "*Program Functions*", then "*Creating and Modifying Linear Systems*", and then "*Combine Transfer-Functions to State Systems*". Using the filename selection menu, select the input and system filenames and click on "*Select Files*" to process the already existing data. In this case the input data file contains three sets of TF data. The following menu shows the titles of the three interconnection sets in file "*TF-Test.Inp*". The user selects the second set "*Lateral Digital Flight Control System*", and clicks on "*Run Input Set*".



The TF utility dialog below shows the TF interconnection details of the flight-control system as described in Figure (2.2). The interconnections are obtained from the input data set. The system's title is shown at the top and the titles of the 13 transfer-function to be combined are shown in the white menu below the title. This system has 5 inputs and 2 outputs. The transfer functions are defined in the z-domain with 0.04 (sec) sampling time. The interconnection details, input/ output definitions and user comments are shown by selecting in the corresponding tabs. To process the data and to generate the new system you must click on "*Run*". The dialog also provides the capability to edit the input file before processing it by clicking on "*Edit Input File*". The "*Exit*" button will return to the Flixan main menu without processing the data.

Transfer Functions Interconnection Dialog	
	Continuous or Discrete, dT= Exit
Lateral Digital Flight Control System	Discrete, dt= 0.04 $TF1 \rightarrow TF2 \rightarrow K1 \rightarrow K1$
Define the Transfer Functions to be combined in file: NewFile.qdr Edit TF Block	
TF: 4, NLLA TF: 5, NROFF (yaw roll-off) TF: 5, NRVF(a) TF: 7, NNY-(A) TF: 8, NNY-(B) TF: 9, NYLAG TF: 10, LLLA Use the Tabs below to View or Modify the Transf. Function Interconnections, Modify the In	System Dimension Number of Transfer Functions Number of Outputs 2 Dupdate Data Edit Input File Save in File Dupdate Data Edit File Save in File Dupdate Data Edit File Save in File Dupdate Data Edit File Save in File Dupdate Data Edit File Save in F
	to TF Connections System Input Definitions System Output Definitions User Comments
Connections from the Combined System Inputs to the Transfer Function Block Inputs Input: 1 {Yaw Attitude Error } goes to T.F.# 2 {NRB- (A) }, Gain= 0.3000000 Input: 3 {Yaw Rate Error } goes to T.F.# 2 {NRB- (A) }, Gain= 1.000000 Input: 3 {Yaw Rate Error } goes to T.F.# 2 {NRB- (A) }, Gain= 1.000000 Input: 3 {Yaw Rate Error } goes to T.F.# 6 {NRHP }, Gain= 1.000000 Input: 4 {Roll Rate Error } goes to T.F.# 10 {LLLA }, Gain= -0.6800000 Input: 4 {Roll Rate Error } goes to T.F.# 10 {LLLA }, Gain= -0.700000 Input: 4 {Roll Rate Error } goes to T.F.# 10 {LLLA }, Gain= 1.000000 Input: 4 {Roll Rate Error } goes to T.F.# 10 {LLLA }, Gain= 1.000000 Input: 5 {Lateral Acceleromete} goes to T.F.# 9 {NYLAG }, Gain= 1.000000 Modify a Connection Add New Connection	

The remaining two TF interconnection sets in file "*TF-Test.Inp*" can also be processed in a similar manner, as shown below. To read or edit the transfer functions, select one TF at a time from the menu, and click on "*Edit TF Block*". A small dialog opens up that shows the TF title and the numerator/ denominator coefficients from where they can be modified.

nsfer Functions Interconnection Dialog	
Combined Transfer Functions System Title:	Continuous or Discrete, dT= Exit
3 Blocks Interconnection Test	Continuous TF1 \rightarrow TF2 \rightarrow K1
Define the Transfer Functions to be combined in file: NewFile.qdrEdit TF Block	
TF: 1, (s2+3s=2)/(s2+2s+0.75)	System Dimension Update Data $u_1 \rightarrow K2 \rightarrow 0$
TF: 2, 1/(s+5)	
IF: 3, (s3+5s2+6.75s+2.25)/(s3+3.4s2+3.2s+0.8)	Functions
	Number of Inputs 3 \longrightarrow TF3 \longrightarrow
	Number of Outputs 2 Save in File U2 VIII V
	$TF5 \rightarrow$
e the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I	
nput to Output Direct Connects Inputs to TF Connects TF to Output Connects T	F to TF Connections System Input Definitions System Output Definitions User Comments
Direct Connections from the Combined System Inputs to the Combined System Outputs	
Input: 1 {System Input 1 to BI} goes to Outp: 1 {System Output 1 from}, Gain= 0.1000000E-02	
Input: 1 {System Input 1 to BI} goes to Outp: 2 {System Output 2 from}, Gain= 0.3555550	Edit Transfer Function Data
	(\$3+5\$2+6.75\$+2.25)/(\$3+3.4\$2+3.2\$+0.8)
	Numerator Coefficients in Descending Order Numerator Order
	1.00000 5.00000 6.75000 2.25000 3 Delay
	Denominator Coefficients in Descending Order Denominator Order Replace it
	t general a tensor a second o general a with a Delay
	1.00000 3.40000 3.20000 0.800000 3 Block
Modify a Connection Add New Connection Delete a Connection	
sfer Functions Interconnection Dialog	
ombined Transfer Functions System Title:	
	Continuous or Discrete, dT= Exit
4 Delays (1 second)	
	Continuous TF1 ++ TF2 → K1
4 Delays (1 second) Define the Transfer Functions to be combined in file: NewFile.qdrEdit TF Block	Continuous Continuous CKI TF1 → TF2 → K1
Define the Transfer Functions to be combined in file: NewFile.qdr	Continuous Run System Dimension Continuous TF1→TF2→K1
efine the Transfer Functions to be combined in file: NewFile.qdr Edit TF Block [FF: 1, Delay (sec)= 1.00000	Continuous Continuous System Dimension Number of Transfer Update Data Update Data Update Data
Define the Transfer Functions to be combined in file: NewFile.qdr Edit TF Block TF: 1, Delay (sec)= 1.00000 TF: 3, Delay (sec)= 1.00000 TF: 3, Delay (sec)= 1.00000	Continuous Run $TF1 \rightarrow TF2 \rightarrow K1$ System Dimension Update Data $u_1 \rightarrow K2 \rightarrow TF4$
efine the Transfer Functions to be combined in file: NewFile.qdr Edit TF Block [F: 1, Delay (sec)= 1.00000 [F: 2, Delay (sec)= 1.00000 [F: 3, Delay (sec)= 1.00000	Continuous System Dimension Number of Transfer Functions $\begin{array}{c} LXIL\\ Run\\ Update Data\\ Edit Input File\\ \end{array}$ $\begin{array}{c} TF1 \rightarrow TF2 \rightarrow K1\\ u_1 \rightarrow K2 \rightarrow fractor TF4\\ TF4 \end{array}$
Define the Transfer Functions to be combined in file: NewFile.qdr Edit TF Block TF: 1, Delay (sec)= 1.00000 TF: 2, Delay (sec)= 1.00000	Continuous System Dimension Number of Transfer Functions 4 Edit Input File Update Data Edit Input File Update Data Edit Input File Update Data
Define the Transfer Functions to be combined in file: NewFile.qdr Edit TF Block TF: 1, Delay (sec)= 1.00000 TF: 3, Delay (sec)= 1.00000 TF: 3, Delay (sec)= 1.00000	Continuous System Dimension Number of Transfer Functions 4 Edit Input File Update Data Edit Input File Update Data Edit Input File Update Data
efine the Transfer Functions to be combined in file: NewFile.qdr Edit TF Block (F: 1, Delay (sec)= 1.00000 (F: 3, Delay (sec)= 1.00000	Continuous System Dimension Number of Transfer Functions 4 Edit Input File Update Data Edit Input File Update Data
efine the Transfer Functions to be combined in file: NewFile.qdr Edit TF Block (F: 1, Delay (sec)= 1.00000 (F: 3, Delay (sec)= 1.00000 (F: 4, Delay (sec)= 1.00000 (F: 4, Delay (sec)= 1.00000	Continuous CAIL TF1 TF2 K1 System Dimension Update Data u_1 $K2$ $TF4$ Number of Transfer Edit Input File u_2 $TF3$ $TF4$ Number of Outputs 4 Save in File u_2 $TF3$ $TF5$
efine the Transfer Functions to be combined in file: NewFile.qdr Edit TF Block (F: 1, Delay (sec)= 1.00000 (F: 3, Delay (sec)= 1.00000 (F: 3, Delay (sec)= 1.00000 (F: 4, Delay (sec)= 1.	Continuous CAIL TF1 TF2 K1 System Dimension Update Data u_1 $K2$ $TF4$ Number of Transfer Edit Input File u_2 $TF3$ $TF4$ Number of Outputs 4 Save in File u_2 $TF3$ $TF5$
efine the Transfer Functions to be combined in file: NewFile.qdr Edit TF Block TF: 1, Delay (sec)= 1.00000 F: 2, Delay (sec)= 1.00000 F: 3, Delay (sec)= 1.00000 F: 4, Delay (sec)= 1.00000 se the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I nput to Output Direct Connects Inputs to TF Connects TF to Output Connects T	Continuous System Dimension Number of Transfer Functions Number of Inputs Number of Outputs Mumber of Outputs Functions Mumber of Outputs Mumber of Outputs
refine the Transfer Functions to be combined in file: NewFile.qdr Edit TF Block [F: 1, Delay (sec)= 1.00000 Fr: 3, Delay (sec)= 1.00000 [F: 3, Delay (sec)= 1.00000 Fr: 4, Delay (sec)= 1.00000 [F: 4, Delay (sec)= 1.00000 Fr: 4, Delay (sec)= 1.00000 [F: 4, Delay (sec)= 1.00000 Fr: 5, Delay (sec)= 1.00000 [F: 4, Delay (sec)= 1.00000 Fr: 6, Delay (sec)= 1.00000 [F: 4, Delay (sec)= 1.00000 Fr: 7, Delay (sec)= 1.00000 [F: 4, Delay (sec)= 1.00000 Fr: 7, Delay (sec)= 1.00000 [F: 4, Delay (sec)= 1.00000 Fr: 7, Delay (sec)= 1.00000 [F: 4, Delay (sec)= 1.00000 Fr: 7, Delay (sec)= 1.00000 [F: 4, Delay (sec)= 1.00000 Fr: 7, Delay (sec)= 1.00000 [F: 4, Delay (sec)= 1.00000 Fr: 7, Delay (sec)= 1.00000 [F: 4, Delay (sec)= 1.00000 Fr: 7, Delay (sec)= 1.00000 [F: 4, Delay (sec)= 1.00000 From the form th	Continuous System Dimension Number of Transfer Functions Number of Inputs Number of Outputs A Number of Outputs Functions Punctions A Punctions
efine the Transfer Functions to be combined in file: NewFile.qdr Edit TF Block (F: 1, Delay (sec)= 1.00000 (F: 3, Delay (sec)= 1.00000 (F: 4, Delay (sec)= 1.0000 (F: 4, Delay (s	Continuous System Dimension Number of Transfer Functions Number of Inputs Number of Outputs Mumber of Outputs Functions Mumber of Outputs Mumber of Outputs
refine the Transfer Functions to be combined in file: NewFile.qdr Edit TF Block If: 1, Delay (sec)= 1.00000 If: 3, Delay (sec)= 1.00000 F7: 3, Delay (sec)= 1.00000 If: 4, Delay (sec)= 1.00000 F7: 4, Delay (sec)= 1.00000 If: 5, Delay (sec)= 1.00000 F7: 4, Delay (sec)= 1.00000 If: 6, Delay (sec)= 1.00000 se the Tabs below to View or Modify the Transf. Function Interconnections, Modify the I nput to Output Direct Connects Inputs to TF Connects Tr to Output Connects TF to Output Connects Block Inputs System Input 1 Input: 2 (System Input 1 3 goes to TF.# 1 (Delay (sec)= 1.00000, Gain= 1.000000 Input: 2 (System Input 2 3 goes to TF.# 2 (Delay (sec)= 1.00000, Gain= 1.000000	Continuous System Dimension Number of Transfer Functions Number of Inputs Number of Outputs Mumber of Outputs Functions Mumber of Outputs Mumber of Outputs
efine the Transfer Functions to be combined in file: NewFile.qdr Edit TF Block F: 1, Delay (sec)= 1.00000 F: 2, Delay (sec)= 1.00000 F: 3, Delay (sec)= 1.00000 F: 4, Delay (sec)= 1.00000 F: 4, Delay (sec)= 1.00000 F: 4, Delay (sec)= 1.00000 F: 4, Delay (sec)= 1.00000 F: 6, Delay (sec)= 1.00000 F: 5, Delay (sec)= 1.00000 F: 6, Delay (sec)= 1.00000 F: 6, Delay (sec)= 1.00000 F: 7, Delay (sec)= 1.00000 F: 7, Delay (sec)= 1.00000 F: 7, Delay (sec)= 1.00000 F: 7, Delay (sec)= 1.00000 F: 7, Delay (sec)= 1.00000 Input: 1 (System input 1) goes to TF# 1 (Delay (sec)= 1.00000, Gain= 1.000000 Input: 2 (System input 2) goes to TF# 3 (Delay (sec)= 1.00000, Gain= 1.000000	Continuous System Dimension Number of Transfer Functions Number of Inputs Number of Outputs Mumber of Outputs Functions Mumber of Outputs Mumber of Outputs
efine the Transfer Functions to be combined in file: NewFile.qdr Edit TF Block F: 1, Delay (sec)= 1.00000 F: 2, Delay (sec)= 1.00000 F: 3, Delay (sec)= 1.00000 F: 4, Delay (sec)= 1.00000 F: 4, Delay (sec)= 1.00000 F: 4, Delay (sec)= 1.00000 F: 4, Delay (sec)= 1.00000 F: 6, Delay (sec)= 1.00000 F: 5, Delay (sec)= 1.00000 F: 6, Delay (sec)= 1.00000 F: 6, Delay (sec)= 1.00000 F: 7, Delay (sec)= 1.00000 F: 7, Delay (sec)= 1.00000 F: 7, Delay (sec)= 1.00000 F: 7, Delay (sec)= 1.00000 F: 7, Delay (sec)= 1.00000 Input: 1 (System input 1) goes to TF# 1 (Delay (sec)= 1.00000, Gain= 1.000000 Input: 2 (System input 2) goes to TF# 3 (Delay (sec)= 1.00000, Gain= 1.000000	Continuous LXIL Run Run System Dimension Update Data Number of Transfer Update Data Functions 4 Number of Inputs 4 Save in File Save in File Imput/Output Labels, or write Notes and Comments TF 5 F to TF Connections System Input Definitions
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This example file can also be processed in batch mode by running the batch set which is located on the top of the input file "*TF-Test.Inp*", as shown below. From the Flixan main menu select "*Edit*", then "*Manage Input Files*" and then "*Process/ Edit Input Data*". The following dialog is used for managing and processing input files. Use the left menu to select the input file "*TF-Test.Inp*" and click on "*Select Input File*". The menu on the right side shows the titles of the data-sets located in this file, also the program that will process each set. The top set is a batch file that will process the remaining three TF sets together in batch, and not interactively. Click on "*Process or View Input Data*", and the batch set will process the data, and save the three systems in file "*TF-Test.Qdr*". The previous systems in this file will be replaced. More transfer-function and system combination examples are located in folder: "*C:\Flixan\Comb_Trfn\Examples*".

Process Input Data Files	
Point to an Input Data Filename and Click on "Select Input File" The following sets of input data are in file: TF-Test.Inp	Exit
TF-Test.Inp Run Batch Mode : Batch for preparing systems from transfer-function combinations Comb_tst.inp CTST.INP ROCK.INP Ruiv.inp Transf-Functions : 3 Blocks Interconnection Test Transf-Functions : Lateral Digital Flight Control System TF-Test.Inp TF-Test.Inp Select Input Edit File	
File Edit File Process or View Input already exists. Do you want to create it again? Data Yes	
Relocate Data Set in File Copy to Another File	
View Data-Set Comments	
This batch creates three systems from 3 TF interconnection sets. (a) a combination of 3 transfer-functions. (b) a discrete Space Shuttle Flight Control System (c) a set of four 1 (sec) delays inplemented at different Pade approximations	*

3.0 Systems Reconstruction Program

This is a utility program used to modify, reduce, simplify, separate or reconstruct an existing statespace system. For example, the analyst may wish to replace the system outputs with a new set of outputs, or change the units of the system variables, or to eliminate some unnecessary inputs, states, or outputs, or to separate pitch and lateral dynamics. The System Modification program reads the statespace system to be modified from a systems file ".Qdr" and creates new systems by modifying the original system's variables or may perform some of the following operations:

- Rescale the original system variables by converting the units of the old system's inputs, state, and output variables into different units. The conversion is defined by a constant scaling factor (S), where the old units = (S) times the new units.
- The utility can also create a new system by replacing the old system outputs with a new set of outputs which are made up from a combination of some of the old system's outputs, the states, and the derivatives of the old system outputs and states. This option is useful for extracting derivatives of outputs which are often needed when constructing control design models for LQG or H-infinity synthesis, where state or output derivatives are often included in the criteria optimization vector.
- It is also used to simplify a system by eliminating some of the unused old system's inputs, states, or outputs. It can also be used to decouple a state-space system. Separating, for example, a coupled flight vehicle model into pitch and a lateral subsystems. This option can also be used to change the sequence of the system's variables.

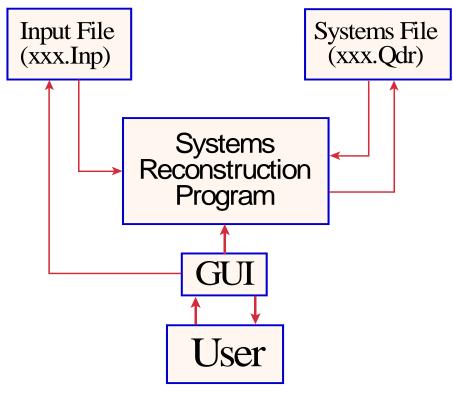
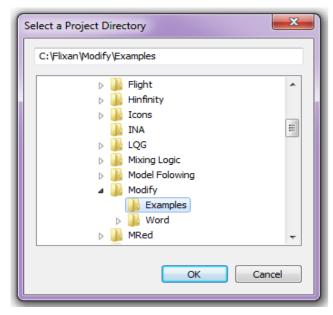


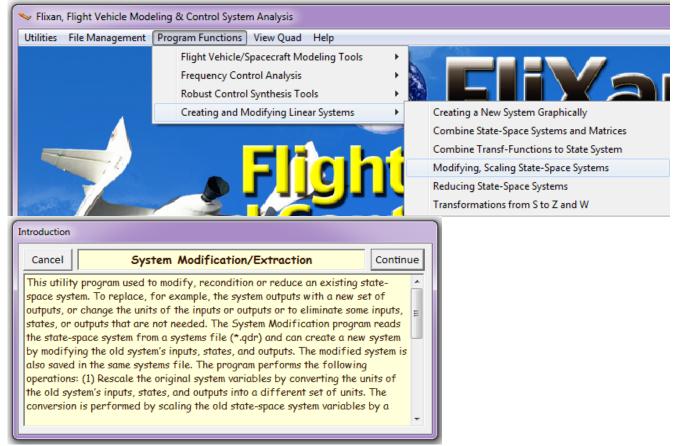
Figure (3.1) Diagram of the Systems Reconstruction Program used to Modify/ Rescale existing systems. It shows the interaction between with the User, Program, and Input/ Output Files

3.1 Program and Files Selection

The example files presented in this section are located in folder "C:\Flixan\Modify\Examples". The Systems Reconstruction/ Modification program can be selected from the Flixan main menu by clicking on "Program Functions", then select the "Creating and Modifying Linear Systems" group, and then click on "Modifying & Scaling State-Space" Systems". Then using the following file selection dialog select the input data file and the systems file from the menus, as shown below. The input file contains the system reconstruction instructions, that is, when the instructions set has already been saved there from a previous run. Otherwise, the user must system modification define the instructions interactively which will be saved in file ".Inp" for a



later use. The systems file originally contains the state-space system that will be modified by the program according to the instructions in the input set, such as, rescaling, selecting variables, creating new outputs, etc. The modified system will also be placed in the same systems file. After selecting the two filenames the user must click on "*Process Files*" to run the program, or if the instructions are not in file click on "*Create New Input Set*" to enter the system modification instructions interactively.



Select Input and System Filenames Select a File Name containing the Input Data Set (x.Inp)	Select a File Name containing the State Systems (x.Qdr)		
Modif1.inp	Modif1.qdr		
Modif1.inp Modif2.inp Modif3.inp Modif4.inp Test2.inp NewFile.Inp	Modif1.qdr Modif2.qdr Modif3.qdr Modif4.qdr Test2.qdr NewFile.Qdr		
Create New Input Set Exit Program Process Files			

3.2 Instructions Already Saved in Input Data File

When the system modification data is already defined in the input file, the user selects the input and systems filenames from the menu above and clicks on "*Process Files*". The input file typically contains several sets of system modification instructions. Three typical system modification data-sets from file "*Modif4.Inp*" are shown below. They all begin with the line: "CREATE A NEW SYSTEM FROM AN OLD SYSTEM" which identifies the type of data and process, followed by system titles and instructions. There are two system titles: (a) the title of the modified new system to be created, and (b) the original system title before the modifications.

```
CREATE A NEW SYSTEM FROM AN OLD SYSTEM... (Titles of the New and Old Systems)
X-45 Descent at Qbar=250, Mach=0.4 (Lateral Outputs)
X-45 Descent at Qbar=250, Mach=0.4
! From the original system, create a new set of outputs only for the lateral axis
NEW SYSTEM OUTPUTS FROM PREVIOUS SYSTEM OUTPUTS/ STATES/ DERIVATIVES
From Old System Output:
                                              Roll Attitude
                                                              (phi-Stabil) (radians)
                       1
                       2
                                                              (p-Stabil) (rad/sec)
From Old System Output:
                                               Roll Rate
                                                             (psi-rigid)
                                                                           (radians)
                      5
6
From Old System State :
                                               Yaw Attitude
From Old System State :
                                              Yaw Rate
                                                              ( r -rigid)
                                                                            (rad/sec)
From Old System Output: 8
                                              Angle of sideslip (beta-rigid) (radians)
                                              Angle of sideslip (beta-rigid) (radians) /Rate
From State Derivative :
                       8
From Old System Output:
                      12
                                              CG Acceleration along Y axis, (ft/sec^2)
From Output Derivative:
                                              Roll Rate ( p -Stabil) (rad/sec) /Rate
                       2
                                                              (r -Stabil) (rad/sec)/Rate
From Output Derivative: 6
                                             Yaw Rate
_____
CREATE A NEW SYSTEM FROM AN OLD SYSTEM... (Titles of the New and Old Systems)
X-45 Descent at Qbar=250, Mach=0.4 (Pitch Dynamics)
X-45 Descent at Qbar=250, Mach=0.4
! Extract the Pitch Dynamic Model from system: " X-45 Descent at Qbar=250, Mach=0.4"
TRUNCATE OR REORDER THE SYSTEM INPUTS, STATES, AND OUTPUTS
Extract Inputs : 1 4
                        5
Extract States : 3 4
Extract Outputs: 3 4
_____
CREATE A NEW SYSTEM FROM AN OLD SYSTEM... (Titles of the New and Old Systems)
X-45 Descent at Qbar=250, Mach=0.4 (Lateral Dynamics)
X-45 Descent at Qbar=250, Mach=0.4
! Extract the Lateral Dynamic Model from system: " X-45 Descent at Qbar=250, Mach=0.4"
TRUNCATE OR REORDER THE SYSTEM INPUTS, STATES, AND OUTPUTS
Extract Inputs : 2 3 5
Extract States : 1 2 5 6 8
Extract Outputs: 1 2 5 6 8 12
                                                _____
```

The program searches through the input data file "Modif4.Inp" looking for system modification datasets. When it finds them it displays their titles in a menu, shown below, and in this case it found many system modification sets in this file. These are the first titles that define the new system to be created and not the original system titles. The user selects one of the new system titles from this menu and clicks on "Run Input Set" to process it. The program reads the input instructions and calculates the modified state-space system from the original system. Then it saves the new system in the systems file "Modif4.Qdr" using the new system title selected from the menu.

Select a Set of Data from Input File			
Select a Set of Input Data for "CREATE A NEW SYSTEM" from an Input File: Modif4.inp	Run Input Set		
X-45 Descent, Pitch Axis at Qbar=250, Mach=0.4 X-45 Descent, Lateral Axes at Qbar=250, Mach=0.4 X-45 Descent, Lateral Axes at Qbar=250, Mach=0.4, Modification-1 X-45 Descent, Lateral Axes at Qbar=250, Mach=0.4, Modification-2 X-45 Descent at Qbar=250, Mach=0.4 (Pitch Outputs) X-45 Descent at Qbar=250, Mach=0.4 (Lateral Outputs) X-45 Descent at Qbar=250, Mach=0.4 (Pitch Dynamics)	Exit Program Create New		
X-45 Descent at Qbar=250, Mach=0.4 (Lateral Dynamics) X-45 Descent at Qbar=250, Mach=0.4 (Reorder System)			

3.3 Creating a New Set of System Modification Instructions

If the system modification instructions are not in file (.Inp) the program will create the instructions set interactively, save it in file (.Inp), and then process it. After selecting the input and system files from the filename selection menu the user must click on "*Create a New Input Set*" instead of "*Process Files*" as in the previous section. If the input filename does not exist the user may enter a new name with an extension (.Inp). The program will receive the system modifications interactively, save them as a data-set in the input file and process the set. The following menu shows the titles of the systems included in file "*Modif4.Qdr*". Select the first one to be modified. It is a vehicle model that includes both pitch and lateral dynamics.

Select a State-Space System from Quad File	
Select a State-Space Model for System Modification, From Systems File: Modif4.qdr	
X-45 Descent at Qbar=250, Mach=0.4	
X-45 Descent, Pitch Axis at Qbar=250, Mach=0.4	
X-45 Descent, Lateral Axes at Qbar=250, Mach=0.4	
X-45 Descent, Lateral Axes at Qbar=250, Mach=0.4, Modification-1	
X-45 Descent, Lateral Axes at Qbar=250, Mach=0.4, Modification-2	=
X-45 Descent at Qbar=250, Mach=0.4 (Pitch Outputs)	
X-45 Descent at Qbar=250, Mach=0.4 (Lateral Outputs)	
X-45 Descent at Qbar=250, Mach=0.4 (Pitch Dynamics)	
X-45 Descent at Qbar=250, Mach=0.4 (Lateral Dynamics)	
X-45 Descent at Qbar=250, Mach=0.4 (Reorder System)	
X-45 Descent at Qbar=250, Mach=0.4-Modified	-
Choose a System Title and then click "Select" Cancel View System Select	ct

In this example we will create a new system by extracting only the pitch variables from the original system. Using the following dialog enter the new system's title "X-45 Descent at Qbar=250, Mach=0.4 (Pitch Axis)". From the menu select the third option "Extract or Reorder some of the System Variables", enter some comments below describing the new system, and click on "Select Option" to continue. The following dialog shows the definitions of the original system's inputs, states, and outputs in three separate menu tabs. From the menus the user selects the variables to be retained in the new system. Click on "Save Changes" every time you modify the choices. Then click on "Continue" to save and process the new set of system modification data.

Select One of the Following System Modification Options	
Define the New System Title	
X-45 Descent at Qbar=250, Mach=0.4 (Pitch Axis)	
Select a type of System Reconstruction Option from Enter some Comments describing the New System	m the Menu below and Select Option
Rescale a System (Change the Units of Inputs, States, or O Define New Outputs (from previous Outputs, States, and D Extract or Reorder some of the System Inputs, States, and	Derivatives) Exit and Run
The Pitch axis System is extracted from the couple of input, state, and output variables.	ed system by selecting a smaller number
Introduction	
Cancel Truncate/Reorder System Outp	Continue Continue
original system. The user must select the variables that he remaining variables (inputs, states, and outputs) will be elin system. The truncated system is saved in the same systems retained variables in the new system appear in the order th selected.	minated from the new file (*.QDR). The
Extract System Variables	Extract System Variables
From the original system you may extract some Inputs, States, Outputs, add some user comments, and give it a new Title X-45 Descent at Qbar=250, Mach=0.4 (Pitch Axis) Extract Inputs Extract Outputs Extract Inputs Extract Outputs Select the Inputs to be extracted from the original system and press either Save for some, or select " All " Elevon Deflection (radians)	From the original system you may extract some Inputs, States, Outputs, add some user comments, and give it a new Title X-45 Descent at Qbar=250, Mach=0.4 (Pitch Axis) Extract Inputs Extract Outputs Select the Outputs to be extracted from the original system and press either Save for some, or select All Outputs Roll Attitude (phi-Stabil) (radians)
Aileron Deflection (radians) Rudder Deflection (radians) Flaps Deflection (radians) Gust, Azim Elevat Angles:(45,45 deg)	Roll Rate (p-Stabil) (rad/ans) Roll Rate (p-Stabil) (rad/sec) Pitch Attitude (theta-Stabil) (rad/sec) Yaw Attitude (psi-Stabil) (rad/sec) Yaw Attitude (psi-Stabil) (rad/sec) Angle of attack (alfa-rigid) (rad/sec) Angle of attack (alfa-rigid) (radians) Angle of sideslip (beta-rigid) (radians) Change in Altitude (delta-h) (feet) Forward Acceleration (V-dot) (ft/sec) CG Acceleration along X axis, (ft/sec^2) CG Acceleration along Z axis, (ft/sec^2) CG Acceleration along Z axis, (ft/sec^2)
Save Changes Continue	Save Changes Continue

3.4 Creating a New Set of System Rescaling Instructions

This option is used for converting the units of some of the system inputs, states, or output variables from one type of units to another. Converting, for example, a system whose inputs are defined in pounds and its outputs in feet to a dynamically equivalent system whose inputs are defined in kilograms and its outputs are in meters. It is used, for example, to transform a plant model in order to combine it with a controller or an actuator systems that is defined in different units. In order to scale a state-space variable from one set of units to another the user must define the conversion factor "S". This scaling factor is defined as: one old unit is equal to "S" times the new unit.

Let us consider, for example, a simple second order system that models the response of a spring to an applied force. The force is applied at one end of a spring and the other side is fixed. The input to this model is the force applied in pounds. The two states are position and velocity at one end of the spring in feet and (feet/sec) respectively. The two outputs are: (1) spring position in feet, and (2) a direct feed-through term that measures the applied force. The state-space representation of this system is in file: Modif1.Qdr. The force in the original system input is defined in (lb) and it must be converted to (oz), the scaling factor S=16. The system output is in (feet) and it must be converted to (inches), the scaling factor S=12.

The diagram in Figure (3.1) shows both: the original and the scaled system in parallel. Both systems are equivalent. The original system is shown on the top. Its input is in (lb) and its two outputs are in (feet) and (lb). This system was transformed, as we shall see, to a new set of units, shown below. Its input is in (ounces) and its outputs are in (inches) and (ounces). The equivalence of the two systems is demonstrated by including unit conversion gains to rescale the inputs and the outputs of the modified system to match the original. The two systems are excited together in parallel and they respond identically, as expected.

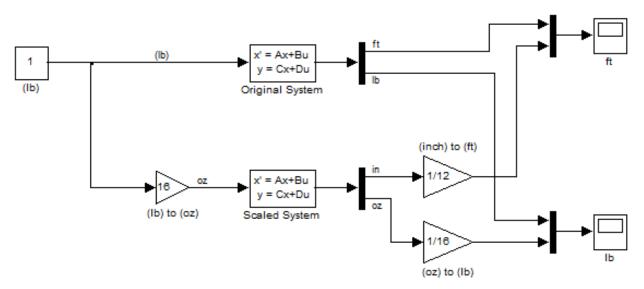
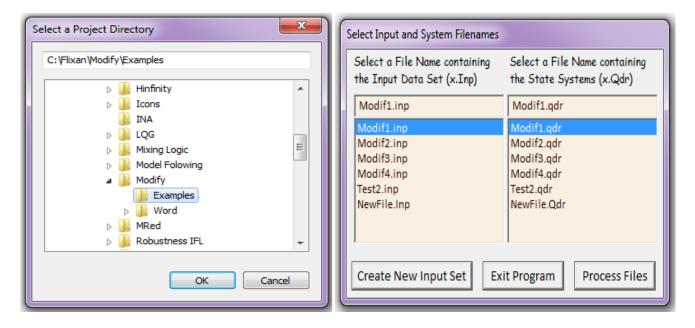


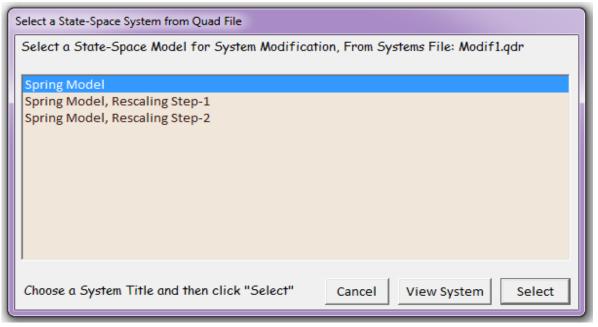
Figure (3.1) Comparison between the Original and the Scaled Systems

Re-scaling a system's input is performed by dividing with the scaling factor (S) the corresponding column in matrices B and D. Similarly, rescaling a system's output is performed by multiplying with the scaling factor (S) the corresponding row in matrices C and D. Rescaling the states affects only matrices A, B, and C. Notice, that it is not necessary to rescale the states in order to combine two

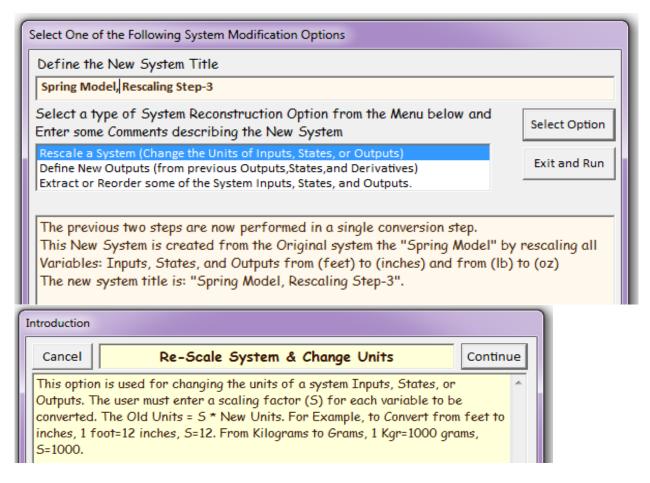
systems together. Rescaling a system's inputs and outputs is not only used for the purpose of changing its units. It is also a good practice to rescale a system when the magnitudes of matrices B, C, or D are either too small or too large. This may avoid numerical problems associated with some control algorithms.

So let us begin by scaling the original system "*Spring Model*" which is in file "*Modif1.Qdr*". We will assume again that the system modification instructions are not in file and the program will create a new set of scaling instructions interactively, save the set in file "*Modif1.Inp*". and process it. The input and systems files "*Modif1.Inp*" and "*Modif1.Qdr*" are located in directory "*C:\Flixan\ Modify\ Examples*". The user must select the two files from the menus and click on "*Create New Input Set*" to create the system rescaling instructions set, and from the following menu one of the systems file "*Modif1.Qdr*" is chosen to be rescaled. It is the original "*Spring Model*".





The program reads the state-space system and opens the following dialog used for selecting system modification options. The user replaces the default title on the top with a new system title: "*Spring Model, Rescaling Step-3*". From the system modifications menu we select the first option to rescale the system variables. In the field below the user enters some comments describing the system modifications, and click on "*Select Option*". The notes are helpful in describing the new system, its characteristics, and how it was derived from the original system. The user notes will also be included as comments in the data files and become available to other utility programs.



The next step is for the user to select some of the system variable to be scaled. The variables are selected from the dialog below that has three menus in separate tabs for selecting and scaling inputs, states, and outputs. The user selects one of the menu tabs, for example, "*Scale Outputs*", from the menu selects one of the outputs, for example, "*Position (ft)*", and enters at the bottom the scaling factor (s) that converts the old units to the new units. Old Units = (s)*NewUnits. For example, select the inputs menu tab and then the "*Applied Force in (lb*)". Enter a scaling factor of 16 at the bottom to convert pounds to ounces. Click on "OK" every time you select and scale a variable. The title of the variable changes because scaling factor is included on its right side. When you finish scaling the variables click on "*Continue*", and the program returns to the previous dialog.

It is also possible to include more than one type of modifications in the same data set under one title, as it will be shown in other examples. For this reason the interactive utility does not terminate after completing one option, but it returns to the menu and waits for additional options to be included in the set before creating the final system. To save and run the new instructions and to create the new system the user must click on the "*Exit and Run*" button. The new set of instructions, shown below, will finally be saved in the input file and be processed to create the modified system in file "*Modifl.Qdr*" under the new title.

Scale System Variables	Scale System Variables
From the Original system you may Select some Inputs, States and Outputs to be Scaled and Enter a New Title below	From the Original system you may Select some Inputs, States and Outputs to be Scaled and Enter a New Title below
Spring Model, Rescaling Step-3	Spring Model, Rescaling Step-3
Scale Inputs Scale Outputs Scale States	Scale Inputs Scale Outputs Scale States
Select an Input from the Original system to be Scaled,	Select an Output from the Original system to be Scaled,
Enter the Scaling Factor and Click "OK"	Enter the Scaling Factor and Click "OK"
Applied Force (lb) / 16.000	Position (ft) * 12.000 Applied Force (lb) * 16.000
Scale Factor 16.000 OK	Scale Factor 16.000 OK
New Units = Old Units / Scale Factor Continue	New Units = Old Units / Scale Factor Continue
Scale System Variables From the Original system you may Select some Inputs, States and Outputs to be Scaled and Enter a New Title below Spring Model, Rescaling Step-3 Scale Inputs Scale Outputs Scale Inputs Scale Outputs Select a State from the Original system to be Scaled, Enter the Scaling Factor and Click "OK" Position (ft) * 12.000 Velocity (ft/sec) * 12.000 Scale Factor 12.000	
New Units = Old Units / Scale Factor Cont	

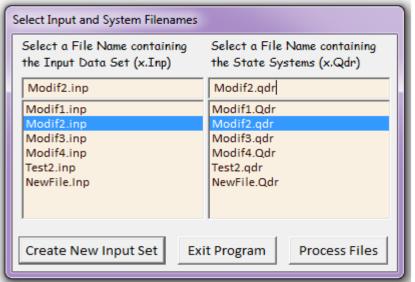
Click on "*Continue*" and the interactive utility returns to the previous dialog with the three options. From there click on "*Exit and Run*" to process the modification data. Notice that the name-list of the rescaled system variables, printed at the bottom of the system in the ".Qdr" file, includes the scaling

factors (S) on the right side of each variable. The input file "*Modif1.Inp*" is shown below. We just demonstrated and processed the third system modification set "*Spring Model, Rescaling Step-3*". Notice that the system scaling can also be performed in two steps for demo purposes, step-1 and step-2. There is also a batch set on the top for fast processing of the entire file.

```
STATE-SPACE SYSTEM RE-SCALING EXAMPLES
     _____
BATCH MODE INSTRUCTIONS .....
Batch for rescaling a system inputs, states, and outputs
! In step-1 we rescale the system inputs and outputs from pounds to ounces, and from feet to inches.
! In step-2 we rescale the states of the system created in step-2 from feet to inches.
! In step-3 we do the rescalings performed in steps 1 and 2 in one set.
Retain System
             : Spring Model
System Modificat : Spring Model, Rescaling Step-1
System Modificat : Spring Model, Rescaling Step-2
System Modificat : Spring Model, Rescaling Step-3
To Matlab Format : Spring Model
To Matlab Format : Spring Model, Rescaling Step-3
_____
                                              _____
CREATE A NEW SYSTEM FROM AN OLD SYSTEM... (Titles of the New and Old Systems)
Spring Model, Rescaling Step-1
Spring Model
! Example: 1,
! A New System is created from the "Spring Model" by having Input #1 converted
! from pounds to ounces (1 lb = 16 oz) and Output #1 converted from feet to inches
! (1 ft = 12 in). The new system title is: "Spring Model, Rescaling Step-1".
RESCALE A SYSTEM, CHANGE THE UNITS OF INPUTS/STATES/OUTPUTS
Rescale Inputs : 1
Scaling Values : 16.00
Rescale Outputs: 1
                        2
                    16.00
Scaling Values : 12.00
           _____
                               _____
                                                                 CREATE A NEW SYSTEM FROM AN OLD SYSTEM... (Titles of the New and Old Systems)
Spring Model, Rescaling Step-2
Spring Model, Rescaling Step-1
! Example: 2,
! This New System is created from the previous one "Spring Model, Rescaling Step-1"
! by rescaling its states from (feet) to (inches), a factor of 12. The new system title
! is: "Spring Model, Rescaling Step-2".
RESCALE A SYSTEM, CHANGE THE UNITS OF INPUTS/STATES/OUTPUTS
Rescale States :
               1
                       2
Scaling Values : 12.00
                       12.00
_____
CREATE A NEW SYSTEM FROM AN OLD SYSTEM... (Titles of the New and Old Systems)
Spring Model, Rescaling Step-3
Spring Model
! Example: 3, The previous two steps are now performed in a single conversion step.
! This New System is created from the Original system the "Spring Model"
! by rescaling all Variables: Inputs, States, and Outputs
! from (feet) to (inches) and from (lb) to (oz)
! The new system title is: "Spring Model, Rescaling Step-3".
RESCALE A SYSTEM, CHANGE THE UNITS OF INPUTS/STATES/OUTPUTS
Rescale Inputs : 1
Scaling Values : 16.00
Rescale States : 1
                        2
Scaling Values : 12.00
                      12.00
Rescale Outputs: 1
                        2
Scaling Values : 12.00 16.00
      _____
CONVERT TO MATLAB FORMAT ...... (Title, System/Matrix, m-filename)
Spring Model
System
Original_Sys.m
               _____
CONVERT TO MATLAB FORMAT .....
                                (Title, System/Matrix, m-filename)
Spring Model, Rescaling Step-3
System
Scaled_Sys.m
```

3.5 Creating a New Set of Outputs Interactively

Sometimes a system's output does not include sufficient variables. Some required states or derivatives do not appear in the output vector and the analyst would like to modify the output vector to include them. This option is used to replace a system's outputs with a new set of outputs from a combination of the original system variables. The new outputs can be selected from: (a) the original system outputs, (b) its output derivatives, (c) the old system states, and (d) the derivatives of the states. This utility is particularly useful in preparing synthesis models for control system design because design models often require additional output criteria to be optimized that may not necessarily appear in the original output. The original system to be modified in this example is "*Shuttle Entry Lateral model with beta-integral*" located in file "*Modif2.Qdr*". The output reconstruction data-set is not available yet so we will create it interactively and place it in file "*Modif2.Inp*". So we begin the program, as in previous examples, by selecting the two files from the filenames selection menu, and click on "*Create a New Input Set*" to begin the interactive data collection process. From the next menu select the original system from file "*Modif2.Qdr*", and click on "Select".



Select a State-Space System from Quad File

Select a State-Space Model for System Modification, From Systems File: Modif2.qdr

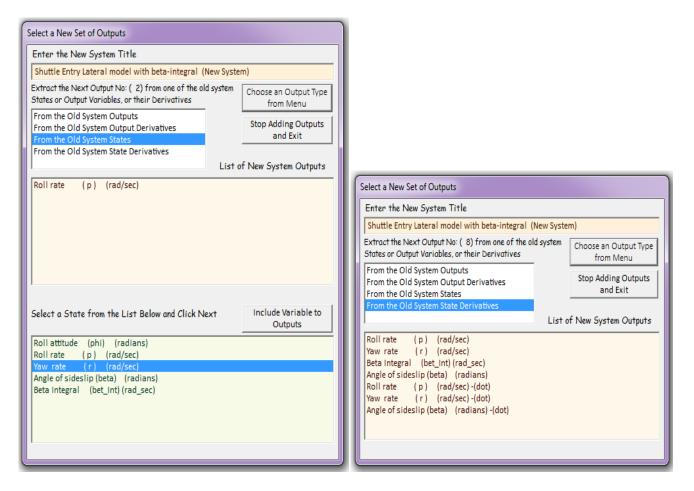
Shuttle Entry Lateral model with beta-integral Shuttle Entry Lateral model with beta-integral (New System)

Choose a System Title and then click "Select" Cancel View System Select

The program opens the following dialog for selecting type of system modification. The new system title is entered on the top, and from the menu select the second option to define a new set of outputs. Some comments may also be included in the field below, and click on "*Select Option*", as shown.

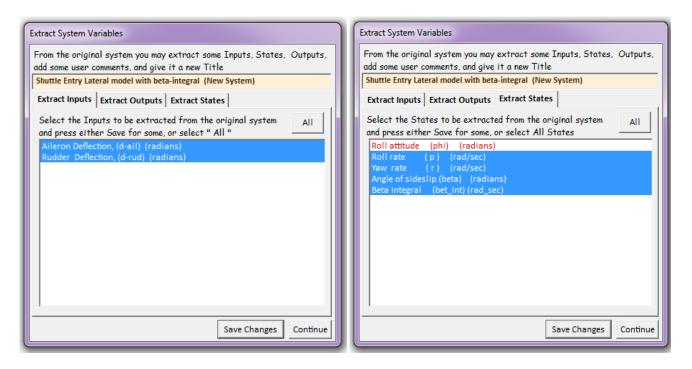
Select One of the Following System Modification Options	
Define the New System Title	
Shuttle Entry Lateral model with beta-integral (New System)	
Select a type of System Reconstruction Option from the Menu below and Enter some Comments describing the New System	Select Option
Rescale a System (Change the Units of Inputs, States, or Outputs) Define New Outputs (from previous Outputs, States, and Derivatives)	Exit and Run
Extract or Reorder some of the System Inputs, States, and Outputs.	Edit Input File
This System was obtained from the previous one by performing a combibed OUTPUTS) and (TRUNCATE) operation. The following modifications are p Keep the previous system Outputs 2,3, and 4 (Roll rate, Yaw rate, and beta State 4, the angle of sideslip (beta) in the Outputs, (c) Include the roll and accelerations p_dot, r_dot in the Outputs, (d) Include the derivative of state in the Outputs, (e) Eliminate state 1 (roll attitude) from the states and from	erformed: (a) , (b) Include d yaw ate 4, (beta_dot)
Introduction	
Cancel Create New System Outputs Conti	nue
This option can be used to create a new system from an already existing system by changing its outputs. The new system has the same inputs and states as the old, but its outputs can be selected from the old system's outputs, its output derivatives, the old system's states, and the state derivatives. The modified system can also be saved in the same systems file (*.Qdr). This option is useful for creating control design models that require derivatives of certain variables in the performance criteria.	

The following dialog is introduced to help the user select the new system outputs. It has a menu that includes four groups of variables from where the user may choose the new outputs: (a) from the original system outputs, (b) from the derivatives of the outputs, (c) from the old system states, and (d) from the derivatives of the states. The new system outputs are selected one at a time from the four groups of variables using this dialog. Select one of the four types of variables from the menu, "*old system states*" in this case, and click on "*Choose an Output Type*". The display below the menu is initially empty. It will eventually contain the selected output variables. The menu at the bottom of the dialog contains the variable titles of the selected group. The user selects one variable at a time from this menu and clicks on "*Include Variable to Outputs*". The selected variable titles are gradually included in the outputs list at the top. Variables from other groups can also be selected, such as, in this case from "*old system state derivatives*". The first four outputs in this demo (roll rate, yaw rate, etc), were selected from the original system states. The last three outputs (p-dot, r-dot, and β -dot) was selected from the state derivatives.



This process of selecting one variable at a time from different groups is repeated multiple times. When a variable from the derivative groups is selected, a short label "-dot" is included at the end of its title. When the outputs list is complete the user clicks on "*Stop Adding Outputs and Exit*", and the utility returns to the previous dialog in case the user wants to include additional modification options for the same system under the same title. In this case we want to eliminate one of the states, the roll attitude, and we select the third option for truncating some of the original system variables, and click on "*Select Option*". The dialog of this option includes three menu tabs for selecting the system inputs, states, and outputs to be retained from the original system. From the menu we select to retain all inputs and all outputs. From the states we truncate the first state (roll attitude). This variable was also excluded from the outputs.

Select One of the Following System Modification Options	
Define the New System Title	
Shuttle Entry Lateral model with beta-integral (New System)	
Select a type of System Reconstruction Option from the Menu below and Enter some Comments describing the New System	Select Option
Rescale a System (Change the Units of Inputs, States, or Outputs) Define New Outputs (from previous Outputs, States, and Derivatives)	Exit and Run
Extract or Reorder some of the System Inputs, States, and Outputs.	Edit Input File
This System was obtained from the previous one by performing a combibed OUTPUTS) and (TRUNCATE) operation. The following modifications are pe Keep the previous system Outputs 2,3, and 4 (Roll rate, Yaw rate, and beta, State 4, the angle of sideslip (beta) in the Outputs, (c) Include the roll and accelerations p_dot, r_dot in the Outputs, (d) Include the derivative of stat in the Outputs, (e) Eliminate state 1 (roll attitude) from the states and from the states and from the outputs, (c) Eliminate state 1 (roll attitude) from the states and from the states and from the outputs, (c) Eliminate state 1 (roll attitude) from the states and from	erformed: (a) (b) Include yaw te 4, (beta_dot)
introduction	
Cancel Truncate/Reorder System Outpts Co	ontinue
This option is used to truncate some of the Inputs, States, or Outputs of the original system. The user must select the variables that he wants to retain. T	



The system modification instructions set is now saved in file "*Modif2.Inp*" and processed. The new system is saved in file "*Modif2.Qdr*" and its title is "*Shuttle Entry Lateral model with beta-integral (New System)*". The system modification data-set is shown below and it consists of two parts: (a) the new outputs reconstruction, and (b) the states extraction and the elimination of roll attitude state.

```
CREATE A NEW SYSTEM FROM AN OLD SYSTEM... (Titles of the New and Old Systems)
Shuttle Entry Lateral model with beta-integral (New System)
Shuttle Entry Lateral model with beta-integral
! This System was obtained from the previous one by performing a combibed (NEW OUTPUTS)
! and (TRUNCATE) operation. The following modifications are performed:
! (a) Keep the previous system Outputs 2,3, and 4 (Roll rate, Yaw rate, and beta
! (b) Include State 4, the angle of sideslip (beta) in the Outputs
! (c) Include the roll and yaw accelerations p_dot, r_dot in the Outputs
! (d) Include the derivative of state 4, (beta_dot) in the Outputs
! (e) Eliminate state 1 (roll attitude) from the states and from the outputs.
NEW SYSTEM OUTPUTS FROM PREVIOUS SYSTEM OUTPUTS/ STATES/ DERIVATIVES
From Old System State :
                                                   Roll rate
                          2
                                                                     (p)
                                                                               (rad/sec)
From Old System State :
                          3
                                                   Yaw rate
                                                                     (r)
                                                                                (rad/sec)
From Old System State :
                          5
                                                   Beta Integral
                                                                     (bet_Int) (rad_sec)
From Old System State :
                                                   Angle of sideslip (beta)
                                                                               (radians)
                          4
From State Derivative :
                                                                                (rad/sec) -(dot)
                          2
                                                   Roll rate
                                                                     (p)
From State Derivative :
                                                                               (rad/sec) -(dot)
                          3
                                                   Yaw rate
                                                                     (r)
From State Derivative :
                          4
                                                   Angle of sideslip (beta)
                                                                               (radians) -(dot)
TRUNCATE OR REORDER THE SYSTEM INPUTS, STATES, AND OUTPUTS
Extract States : 2 3 4 5
```

3.6 Example 3 Separating a Coupled Vehicle Model

In this example we will demonstrate how to separate a coupled flight vehicle model into separate subsystems. The original state-space system represents a reentry vehicle near landing and it was generated by the flight vehicle modeling program. The system title is "*Re-entry Vehicle, Landing Model (Coupled Pitch and Lateral Axes)*" and it is included in file "*Modif3.Qdr*". This example files are also located in "*C:\Flixan\Modify\ Examples*". The pitch and lateral dynamics are both included and are coupled in this dynamic model. We will use the systems truncation option to split the original system and to create two separate pitch and a lateral subsystems. We will also use the scaling option to rescale the output angles from radian to degrees. Two sets of system modification instructions are created: one set for pitch and one for lateral system extractions. Each set performs two functions: scaling and truncating. In the pitch system the pitch variables are extracted from the original inputs, states, and outputs. The same for the lateral system. Initially we assume that the input file is empty so we will create the system modifications interactively and save them in file "*Modif3.Inp*".

So we begin the program as in previous examples by selecting the two files "*Modif3.Qdr*" and "*Modif3.Inp*" from the filenames selection menu, and click on "*Create a New Input Set*" to begin the interactive data collection process. From the systems selection menu chose the original system title "*Re-entry Vehicle, Landing Model (Coupled Pitch and Lateral Axes)*", and click on "Select".

Select Input and System Filenames		
Select a File Name containing the Input Data Set (x.Inp)	Select a File Name containing the State Systems (x.Qdr)	
Modif3.inp	Modif3.qdr	
Modif1.inp Modif2.inp	Modif1.Qdr Modif2.qdr	
Modif3.inp	Modif3.qdr	
Modif4.inp Test2.inp NewFile.Inp	Modif4.Qdr Test2.qdr NewFile.Qdr	
Create New Input Set Ex	it Program Process Files	
🥆 Flixan, Flight Vehicle Modeling & Contr	ol System Analysis	
Utilities File Management Program Fu	nctions View Quad Help	
Flight	/ehicle/Spacecraft Modeling Tools	
Freque	ncy Control Analysis	
Robust	Control Synthesis Tools	
Creatin	ng and Modifying Linear Systems	Creating a New System Graphically
		Combine State-Space Systems and Matrices
		Combine Transf-Functions to State System
		Modifying, Scaling State-Space Systems
		Reducing State-Space Systems
		Transformations from S to Z and W

Select a State-Space System from Quad File		
Select a State-Space Model for System Modification, From Systems File: Modif3.qdr		
Re-Entry Vehicle Landing Model, (Coupled Pitch and Lateral Axes) Re-Entry Vehicle Landing Model, (Pitch Axis)		
Re-Entry Vehicle Landing Model, (Lateral Axes)		
Choose a System Title and then click "Select" Cancel View System Select		

The program opens the following dialog where the user selects the type of system modification and enters the new system title, which is: "*Re-entry Vehicle, Landing Model (Pitch Axis)*". From the menu select the first option to rescale the new system outputs. Some comments are also included in the field below, and click on "*Select Option*", as shown

Select One of the Following System Modification Options	
Define the New System Title	
Re-Entry Vehicle Landing Model, (Pitch Axis)	
Select a type of System Reconstruction Option from the Menu below and Enter some Comments describing the New System	Select Option
Rescale a System (Change the Units of Inputs, States, or Outputs) Define New Outputs (from previous Outputs, States, and Derivatives) Extract or Reorder some of the System Inputs, States, and Outputs.	Exit and Run
Extract the Pitch Variables from the Coupled System and Scale the Outputs (degrees)	from (rad) to

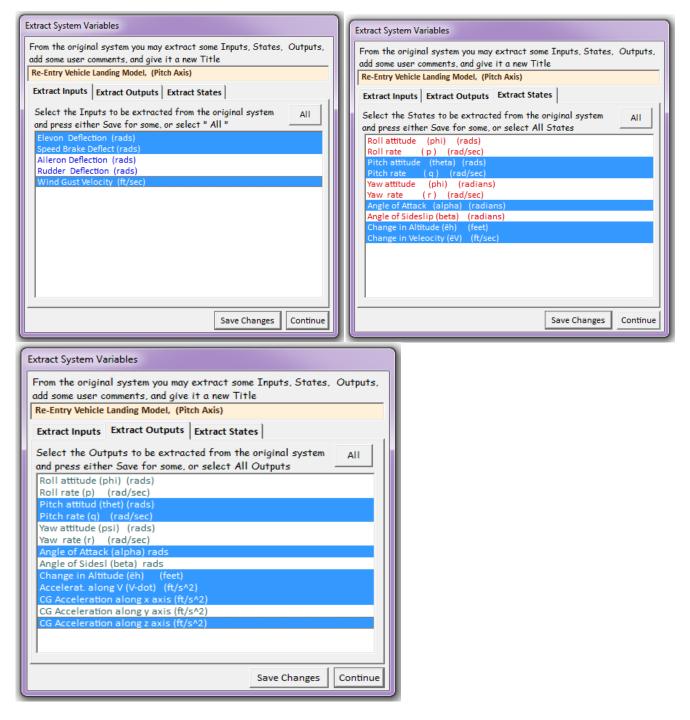
The next step is to scale the output angles. Another dialog comes up that includes three menu tabs for selecting and scaling the original system variables. Select the outputs menu tab and from there select three outputs: (#3) the pitch attitude, (#4) the pitch rate, and (#7) the angle of attack, and enter a scaling factor of 57.3 to convert them to degrees, because 1 (radian) = 57.3 (degrees). Click on "OK" every time you select and scale a variable. The variable title changes because scaling factor is included on the title right side. When you finish scaling the outputs click on "*Continue*", and the program returns to the previous dialog.

Scale System Variables		
From the Original system you may Select some Inputs, States and Outputs to be Scaled and Enter a New Title below		
Re-Entry Vehicle Landing Model, (Pitch Axis)		
Scale Inputs Scale Outputs Scale States		
Select an Output from the Original system to be Scaled, Enter the Scaling Factor and Click "OK"		
Roll attitude (phi) (rads)Roll rate (p) (rad/sec)Pitch attitud (thet) (rads)/ 57.300Pitch rate (q) (rad/sec)Yaw attitude (psi) (rads)Yaw rate (r) (rad/sec)Angle of Attack (alpha) rads/ 57.300Angle of Sidesl (beta) radsChange in Altitude (ëh) (feet)Accelerat. along V (V-dot) (ft/s^2)CG Acceleration along x axis (ft/s^2)CG Acceleration along z axis (ft/s^2)CG Acceleration along z axis (ft/s^2)		
Scale Factor 57.300 OK		
New Units = Old Units / Scale Factor Continue		

From the systems modification options menu, this time we choose the third option "*Extract or Reorder*" to extract the variables that we want to retain in the new pitch system, and click on "Select Option". A new dialog comes up that includes three menu tabs for extracting from the original system inputs, states, and outputs.

Select One of the Following System Modification Options	
Define the New System Title	
Re-Entry Vehicle Landing Model, (Pitch Axis)	
Select a type of System Reconstruction Option from the Menu below and Enter some Comments describing the New System	Select Option
Rescale a System (Change the Units of Inputs, States, or Outputs) Define New Outputs (from previous Outputs, States, and Derivatives)	Exit and Run
Extract or Reorder some of the System Inputs, States, and Outputs.	Edit Input File
Extract the Pitch Variables from the Coupled System and Scale the Output (degrees)	's from (rad) to

Using this system variables dialog and by selecting the appropriate menu tabs, we can extract the desired inputs, states and outputs for the pitch model, from the original system variables. From the 5 original system inputs we select 3: the elevon deflection, the body flap deflection, and the wind gust velocity. From the 10 original states we select 5: pitch attitude and rate, angle of attack (α), change in altitude (dh), and change in velocity (dV). From the 13 original outputs we select 7: pitch attitude and rate, angle of attack (α), change in altitude (dh), acceleration (V-dot), CG acceleration along x axis, and CG acceleration along z axis. Click on "Continue" and the program will save the system modification instructions in file "*Modif3.Inp*", process it, create the pitch system and save it in file "*Modif3.Qdr*".



The extraction of the lateral system from the original system is very similar with the pitch axis. The lateral system consists of 2 Inputs, 5 States, and 6 Outputs. The inputs are the aileron and rudder deflections in (radian). For outputs we select roll and pitch attitude and rates, the angle of sideslip (beta), and the Ny acceleration. The output angles are converted from radians to degrees. This time we will not construct the modification instructions from scratch but we will process the data-set already saved in file "*Modif3.Inp*". Its title is "*Re-Entry Vehicle Landing Model, (Lateral Axes)*". When the program gets to the point of selecting the filenames, this time click on "*Process Files*". The following menu shows the titles of the system modification sets in file "*Modif3.Inp*". Select the title of the second set which extracts the lateral model and click on "*Run Input Set*" to process the data. The extracted lateral system with the scaled outputs will be saved in file "*Modif3.Qdr*".

Select a File Name containing the Input Data Set (x.Inp)	Select a File Name containing the State Systems (x.Qdr)
Modif3.inp	Modif3.qdr
Modif1.inp Modif2.inp	Modif1.Qdr Modif2.gdr
Modif3.inp	Modif3.qdr
Modif4.inp Test2.inp	Modif4.Qdr Test2.qdr
NewFile.Inp	NewFile.Qdr

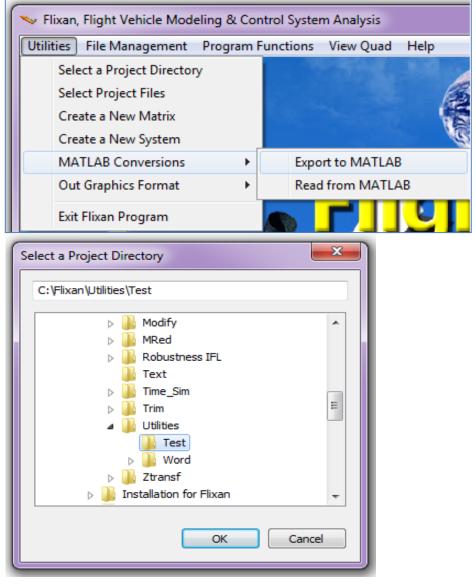
Select a Set of Data from Input File	
Select a Set of Input Data for "CREATE A NEW SYSTEM" from an Input File: Modif3.inp	Run Input Set
Re-Entry Vehicle Landing Model, (Pitch Axis) Re-Entry Vehicle Landing Model, (Lateral Axes)	Exit Program Create New

The input file "Modif3.Inp" is shown below. It includes the two pitch and lateral subsystem extraction data-sets. There is also a batch set included for processing the file in batch.

```
Flight Vehicle Landing Model
     Pitch and Lateral Decoupling Example
_____
                                        _____
BATCH MODE INSTRUCTIONS .....
Batch for separating a flight vehicle model to Pitch and Lateral
! The original system is a Shuttle Landing model that includes both pitch and lateral
! dynamics. This system will be separated to two subsystems: a pitch subsystem and a
! lateral subsystem. The subsystem outputs are scaled from (radians) to (degrees)
              : Re-Entry Vehicle Landing Model, (Coupled Pitch and Lateral Axes)
Retain System
System Modificat : Re-Entry Vehicle Landing Model, (Pitch Axis)
System Modificat : Re-Entry Vehicle Landing Model, (Lateral Axes)
  _____
                                        _____
                                               _____
CREATE A NEW SYSTEM FROM AN OLD SYSTEM (Titles of the New and Old Systems)
Re-Entry Vehicle Landing Model, (Pitch Axis)
Re-Entry Vehicle Landing Model, (Coupled Pitch and Lateral Axes)
! The original system consists of the coupled (pitch and lateral)
! dynamics of a flight vehicle. We will use the system extraction
! program to extract the pitch variables in a separate pitch systems
! The Pitch System consists of: Inputs: (1, 2, & 5),
! States: (3, 4, 7, 9, & 10), and Outputs: (3, 4, 7, 9, 10, 11, & 13)
! The output angles must first be converted from radian to degrees
RESCALE A SYSTEM, CHANGE THE UNITS OF INPUTS/STATES/OUTPUTS
Rescale Outputs: 3 4 7
Scaling Values: 57.3 57.3 57.3
TRUNCATE OR REORDER THE SYSTEM INPUTS, STATES, AND OUTPUTS
Extract Inputs : 1, 2, 5
Extract States : 3, 4, 7, 9, 10
Extract Outputs: 3, 4, 7, 9, 10, 11, 13
CREATE A NEW SYSTEM FROM AN OLD SYSTEM (Titles of the New and Old Systems)
Re-Entry Vehicle Landing Model, (Lateral Axes)
Re-Entry Vehicle Landing Model, (Coupled Pitch and Lateral Axes)
! We will use the system extraction program to extract the lateral variables
! The Lateral System consists of: Inputs: (3, 4),
! States: (1, 2, 5, 6, & 8), and Outputs: (1, 2, 5, 6, 8, & 12)
! The output angles must first be converted from radian to degrees
RESCALE A SYSTEM, CHANGE THE UNITS OF INPUTS/STATES/OUTPUTS
Rescale Outputs: 1 2 5 6
                                      8
Scaling Values : 57.3 57.3 57.3 57.3 57.3
TRUNCATE OR REORDER THE SYSTEM INPUTS, STATES, AND OUTPUTS
Extract Inputs : 3, 4
Extract States : 1, 2, 5, 6, 8
Extract Outputs: 1, 2, 5, 6, 8, 12
                                     _____
```

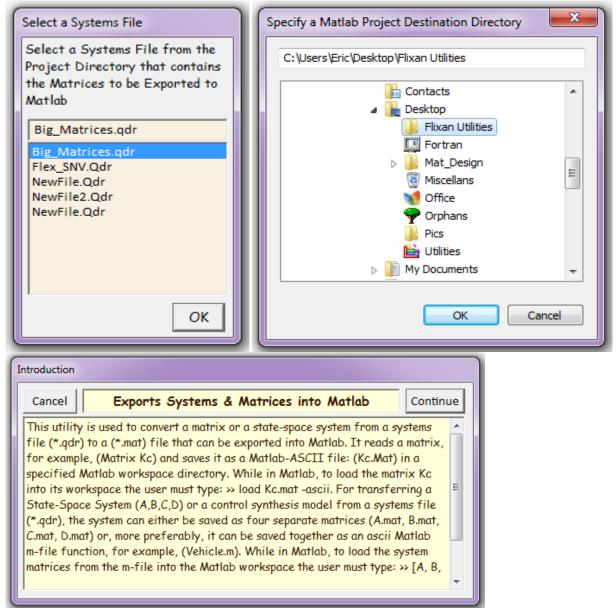
4.0 Utilities for Exporting data to Matlab and Importing data from Matlab

The Flixan program includes utility functions that convert Flixan data to Matlab format and also read data from Matlab generated files. The "Matlab exporting" utility reads matrices or state-space systems from systems files (.Qdr) and converts them into Matlab "ascii" matrices (.Mat) or m-file functions (.m), where they can be loaded into Matlab. The "from Matlab " importing utility reads Matlab "ascii" matrices (.Mat) and saves them in a systems file (.Qdr), either as a state-space system or as individual matrices using names other than [A,B,C,D], which identify a system. The Matlab data are not necessarily located in the same directory folder as the Flixan data. The user is prompted to specify separate directories, one for the data files used for the Flixan analysis, and a separate directory for the Matlab analysis containing the Simulink files (.Mdl), m-files (.m), and Matlab matrices (.Mat). The Flixan project directory is selected first. Then go to the Flixan main menu and click on "*Utilities*" to select the Matlab conversion utilities, as shown.



4.1 Exporting Data from Flixan to Matlab

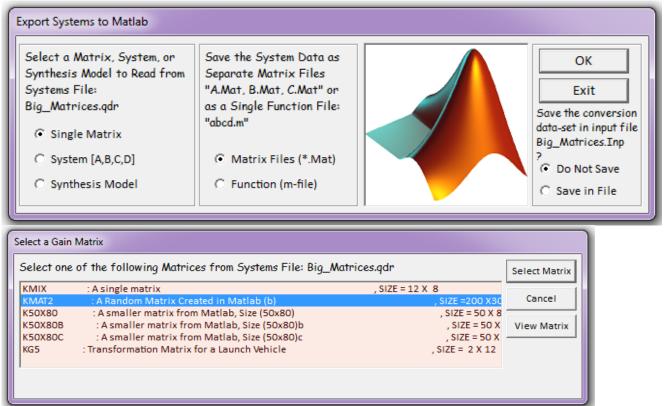
To convert systems or single matrices from Flixan files to Matlab format, go to "*Matlab Conversions*" and select "*Export to Matlab*". This will open a systems filename (.Qdr) selection menu where the user selects a systems file. This file contains the data to be exported to Matlab. The program also asks the user to select the Matlab destination directory which may be different from the location of the systems file.



A Matlab exporting dialog comes up from where the user has a choice to select between three different types of data to be transferred from the systems file to Matlab format: (a) a single gain matrix (other than A, B, C, D), (b) a state-space system [A, B, C, D], and (c) a synthesis model for H-infinity control design [A, B1, B2, C1, C2, D11, D12, D21, D22]. The user can also select the Matlab output format: either as "ascii" matrix files (.mat), or as function that includes several matrices in a single function m-file (.m). There is a third choice where the user may wish to save the "To Matlab" instructions data-set in the input file. This data-set can be used for reprocessing the input file in batch mode.

Exporting a Matrix

If the input data is a single matrix it will be converted into a Matlab (.mat) ascii file. The filename is the same as the matrix name in the (.Qdr) file. For example, if the matrix name was "Kmix2" in the systems file it will be saved as "Kmix2.mat" in the Matlab folder. The matrix to be transferred is selected from a menu that includes all the individual matrices, other than (A, B, C, D), which are saved in the selected systems file. The matrix name, a short description, and its size appear in the menu.



Exporting a System

From the Matlab exporting dialog we have the choice to save the four state-space matrices either as individual matrices (A.mat, B.mat, C.mat, D.mat) or as a system function (m-file). In this example we select to save them as a function m-file, and click on "OK".

Select a Matrix, System, or Synthesis Model to Read from Systems File: Big_Matrices.qdr © Single Matrix © System [A,B,C,D]	Save the System Data as Separate Matrix Files "A.Mat, B.Mat, C.Mat" or as a Single Function File: "abcd.m"	OK Exit Save the conversion data-set in input file Big_Matrices.Inp ? (* Do Not Save
O Synthesis Model	Function (m-file)	C Save in File

The following systems menu comes up showing the systems already saved in the selected file. From this menu we must select one of the systems to be converted. The utility reads the four system matrices and the system title from the (.Qdr) file. The exported data will be saved as an m-file in this case. We must also enter a name for the function m-file that will receive the system data, for example, "Control_System" or "Flight_Vehicle". The extension ".m" is added at the of the name, for example, "Control_System.m". The m-file will be saved in the selected Matlab directory. In case of a control synthesis model the process is similar to the quadruple state-space model except that there are nine matrices being defined there instead of four. The m-file function in this case contains all nine matrices.

Select a State-Space System from Quad File
Select a State-Space Model for Matlab Conversion, From Systems File: Big_Matrices.qdr
Actuator Rocket Plane at Mach=0.85, Q=150, T=1778.0 sec, Pitch Axis (14-Modes) ROCKET PLANE AT MACH=0.85, Q=150, T=1778.0 sec (Lateral RB) Aileron and Rudder Actuators Lateral Axes Rigid Body Model with Controller Open-Loop Lateral Forward Loop (Actuator, Flex Vehicle, Sensors, Controller) Pitch Controller (q and Nz f/b with Notch) A System Transfer from Matlab (a) A System Transfer from Matlab (b) User Typed-in System number 2 User Created System
Choose a System Title and then click "Select" Cancel View System Select
Enter a file name (ex. Vehicle) to save the [A,B,C,D] matrices as a Matlab m-file OK function (ex. Vehicle.m) Rocket_Pitch
Matrices Saved
Matrices will be Saved in Matlab Directory: C:\Users\Eric\Desktop\Flixan Utilities

4.2 Loading the Flixan Data in Matlab Workspace

The next step is to load the matrix or system to Matlab workspace. Start Matlab, change directory and go to the folder that contains the Matlab matrices or m-files. To load a ascii matrix file, for example "Kc2.mat", from the Matlab command prompt you must type the following command

>> load Kc2.mat -ascii

and the matrix Kc2 will be added in the Matlab workspace. If the data is a state-space system described by four separate ascii matrix files [A.mat, B.mat, etc], you may load each matrix separately, as follows:

>>load A.mat -ascii % will become matrix A in Matlab workspace >>load B.mat -ascii % will become matrix B in Matlab workspace >>load C.mat -ascii % will become matrix C in Matlab workspace >>load D.mat -ascii % will become matrix D in Matlab workspace

If the system or synthesis model were saved as function m-files all matrices are in the same file. The m-file has a name (for example: pitch.m, as shown below). The same name appears inside the file and defines the Matlab function. The definitions of the state-variables, inputs, and outputs are also included in the Matlab function file. Also the system title and its comments are transferred to the function file.

```
function [Api, Bpi, Cpi, Dpi]= pitch
% X-45 Descent, Pitch Axis at Qbar=250, Mach=0.4
% The Pitch axis System is extracted from the coupled system by selecting a smaller number of
% input, state, and output variables
Api= [
  0.00000000E+00 0.1000000E+01 0.0000000E+00
0.00000000E+00 0.0000000E+00 0.17443050E+01
  0.0000000E+00 0.1000000E+01 -0.81841860E+00];
Bpi= [
  0.0000000E+00 0.0000000E+00 0.000000E+00
  -0.18048657E+02 -0.18430048E+01 0.24435920E-02
 -0.14332058E+00 -0.12162023E+00 -0.11790709E-02];
Cpi= [
  0.1000000E+01 0.0000000E+00 0.000000E+00
  0.00000000E+00 0.1000000E+01 0.0000000E+00
0.0000000E+00 0.0000000E+00 0.10000000E+01
  0.0000000E+00 0.0000000E+00 -0.44052295E+03];
Dpi= [
   0.0000000E+00 0.0000000E+00 0.000000E+00
   0.0000000E+00 0.0000000E+00 0.000000E+00
 0.00000000E+00 0.0000000E+00 0.13047952E-02
-0.72512183E+02 -0.62899919E+02 -0.60757972E+00];
% Definition of State-Space System Variables
°
   Inputs = 3
   1 Elevon Deflection (radians)
°
     2
        Flaps Deflection (radians)
°
°
    3
         Gust, Azim Elevat Angles:(45,45 deg)
°
  States =
              3
   1 Pitch Attitude (theta-rigid) (radians)
%
     2
       Pitch Rate ( q -rigid) (rad/sec)
Angle of attack (alfa-rigid) (radians)
%
    3
%
% Outputs =
              4
°
   1 Pitch Attitude (theta-Stabil) (radians)
                           (q-Stabil) (rad/sec)
        Pitch Rate
°
    2
  3 Angle of attack (alfa-rigid) (radians)
°
         CG Acceleration along Z axis, (ft/sec<sup>2</sup>)
%
    4
```

To load the state-space or synthesis model matrices the user must execute the function, as follows:

>> [Ap, Bp, Cp, Dp]= Pitch % for a state-space system >> [A, B1, B2, C1, C2, D11,D12,D21,D22]= Synthesis_Model % for a SM

4.3 Saving Matlab data to Matrix Files to be Uploaded to Flixan

The systems or individual matrices created in Matlab can be uploaded and saved in Flixan. They must first be saved in Matlab as ascii (.mat) files. Then they can be converted and included in Flixan system files using the "From Matlab" utility. To save, for example, a single matrix Kmix from Matlab, as an ascii file, the user must type

save Kmix.mat Kmix -ascii % Save it as a single file

In case of a system the four matrices can be saved from the Matlab workspace as separate matrix files (for example, A1.mat, B1.mat, etc)

```
save A1.mat a -ascii
% Save system in 4 separate [A,B,C,D] files
save B1.mat b -ascii
save C1.mat c -ascii
```

To make things more compact a system of four matrices can be exported from Matlab as a single file containing the four matrices with an additional line on the top. The first line is a single row vector with four elements containing the system dimensions. The number of inputs, states, and outputs, and also the sampling frequency if the system is discrete (zero for a continuous system). For example, the following Matlab script file generates a random system and saves it in a single file "system.mat"

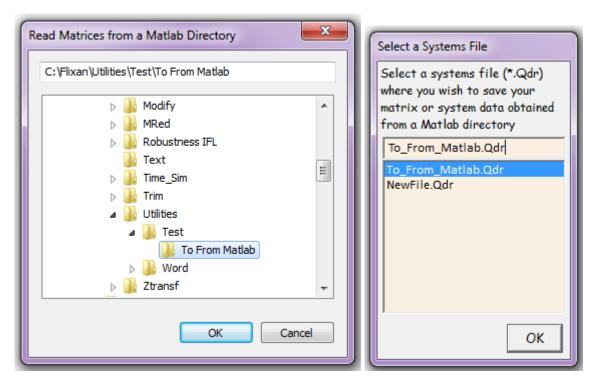
```
% Program to create a random system and save it in an ascii Matlab file
Nu=8;
                                 % Inputs
Nx=56;
                                 % States
No=11;
                                 % Outputs
dT=0.02;
                                 % System Sampling Period
e=[Nu, Nx, No, dT];
                                 % Row vector with system dimension
a=rand(Nx,Nx)-0.6;
                                 % A matrix
b=rand(Nx,Nu)-0.5;
                                 % B matrix
c=rand(No,Nx)-0.4;
                                 % C matrix
d=zeros(No,Nu);
                                 % D matrix = 0
save System.mat e a b c d -ascii % Save it as a single ascii file
```

The "From Matlab" utility is also capable to read control synthesis models in this format. Synthesis models consist of 9 matrices.

4.4 Transferring Matlab Generated Data to Flixan System Files

The process of reading Matlab data into Flixan system files (.Qdr) is similar. First, select the directory where the Flixan files are located and from Flixan main menu select "*Utilities*", "*Matlab Conversions*", and "*Read from Matlab*". You must also select the Matlab directory that contains the Matlab generated matrix files to be transferred. In this case shown both directories are the same. From the system filename selection menu select a systems file to save the imported matrices or systems.

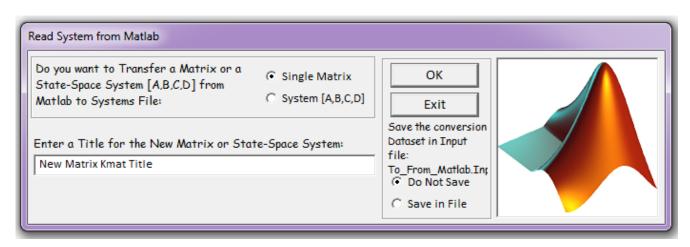
Select a Project	t Directory	×
C: \Flixan \Ut	ilities\Test\To From Matlab	
	 Text Time_Sim Trim Utilities Test To From Matlab Word Ztransf Installation for Flixan Intel PerfLogs 	
	light Vehicle Modeling & Con	
	ile Management Program F	unctions View Quad Help
	a Project Directory	
	: Project Files e a New Matrix	
	e a New System .AB Conversions	Export to MATLAB
	raphics Format	Read from MATLAB
Exit Fl	ixan Program	
Introduction		
Cancel	Imports Systems or Ma	trices from Matlab
matrices fro matrix, for and D.Mat) user selects extension *, name of the	example (Kc.Mat), or the System should be generated from Matle the matrices from a pop-up mer Mat) in the Matlab project dire	e or a quadruple set of system systems file (*.Qdr). The single a of matrices (A.Mat, B.Mat, C.Mat, ab and saved in "Ascii" format. The nu that displays all matrices (having ctory. The user must also provide the that will be placed over the system



The following dialog is used to select if you want to read an individual matrix (other than A,B,C,D) or a state-space system. You must also enter a title for this system or matrix different from other elements in the systems file, and click OK. The user may also save the "From Matlab" instructions data-set in the input file. This data-set can be used for reprocessing the input file in batch mode at a later time.

Reading a Matrix from Matlab

When the input is a matrix the user clicks on "*Single Matrix*", enters its new title, and clicks on "OK". The Matlab generated matrix is expected to be a (.Mat) file in ascii format. The following menu shows all (.Mat) files located the selected Matlab folder. The user selects one of the files "Kmat.mat" in this case, which is a single matrix, and clicks on "Select File". The other two (.Mat) files are systems containing quadruple matrices. The matrix will then be saved in the selected systems file as "Matrix Kmat", under the title entered: "New Matrix Kmat Title".



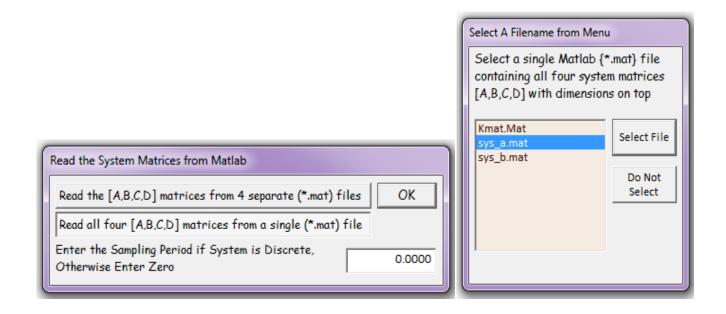
Select A Filename from Menu	
Select one of the following matrices (*.Mat) from the Matlab project directory Kmat.Mat sys_a.mat sys_b.mat Do Not Select	Matrices Saved
	ОК

Reading a System from Matlab

When the input from Matlab is a system, the user selects "*System* [A,B,C,D]" in the read from Matlab dialog, enters its new title, and clicks on "OK". The Matlab generated system is expected to be in (.Mat) ascii format, either as four separate (.Mat) files, or as a single (.Mat) file containing all four matrices, the system inputs, states, and output dimensions, and the sampling period. The single file formatting of the four matrices was described in section 4.3. The selection between the two options is defined in the next dialog where the system's sampling period is also entered in seconds (zero for a continuous system), click OK.

From the following filename selection menu the user must select the proper Matlab generated matrix filenames (.Mat) from the Matlab folder. If the system is defined in a single file only one filename (containing all four matrices) will be selected. If the system is defined in separate matrices then four matrix filenames must be selected. In this example we have selected a single file "sys_a.mat". If the matrix dimensions are defined correctly a new system will be created in the (.Qdr) file. Otherwise, an error will occur "Matrix dimensions do not match for a system" and the program returns to the main menu. The title and the system dimensions are also included in the system data.

Do you want to Transfer a Matrix or a State-Space System [A,B,C,D] from Matlab to Systems File: Single Matrix Enter a Title for the New Matrix or State-Space System: New System (A) Title OK Image: System (A) Title Save the conversion Dataset in Input file: To_From_Matlab.Inp ? (C) Do Not Save	Read System from Matlab			
C Save in File	State-Space System [A,B,C,D] from Matlab to Systems File: Enter a Title for the New Matrix or Sta	System [A,B,C,D]	Exit Save the conversion Dataset in Input file: To_From_Matlab.Inp ?	



Transferring Data in Batch Mode

It is a lot easier, however, to transfer data between Flixan and Matlab programs in batch mode. In this case the transfer information is defined in an input file (.Inp) and a batch set processes the input file, as shown in the example below which is located in " $C:\Flixan Utilities Test To From Matlab$ ". In this example we will transfer two systems and a matrix from a systems file " $To_From_Matlab.Qdr$ " and load them into Matlab. Then from Matlab we will transfer them back to Flixan and save them in the same systems file under different titles. The input file " $To_From_Matlab.Inp$ ", is shown below. It contains data conversion sets and a batch set that processes them. The first two sets below the batch convert the two systems "*System* (*A*)" and "*System* (*B*)" from the systems file to two function m-files "sys_a.m" and "sys_b.m" that canbe loaded into Matlab. The third set converts the matrix Kmat, title: "*Matrix Kmat Title*" from the systems file to matrix "Kmat.mat" that can also be loaded to Matlab. When in Matlab the system quadruple matrices are compacted into single ascii matrices (.mat), and saved as following:

```
% Load the two systems and convert them to single matrices
[a1,b1,c1,d1]= sys_a; % load system (a)
[nx,nx]= size(a1);
[nr,nu]= size(d1);
el=[nu, nx, nr, 0.0]; % Row vector with system dimension
save sys_a.mat el al bl cl dl -ascii % Save it as a single ascii file
[a2,b2,c2,d2]= sys_b;
[nx,nx]= size(a2);
[nr,nu]= size(d2);
e2=[nu, nx, nr, 0.0]; % Row vector with system dimension
save sys_b.mat e2 a2 b2 c2 d2 -ascii % Save it as a single ascii file
```

The last three data conversion sets in the input file read the two systems and matrix from files "sys_a.mat", "sys_b.mat", and "Kmat.mat" and transfer them back in the systems file "*To_From-Matlab.Qdr*" using different titles.

```
BATCH MODE INSTRUCTIONS .....
Batch for Converting Systems To and From Matlab
! Convert systems (A) and (B) to Matlab System Functions: sys_a.m, sys_b.m
! Convert Matrix Kmat from Systems file to Kmat.Mat
! Convert Matlab system of matrices sys_a.mat to a new system "New System (A)" in Flixan .Qdr file
! Convert Matlab system of matrices sys_b.mat to a new system "New System (B)" in Flixan .Qdr file
! Convert Matlab matrix Kmat.mat to a matrix title: "New Matrix Kmat", name Kmat in Flixan Qdr file
           : System (A)
Retain System
             : System (B)
Retain System
             : Matrix Kmat Title
Retain Matrix
To Matlab Format : System (A)
To Matlab Format : System (B)
To Matlab Format : Matrix Kmat Title
From Matlab Form : New System (A)
From Matlab Form : New System (B)
From Matlab Form : New Matrix Kmat
_____
CONVERT TO MATLAB FORMAT ...... (Title, System/Matrix, m-filename)
System (A)
! Convert the system "System (A)" from .Qdr file ...
! to a Matlab system function "sys_a.m"
System
Sys_A.m
_____
CONVERT TO MATLAB FORMAT .....
                              (Title, System/Matrix, m-filename)
System (B)
! Convert the system "System (B)" from .Qdr file ...
! to a Matlab system function "sys_b.m"
System
Sys_B.m
_____
CONVERT TO MATLAB FORMAT ..... (Title, System/Matrix, m-filename)
Matrix Kmat Title
! Convert the Matrix "Matrix Kmat Title from .Qdr file ...
! to a Matlab ascii matrix "Kmat.mat"
Matrix Kmat.mat
             _____
CONVERT FROM MATLAB FORMAT ..... (Title, System/Matrix, Mat filename)
New System (A)
! Converts System "sys_a.mat" from Matlab matrix file ...
! to a Flixan System "New System (A)" in .qdr file
System sys_a.mat
_____
CONVERT FROM MATLAB FORMAT ..... (Title, System/Matrix, Mat filename)
New System (B)
! Converts System "sys_b.mat" from Matlab matrix file ...
! to a Flixan System "New System (B)" in .qdr file
System sys_b.mat
_____
CONVERT FROM MATLAB FORMAT ..... (Title, System/Matrix, Mat filename)
New Matrix Kmat
! Converts the Matrix from Matlab file "Kmat.mat" ...
! to a Flixan Matrix Kmat, titled "New Matrix Kmat" in (.qdr) file
Matrix Kmat.mat
     _____
```

This input file can now processed in batch mode by running the batch set located on the top of the file. From the Flixan main menu select "*Edit*", then "*Manage Input Files*" and then "*Process/ Edit Input Data*". From the next dialog use the left menu to select the input file "*To_From_Matlab.Inp*" and click on "*Select Input File*". The menu on the right shows the titles of the data-sets located in this file, also the program that will process each set. Select the first title which is the batch set and click on "*Process or View Input Data*", and the batch set will process the data. The Matlab generated systems and matrix are saved in file *To_From_Matlab.Qdr*". Notice that the original systems and matrix are retained in the systems file after reprocessing. A display pos-up highlighting the batch statements as they are executing.

File Edit Analysis Tools View Quad Help	
Manage Input Files (*.Inp)	Create or Edit Batch Data
Manage System Files (*.Qdr)	Process / Edit Input Data
Process Input Data Files	
Point to an Input Data Filename and Click on "Select Input File" The following sets of input data are in fi	le: To_From_Matlab.Inp
To_From_Matlab.Inp Run Batch Mode : Batch for Conv To Matlab Format : System (A)	verting Systems To and From Matlab
To_From_Matlab.inp To Matlab Format : System (B) To Matlab Format : Matrix Kmat Ti From Matlab Form : New System (A) From Matlab Form : New System (B) From Matlab Form : New Matrix Kmatrix Kmat	
	Batch Mode Execution
Select Input File Edit File	Retain System : System (A)
Process or View Input	Retain System : System (B) Retain Matrix : Matrix Kmat Title
Data	To Matlab Format : System (A)
Delete Data Set in File	To Matlab Format : System (B)
	To Matlab Format : Matrix Kmat Title
Relocate Data Set in File	From Matlab Form : New System (A)
Copy to Another File	From Matlab Form : New System (B) From Matlab Form : New Matrix Kmat
View Data-Set Comments	401 1
	ys_b.m Convert Matrix Kmat from Systems file to Kmat.Mat Convert Matlab system of r file Convert Matlab system of matrices sys_b.mat to a new system "New System (B)" in "New Matrix Kmat", name: Kmat in Flixan .Qdr fil

5.0 Continuous to Discrete System Transformations

This program is mainly used for transforming continuous state-space systems to discrete systems described by a set of state difference equations.

x(k+1) = Fx(k) + Gu(k);y(k) = Hx(k) + Eu(k)

It is also used for transforming a discrete system from the z-plane to the w-plane, and from the w-plane back to the z-plane. The program reads the state-space system data of the system to be converted from a systems file ".Qdr", the transformation instructions from an input file ".Inp", and can perform the following transforms:

- Transform a continuous system to a discrete system using the Z-transform.
- Transform a continuous system to a discrete system using the Tustin transform.
- Transform a continuous system with delays at its inputs to a discrete system using the Z-transform. The delays at the system inputs are (from 0 to δT), where δT is the sampling period.
- Transform a discrete system defined in the z-plane to a discrete system in the w-plane, and
- Transform a discrete system in the defined w-plane to a discrete system in the z-plane.

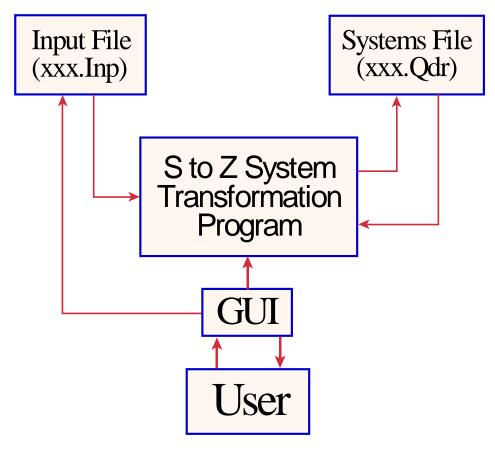


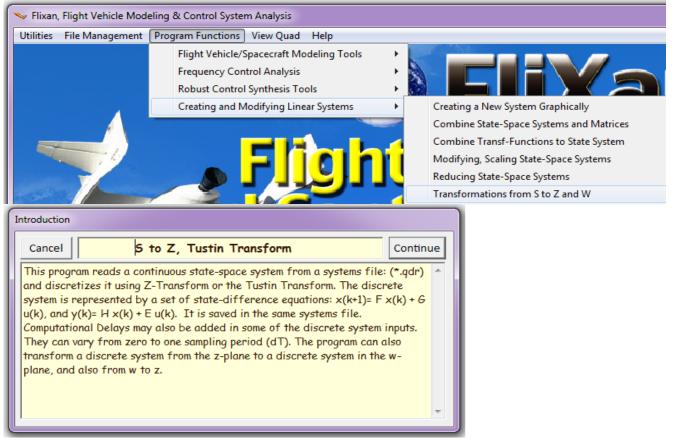
Figure (5.1) Systems S to Z to W Transformation Program

5.1 Running the Z-Transform Program

The Z-Transformation program like most Flixan programs requires two files: an input data file ".Inp" and a systems file ".Qdr". The systems file initially contains the state-space system to be transformed by the program. The transformed system will also be saved in this file by the z-transformation program. The input file contains a set of instructions defining the process, such as the one shown below. The data set first contains a line that identifies the data process: "TRANSFORM A SYSTEM (S-Z-W)". The next line is the title of the transformed new system (blue). Some comment lines (shown in green) may be included below the title. Next line is the title of the original system to be transformed (blue). The last line (black) shows the type of transformation to be performed and the sampling period (\deltaT) of the transformed system, for example:

```
TRANSFORM A SYSTEM (S-Z-W) .... (Titles of the New and Old Systems)
Flexible System (7-Modes) (Z-Transform)
! This data-set discretizes the system "Flexible System (7-Modes)"
! The new discrete system title is "Flexible System (7-Modes) (Z-Transform)"
Flexible System (7-Modes)
From S-plane to Z-plane using the Z-Transform, dT= 0.002
```

To run the z-transform program start from the Flixan main menu, click on "*Program Functions*", select "*Creating and Modifying Linear Systems*", and then click on "*Transformations from S to Z and W*". Then use the following filename selection dialog to select the input data and the systems files from the menus, as shown below, and click on "*Process Files*". The input file contains the system transformation instructions previously created such as the ones above. If not, they must be defined them interactively by clicking on "*Create New Input Set*".



Select Input and System Filenames	
Select a File Name containing the Input Data Set (x.Inp)	Select a File Name containing the State Systems (x.Qdr)
Ztran_Ex2.inp	Ztran_Ex2.Qdr
Ztran_Ex2.inp NewFile.Inp	NewFile.qdr Ztran Ex2 - Copy.qdr
	Ztran_Ex2.Qdr
	NewFile.Qdr
Create New Input Set Exi	t Program Process Files

5.2 Transformation Data-Set is already Saved in the Input File

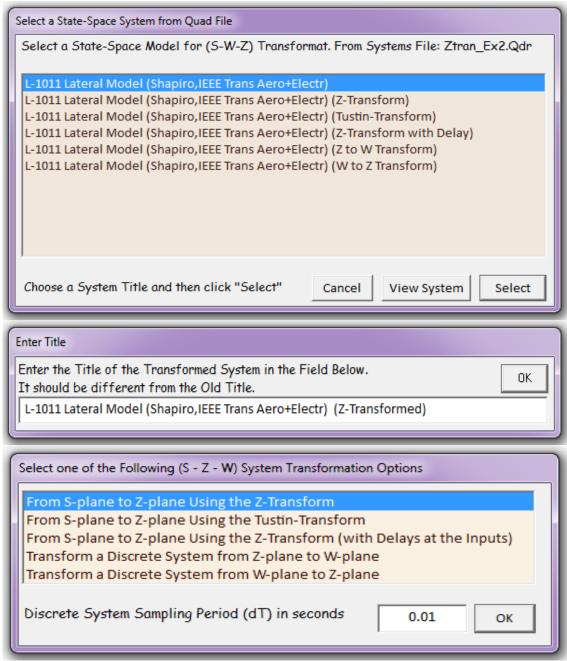
When you click on "*Process Files*" in the above menu, the program searches the input file, "*Ztran-Ex2.Inp*" in this case, and looks for data-sets containing (S-Z-W) transformation instructions, which begin with: "TRANSFORM A SYSTEM (S-Z-W)" in the top line. In this case it finds five transform sets and their titles appear in the menu below, from where the user selects one of the transform titles and clicks on "*Run Input Set*". The program reads the system to be transformed from the systems file "*Ztran-Ex2.*qdr", discretizes it at the sampling rate defined in the input set and saves the z-transformed system in the same systems file under the new title.

	Select a Set of Data from Input File	
	Select a Set of Input Data for "TRANSFORM A SYSTEM" from an Input File: Ztran_Ex2.inp	Run Input Set
	L-1011 Lateral Model (Shapiro,IEEE Trans Aero+Electr) (Z-Transform) L-1011 Lateral Model (Shapiro,IEEE Trans Aero+Electr) (Tustin-Transform) L-1011 Lateral Model (Shapiro,IEEE Trans Aero+Electr) (Z-Transform with Delay) L-1011 Lateral Model (Shapiro,IEEE Trans Aero+Electr) (Z to W Transform) L-1011 Lateral Model (Shapiro,IEEE Trans Aero+Electr) (W to Z Transform)	Exit Program Create New
U		

5.3 Transformation Data-Set Not Included in Input File

If the transformation data-set does not exist in the input file the user must create it interactively by entering the information and then process it. In the filenames selection menu instead of processing the files the user must click on "*Create a New Input Set*" button. At this point the program wants to know the state-space system that must be transformed from s to z. The following menu shows the titles of the systems which are already saved in file "*Ztran_Ex2.Qdr*". Most of them are already discrete, but select the first one which is a continuous s-plane system to discretize. Do not choose a discrete system unless

you want a "z to w" transformation. The program reads the state-space matrices of the selected system and it attempts to create a title for the transformed new system. Its title is similar to the original system title with a short extension at the end describing the type of transformation. The user can modify the new title as desired and click "OK".



Finally, the program wants to know what type of transformation to perform on the selected continuous system. The above menu shows the transform options. Choose the first option which is a "from s to z transformation", enter a 10 msec sampling period (δ T), as shown, and click "OK". The new set is then added to file "Ztran_Ex2.Inp", and the transformed new system is added at the bottom of file "Ztran_Ex2.Qdr" using the new title. The new system's title is the same as the original title with a short extension at the end of the title which identifies the transformation.

5.4 Types of Transformations

The program basically uses two methods to discretize a continuous system. The z-transform and the Tustin transformation methods. A third option that ads delays at the system inputs is also included.

S to Z via the Z-Transform

A continuous state-space system (A, B, C, D) can be transformed to a discrete system described by a set of state difference matrices (F, G, H, E) using the following z-transformation.

$$F = e^{At}$$
; $G = (e^{At} - I)A^{-1}B$; $H = C$; $E = D$

The program uses the following equation to calculate the matrix exponential { e^{AT} }.

$$e^{At} = \left(I + e^{-At}\right)^{-1} \left(I + e^{At}\right)$$
$$e^{At} = \left(I - \frac{AT}{2} + \frac{\left(AT\right)^{2}}{4} - \frac{\left(AT\right)^{3}}{12}\right)^{-1} \left(I + \frac{AT}{2} + \frac{\left(AT\right)^{2}}{4} + \frac{\left(AT\right)^{3}}{12}\right)$$

S to Z via the Tustin-Transform

The second method used for transforming a continuous state-space system (A, B, C, D) to a discrete system described in terms of state difference matrices (F, G, H, E) is the Tustin transformation described by the following equations.

$$F = F_1^{-1}F_2; \qquad G = 2F_1^{-2}\left(\frac{BT}{2}\right)$$
$$H = C; \qquad E = D + CF_1^{-1}\left(\frac{BT}{2}\right) \text{ where}$$
$$F_1 = \left(I - \frac{AT}{2}\right) \qquad F_2 = \left(I + \frac{AT}{2}\right)$$

Z-Transform of a System with an Input Delay

This option is used for including additional delays (δ) sec at the inputs of a system, where the delays are less than one sampling period (δ <T). It requires that the system be z-transformed at two different rates. Figure (5-2) is a timing diagram showing an input/output sequence of a discrete system with a delay (δ). The system's output and state equations are shown below. The state vector propagation is described in two steps:

y(n) =	C x(n)	+Du(n-1)
$x(n+\delta) =$	$\Phi(\delta)x(n)$	$+\Gamma(\delta)u(n-1)$
x(n+1) =	$\Phi(T-\delta)x(n+\delta)$	$+\Gamma(T-\delta)u(n)$

The matrices $\Phi(.)$ and $\Gamma(.)$ are the discrete system's state transition matrix and input matrix. This approach is implemented by z-transforming the continuous system at two different sampling rates: at (δ), and at (T- δ) seconds. By combining the state difference equations and augmenting the state vector, the discrete system with the computational delay can be expressed by the following augmented state-space representation.

$$\begin{bmatrix} x(n+1) \\ u(n) \end{bmatrix} = \begin{bmatrix} \Phi(T) & \Gamma(T) \\ 0 & 0 \end{bmatrix} \begin{bmatrix} x(n) \\ u(n-1) \end{bmatrix} + \begin{bmatrix} \Gamma(T-d) \\ I \end{bmatrix} u(n)$$
$$y(n) = \begin{bmatrix} C & D \end{bmatrix} \begin{bmatrix} x(n) \\ u(n-1) \end{bmatrix} where$$
$$\Phi(T) = \Phi(T-\delta)\Phi(d) \text{ and } \Gamma(T) = \Phi(T-\delta)\Gamma(d)$$

When the z-transform option with delay is selected the program opens the following dialog and asks for the transport delay (δ), in addition to the sampling period (T). The delay (δ) must be less than (T). Note, that for delays which are multiple to one sampling period (nT) they can be implemented using discrete transfer functions { z^{-n} } in series with the z-transformed system, see example 1 below.

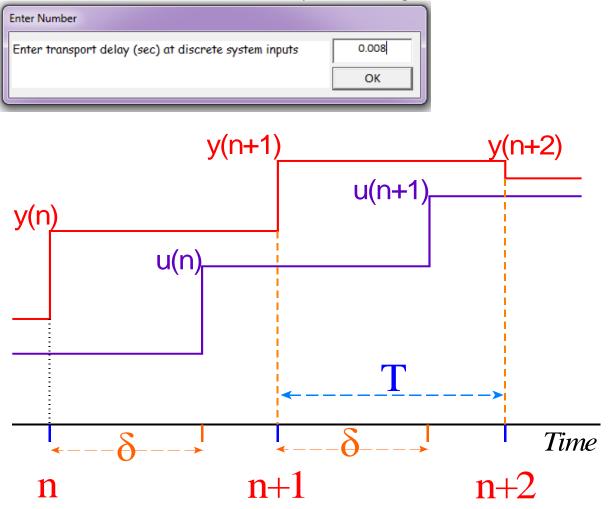


Figure (5.2) Input/ Output Timing Diagram

5.5 More Z-Transform Examples

The following examples demonstrate some more applications of the Z-transform program. The first example uses a model of a lightly damped structure. The second example is a lateral model of a Lockheed 1011 aircraft. The third example is a model of the Shuttle vehicle during ascent which includes structural flexibility and fuel sloshing.

Flexible Plate

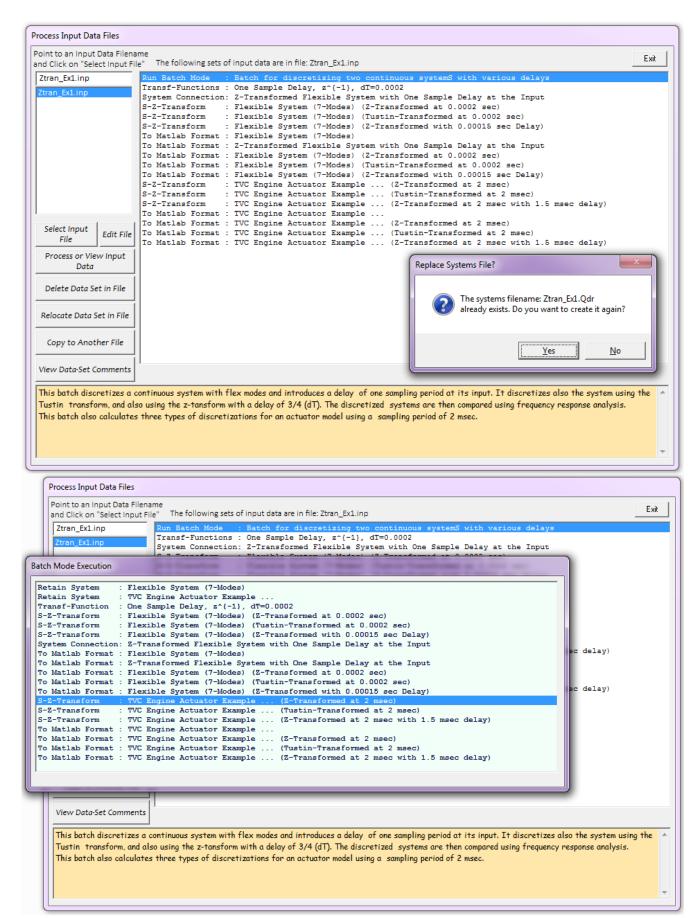
The first example is a SISO model of a flexible plate consisting of seven flex resonances. The input to this model is force at a certain location perpendicular to the surface and the output is acceleration at a different location. This system is in file: "*Ztran_Ex1.Qdr*", located in folder "*C:\Flixan\Ztransf\Examples\Ex-1*", and its title is: "*Flexible System (7-Modes)*". The transformations to be performed are already defined in the input file "*Ztran_Ex1.Inp*", shown below. The z-transform program will be used to discretize this system using the three options: (a) Z-Transform, (b) Tustin Transform, and (c) Z-Transform with delay. An additional system is created by combining the z-transformed system with one sample delay in series. We will then analyze the three discrete systems by comparing their frequency responses against those of the continuous system. Similar transformations are performed for TVC engine actuator model located in the same files. The input file for this example is shown below and it will be processed in batch mode. The transformed new systems are also converted into Matlab format for further analysis.

```
BATCH MODE INSTRUCTIONS
                         . . . . . . . . . . . . . . .
Batch for discretizing two continuous systems with various delays
! This batch discretizes a continuous system with flex modes and introduces a delay
! of one sampling period at its input. It discretizes also the system using the Tustin
! transform, and also using the z-tansform with a delay of 3/4 (dT). The discretized
! systems are then compared using frequency response analysis.
! This batch also calculates three types of discretizations for an actuator model using a
! sampling period of 2 msec.
Retain System
                 : Flexible System (7-Modes)
               : TVC Engine Actuator Example ...
Retain System
1
                   FLEXIBLE PLATE EXAMPLE
Transf-Function : One Sample Delay, z^{-1}, dT=0.0002
S-Z-Transform : Flexible System (7-Modes) (Z-Transformed at 0.0002 sec)
S-Z-Transform : Flexible System (7-Modes) (Tustin-fransformed at 0.00015 sec Delay)
S-Z-Transform : Flexible System (7-Modes) (Z-Transformed with 0.00015 sec Delay)
System Connection: Z-Transformed Flexible System with One Sample Delay at the Input
To Matlab Format : Flexible System (7-Modes)
To Matlab Format : Z-Transformed Flexible System with One Sample Delay at the Input
To Matlab Format : Flexible System (7-Modes) (Z-Transformed at 0.0002 sec)
To Matlab Format : Flexible System (7-Modes) (Tustin-Transformed at 0.0002 sec)
To Matlab Format : Flexible System (7-Modes) (Z-Transformed with 0.00015 sec Delay)
                   ACTUATOR EXAMPLE
S-Z-Transform : TVC Engine Actuator Example ... (Z-Transformed at 2 msec)
S-Z-Transform : TVC Engine Actuator Example ... (Tustin-Transformed at 2 msec)
S-Z-Transform : TVC Engine Actuator Example ... (Z-Transformed at 2 msec with 1.5 msec delay)
To Matlab Format : TVC Engine Actuator Example ...
To Matlab Format : TVC Engine Actuator Example ... (Z-Transformed at 2 msec)
To Matlab Format : TVC Engine Actuator Example ... (Tustin-Transformed at 2 msec)
To Matlab Format : TVC Engine Actuator Example ... (Z-Transformed at 2 msec with 1.5 msec delay)
```

FLEX PLATE EXAMPLE _____ _____ SYSTEM OF TRANSFER FUNCTIONS ... One Sample Delay, z^{-1} , dT=0.0002 ! Delay implemented as discrete transfer function Discrete, dt= 0.20000E-03 TF. Block # 1 0.0002 sec Delay Order of Numer, Denom= 1 1 Numer 0.00000 1.00000 Denom 1.00000 0.00000 _____ Block #, from Input #, Gain: 1 1 1.00000 Outpt #, from Block #, Gain: 1 1 1.00000 _____ _____ INTERCONNECTION OF SYSTEMS Z-Transformed Flexible System with One Sample Delay at the Input ! This system is obtained by combining the "(Z-Transform)" system in ! series with the "One Sample Delay {z^-1}" system. Titles of the Systems to be Connected .. Title 1 One Sample Delay, z^{-1} , dT=0.0002 Title 2 Flexible System (7-Modes) (Z-Transformed at 0.0002 sec) SYSTEM INPUTS TO SUBSYSTEM 1 System Input 1 to Subsystem 1, Input 1, Gain= 1.00000 SYSTEM OUTPUTS FROM SUBSYSTEM 2 System Output 1 from Subsystem 2, Output 1, Gain= 1.00000 SUBSYSTEM NO 1 GOES TO SUBSYSTEM NO 2 Subsystem 1, Output 1 to Subsystem 2, Input 1, Gain= 1.00000 Definitions of Inputs = 1 One Sample Delay Definitions of Outputs = 1 Flexible System (7-Modes) _____ TRANSFORM A SYSTEM (S-Z-W) (New system title, Comments, Old System title, Transform) Flexible System (7-Modes) (Z-Transformed at 0.0002 sec) ! Continuous System Model: Acceleration of a Flexible Plate at a point in response to a Force ! Input which is applied at a different point. Z-Transformed at 0.0002 sec Flexible System (7-Modes) From S-plane to Z-plane using the Z-Transform, dT= 0.20000E-03 TRANSFORM A SYSTEM (S-Z-W) (New system title, Comments, Old System title, Transform) Flexible System (7-Modes) (Tustin-Transformed at 0.0002 sec) ! Continuous System Model: Acceleration of a Flexible Plate at a point in response to a Force ! Input which is applied at a different point. Discretized using Tustin Transform, dT=0.0002 sec Flexible System (7-Modes) From S-plane to Z-plane using the Tustin-Transform, dT= 0.20000E-03 _____ TRANSFORM A SYSTEM (S-Z-W) (New system title, Comments, Old System title, Transform) Flexible System (7-Modes) (Z-Transformed with 0.00015 sec Delay) ! Continuous System Model: Acceleration of a Flexible Plate at a point in response to a Force ! input which is applied at a different point. Z-Transformed at 0.0002 sec with 0.00015 sec Delay Flexible System (7-Modes) From S-plane to Z-plane using the Z-Transform with Delay, dT, Delay= 0.20000E-03 0.15000E-03 CONVERT TO MATLAB FORMAT (Title, System/Matrix, m-filename) Flexible System (7-Modes) System Flex7 s.m _____ CONVERT TO MATLAB FORMAT (Title, System/Matrix, m-filename) Z-Transformed Flexible System with One Sample Delay at the Input System Flex7_z1.m _____ ------

```
CONVERT TO MATLAB FORMAT .....
                                (Title, System/Matrix, m-filename)
Flexible System (7-Modes) (Z-Transformed at 0.0002 sec)
System
Flex7_z.m
                                                        _____
CONVERT TO MATLAB FORMAT ..... (Title, System/Matrix, m-filename)
Flexible System (7-Modes) (Tustin-Transformed at 0.0002 sec)
System
Flex7_zt.m
CONVERT TO MATLAB FORMAT ..... (Title, System/Matrix, m-filename)
Flexible System (7-Modes) (Z-Transformed with 0.00015 sec Delay)
System
Flex7_zd.m
_____
                                        _____
                          ACTUATOR EXAMPLE
TRANSFORM A SYSTEM (S-Z-W) ..... (New system title, Comments, Old System title, Transform)
TVC Engine Actuator Example ... (Z-Transformed at 2 msec)
! The following system is an actuator model for the Space Shuttle main engine operating during
! nominal conditions. It must be discretized with a sample period of 0.002 seconds
TVC Engine Actuator Example ...
From S-plane to Z-plane using the Z-Transform, dT= 0.002
                                     _____
      TRANSFORM A SYSTEM (S-Z-W) ..... (New system title, Comments, Old System title, Transform)
TVC Engine Actuator Example ... (Tustin-Transformed at 2 msec)
! The following system is an actuator model for the Space Shuttle main engine operating during
! nominal conditions. It must be discretized with a sample period of 0.002 seconds
TVC Engine Actuator Example ...
From S-plane to Z-plane using the Tustin-Transform, dT= 0.002
TRANSFORM A SYSTEM (S-Z-W) ..... (New system title, Comments, Old System title, Transform)
TVC Engine Actuator Example ... (Z-Transformed at 2 msec with 1.5 msec delay)
! The following system is an actuator model for the Space Shuttle main engine operating during
! nominal conditions. It must be discretized with a sample period of 0.002 seconds
TVC Engine Actuator Example ...
From S-plane to Z-plane using the Z-Transform with Delay, dT, Delay= 0.20000E-02 0.15000E-02
     _____
CONVERT TO MATLAB FORMAT ..... (Title, System/Matrix, m-filename)
TVC Engine Actuator Example ...
System
Actuat s.m
_____
CONVERT TO MATLAB FORMAT .....
                             (Title, System/Matrix, m-filename)
TVC Engine Actuator Example ... (Z-Transformed at 2 msec)
System
Actuat z.m
_____
CONVERT TO MATLAB FORMAT .....
                             (Title, System/Matrix, m-filename)
TVC Engine Actuator Example ... (Tustin-Transformed at 2 msec)
System
Actuat zt.m
                                                            _____
CONVERT TO MATLAB FORMAT .....
                             (Title, System/Matrix, m-filename)
TVC Engine Actuator Example ... (Z-Transformed at 2 msec with 1.5 msec delay)
System
Actuat_zd.m
_____
```

The above input file is now processed in batch mode by running the batch set located on the top of the file. From the Flixan main menu select "*Edit*", then "*Manage Input Files*" and then "*Process/ Edit Input Data*". From the following dialog use the left menu to select the input file "*Ztran_Ex1.Inp*" and click on "*Select Input File*". The menu on the right shows the titles of the data-sets located in this file, also the program that will process each set. Select the first title which is the batch set, click on "*Process or View Input Data*", and the batch set will process the data, and save the transformed systems in file "*Ztran_Ex1.Qdr*". Notice that the two original continuous systems are retained in the systems file after reprocessing. A display shows the batch statements as they are executing. A Matlab script "run_flx.m", located in the same folder, loads the systems and calculates their frequency responses, as shown below.



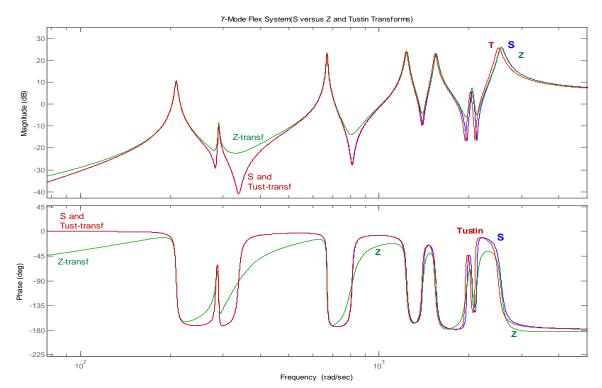


Figure (5.3) Frequency Response comparison between the continuous, the z-transformed, and the Tustin-transformed systems. The Tustin transform is a closer match to the continuous system. It causes less phase lag but it creates a slight shift at the high frequency resonance.

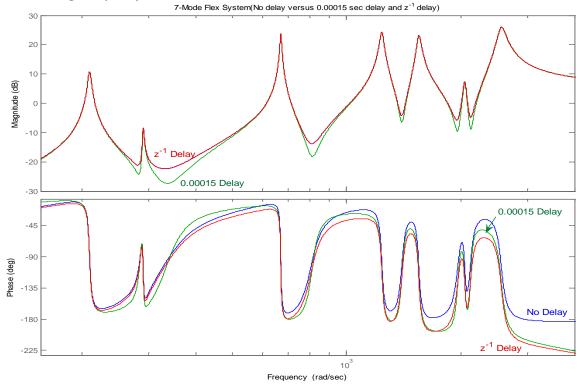


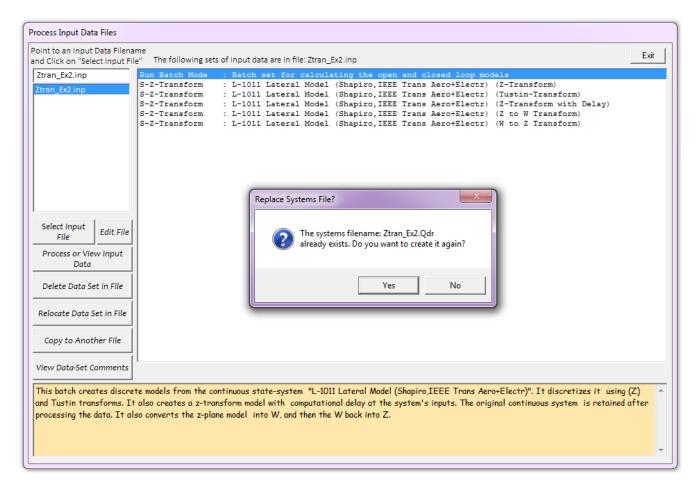
Figure (5.4) Frequency Response comparison between three z-transformed systems, (a) the z-transformed system without delays, (b) the system with the 0.00015 sec input delay, and (c) the system with the (z^{-1}) delay at its input. Notice that the z-transformed systems with the delays have significantly more phase lag at high frequencies than the z-transformed system without delay, and the system with the one sampling period (T) delay has more phase lag than the system with (0.75T) delay, as expected.

Lockheed-1011 Aircraft Lateral Model

In this example we have a lateral model of a Lockheed-1011 aircraft. Its title is "L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr)". It is located in systems file "Ztran-Ex2.Qdr", in directory "FlixanZtransf ExamplesEx-2". We will discretize this system using (a) the z-transform, (b) the Tustin transform, and (c) the z-transform with delay. The transformation instructions are in input file "Ztran_Ex2.Inp", below. We will calculate and compare the frequency responses of the continuous and discrete-time systems. We will also demonstrate the z to w domain transformation capability by transforming a discrete system from the z-plane to the w-plane using the (z to w) transformation option in the program. We will also use the w-plane to z-plane transformation option to change it back from the w-plane to the z-plane.

```
BATCH MODE INSTRUCTIONS .....
Batch set for calculating the open and closed loop models
! This batch creates discrete models from the continuous state-system
! "L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr)". It discretizes it
! using (Z) and Tustin transforms. It also creates a z-transform model with
! computational delay at the system's inputs. The original continuous system
! is retained after processing the data. It also converts the z-plane model
! into W, and then the W back into Z.
Retain System
               : L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr)
S-Z-Transform : L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr) (Z-Transform)
S-Z-Transform : L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr) (Tustin-Transform)
S-Z-Transform
               : L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr) (Z-Transform with Delay)
S-Z-Transform : L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr) (Z to W Transform)
S-Z-Transform : L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr) (W to Z Transform)
_____
TRANSFORM A SYSTEM (S-Z-W) ..... (New system title, Old System title, Transform)
L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr) (Z-Transform)
! This data-set discretizes the following s-plane system from s to z using
! the Z-transformation. The sample time is 0.01 sec. The new system title is
! L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr) (Z-Transform)
L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr)
From S-plane to Z-plane using the Z-Transform, dT= 0.01
_____
TRANSFORM A SYSTEM (S-Z-W) ..... (New system title, Old System title, Transform)
L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr) (Tustin-Transform)
! This data-set discretizes the following s-plane system from s to z using
! the Tustin-transformation. The sample time is 0.01 sec. The new system title is
! L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr) (Tustin-Transform)
L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr)
From S-plane to Z-plane using the Tustin-Transform, dT= 0.01
TRANSFORM A SYSTEM (S-Z-W) ..... (New system title, Old System title, Transform)
L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr) (Z-Transform with Delay)
! This data-set discretizes the following s-plane system from s to z using
! the Z-transformation. An additional 0.008 sec delay is included at the system input
! The sample time is 0.01 sec. The new system title is
! L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr) (Z-Transform with Delay)
L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr)
From S-plane to Z-plane using the Z-Transform with Delay, dT, Delay= 0.01, 0.008
_____
TRANSFORM A SYSTEM (S-Z-W) ..... (New system title, Old System title, Transform)
L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr) (Z to W Transform)
L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr) (Z-Transform)
From Z-plane to W-plane Transform
_____
TRANSFORM A SYSTEM (S-Z-W) ..... (New system title, Old System title, Transform)
L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr) (W to Z Transform)
L-1011 Lateral Model (Shapiro, IEEE Trans Aero+Electr) (Z to W Transform)
From W-plane to Z-plane Transform
                                                  _____
```

This input file can be processed in batch mode by running the batch set located on the top of this file. From the Flixan main menu select "*Edit*", then "*Manage Input Files*" and then "*Process/ Edit Input Data*". From the following dialog use the left menu to select the input file "*Ztran_Ex2.Inp*" and click on "*Select Input File*". The menu on the right shows the titles of the data-sets located in this file, also the program that will process each set. The batch comments are shown at the bottom. Click on "*Process or View Input Data*", and the batch set will process the data and save the transformed systems in file "*Ztran_Ex2.Qdr*". Notice that the original continuous system is retained in the systems file after reprocessing.

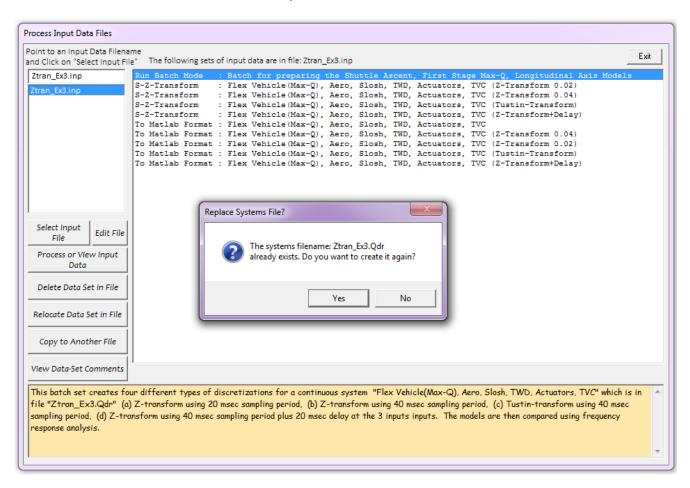


Flexible Launch Vehicle Model

The third example uses a lateral axes model of the Space Shuttle during ascent. The input and system files are "*Ztran_Ex3.Inp*" and "*Ztran_Ex3.Qdr*" located in "*C:\Flixan\Ztransf\EXAMPLES\Ex-3*". The title of the continuous system to be transformed is: "*Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC*". It has 3 inputs and 12 outputs and contains several low damped flexible modes. The first resonance is fuel sloshing in the external tank. We will use the Z-transform program to discretize this system and to create three transformations using: (a) the standard Z-transform, (b) the Tustin Transform, and (c) the Z-transform with a 0.02 seconds delay at the inputs. The sampling period is 0.04 seconds in all three cases. The discrete systems are also saved in systems file "*Ztran_Ex3.Qdr*".

```
BATCH MODE INSTRUCTIONS .....
Batch for preparing the Shuttle Ascent, First Stage Max-Q, Longitudinal Axis Models
! This batch set creates four different types of discretizations for a continuous system
! "Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC" which is in file "Ztran_Ex3.Qdr"
! (a) Z-transform using 20 msec sampling period,
! (b) Z-transform using 40 msec sampling period,
! (c) Tustin-transform using 40 msec sampling period,
! (d) Z-transform using 40 msec sampling period plus 20 msec delay at the 3 inputs inputs.
! The models are then compared using frequency response analysis.
Retain System
              : Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC
S-Z-Transform : Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC (Z-Transform 0.02)
S-Z-Transform : Flex Vehicle (Max-Q), Aero, Slosh, TWD, Actuators, TVC (Z-Transform 0.04)
S-Z-Transform: Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC (Tustin-Transform)S-Z-Transform: Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC (Z-Transform+Delay)
To Matlab Format : Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC
To Matlab Format : Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC (Z-Transform 0.04)
To Matlab Format : Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC (Z-Transform 0.02)
To Matlab Format : Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC (Tustin-Transform)
To Matlab Format : Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC (Z-Transform+Delay)
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                                                                       _____
TRANSFORM A SYSTEM (S-Z-W) ..... (Titles of the New and Old Systems)
Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC (Z-Transform 0.02)
Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC
From S-plane to Z-plane using the Z-Transform, dT= 0.02
      _____
                                                                   _____
TRANSFORM A SYSTEM (S-Z-W) ..... (Titles of the New and Old Systems)
Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC (Z-Transform 0.04)
! Transform the Continuous Vehicle Model to Discrete with a
! Sample Period dT=0.04 seconds Using the Z-Transform
Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC
From S-plane to Z-plane using the Z-Transform, dT= 0.04
_____
TRANSFORM A SYSTEM (S-Z-W) ..... (Titles of the New and Old Systems)
Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC (Tustin-Transform)
! Transform the Continuous Vehicle Model to Discrete with a
! Sample Period dT=0.04 seconds Using the Tustin-Transform
Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC
From S-plane to Z-plane using the Tustin-Transform, dT= 0.04
TRANSFORM A SYSTEM (S-Z-W) ..... (Titles of the New and Old Systems)
Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC (Z-Transform+Delay)
! Transform the Continuous Vehicle Model to Discrete with a
! Sample Period dT=0.04 seconds Using the Z-Transform
! Add a 0.02 seconds Computational Delay at the (3) Plant Inputs
Flex Vehicle(Max-Q), Aero, Slosh, TWD, Actuators, TVC
From S-plane to Z-plane using the Z-Transform with Delay, dT, Delay= 0.04, 0.02
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This input file is processed in batch mode by running the batch set located on the top of the file, as before and shown below. Click on "*Process or View Input Data*", and the batch set will process the data and save the transformed systems in file "*Ztran_Ex3.Qdr*". The original continuous system is retained in the systems file after reprocessing. The continuous and the four discrete systems are also converted to Matlab format for further analysis.



We will now calculate the frequency responses of the four systems and compare them with each other. There is a Matlab script "*run_vehi.m*" included in this folder that loads the four systems and plots their frequency response. In this case between yaw TVC deflection (input 2) to the yaw gyro response (output 7), shown below. The Figure compares: (a) the continuous system response, against (b) the responses of the Z-Transform, (c) the Tustin Transform, and (d) the Z-transform with delay. The results are shown in Figure (5.6). The zero-order-hold is not included. The frequency response obtained from the Tustin transform does not match the resonance amplitudes of the flex mode frequencies as well as the z-transformations match. The magnitudes of the continuous system, the z-transform causes almost the same amount of phase lag at high frequencies as the z-transform. The z-transform with delay (red) has a considerably more phase lag and a little more attenuation near the Nyquist frequency.

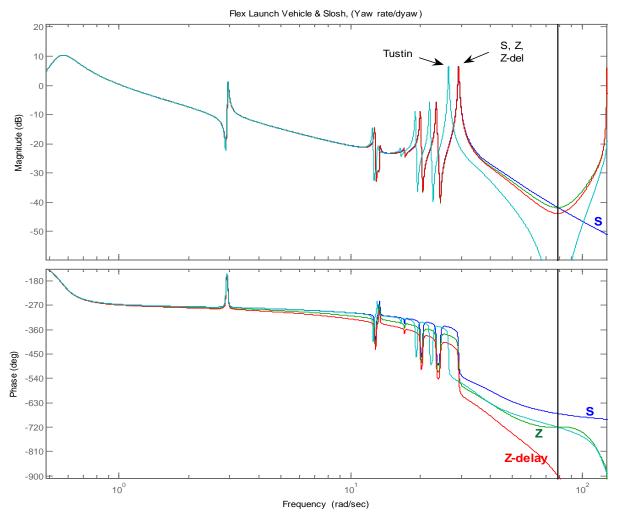


Figure (5.6) Open-Loop Frequency Response between gimbal deflection and yaw rate showing the comparison between four systems: (a) the continuous system (blue), (b) the z-transformed system (green), (c) the Tustin transformed system (cyan), and (d) the z-transformed system with 20 msec delay (red). This system has a lot of flex resonances and the first resonance is fuel sloshing. The discrete systems are sampled at 40 msec. The Tustin transform causes significantly more frequency shift. The magnitudes of the other two systems are very close to the continuous system. The 20 msec input delay, however, causes additional phase lag at high frequencies, as expected.

6.0 Managing Input/Output Files

The Flixan program includes several utility programs for managing the input data and systems files. The input files (.Inp) contain sets of data or instructions which are processed by various Flixan programs generating matrices and state-space systems in (.Qdr) files for system analysis. Input data files typically contain multiple sets of data and system files may also contain several systems and single matrices related to a particular vehicle or project. All files associated with the same project are located in the same directory which is typically named after the vehicle name or flight condition. The purpose of the file management utilities is to organize the files and process the input data. They perform functions, such as: cleaning the files from unused data, viewing and editing batch sets for fast processing. The file management utilities are user friendly and fully interactive by means of window menus and dialogs.

6.1 Input Data files (*.Inp)

The input data files are typically created interactively by the various Flixan utilities and programs. They can also be created by the user, by copying, pasting and modifying previously generated data sets using a text editor. Each input file contains multiple sets of input data that correspond to various Flixan programs, such as: flight vehicle or actuator modeling, system or transfer function interconnections, system discretization or restructuring, effector mixing logic, etc. Each program processes its corresponding data and creates a system or a matrix. The data sets in an input file can either be processed interactively by selecting the corresponding utility through the Flixan menus or they can be processed through the file manager utility. They can also be processed much faster by running a batch data-set, again through the file manager utility. The first line of a data-set (red) identifies the type of data and the utility that will process it. For example, FLIGHT VEHICLE INPUT DATA, INTERCONNECTION OF SYSTEMS, ACTUATOR INPUT DATA, MIXING LOGIC, BATCH MODE INSTRUCTIONS, etc. The second line is a unique title for the data-set (blue) and it should be less than 100 characters long. The same title is also used to identify the system or the matrix that will be created by the program or utility and it is saved in a systems file. The lines below the title, starting with an exclamation mark (!) are user comments (green) which are inserted there, either directly by editing the input data file, or transferred there by another utility. Each comment line should be less than 100 characters long and they should be limited to 10 lines. A sample input data file is shown below.

BATCH MODE INSTRUCTIONS Batch for calculating the Closed-Loop model for a Zulu Rocket ! This batch set creates a state-space model for a rigid Zulu rocket during first stage ! at Max-Q and then extracts the longitudinal subsystem. It creates also a flex vehicle ! model with fuel sloshing and extracts also the longitudinal flex subsystem. ! It creates also state-space systems for the angle of attack estimator, the flight ! control system, and the closed-loop system. The state-space systems are converted to ! Matlab format. Flight Vehicle : Zulu, Stage-1, Max-Q, Rigid Body System Modificat : Zulu, Stage-1, Max-Q, Rigid Body, Pitch Axis Flight Vehicle : Zulu, Stage-1, Max-Q, 8 Flex Modes with Slosh System Modificat : Zulu, Stage-1, Max-Q, 8 Flex Modes with Slosh, Pitch Axis Transf-Function : Alpha Estimator Transf-Function : Pitch Flight Control System System Connection: Pitch Closed-Loop System To Matlab Format : Zulu, Stage-1, Max-Q, Rigid Body, Pitch Axis _____ _____

FLIGHT VEHICLE INPUT DATA Zulu, Stage-1, Max-Q, Rigid Body ! This is a Launch Vehicle during First Stage at Maximum Dynamic Pressure. It is launched from ! a high altitude to maximize orbit performance. At Max-Q and while flying at 2.5 Mach it ! experiences a strong wind shear that causes 4 deg of angle of attack. The vehicle has two side ! liquid oxygen rockets that can provide 320,000 (lb) of thrust each. The two fuel tanks, one ! on each side cause a significant amount of slosh disturbance.

Body Axes Output, Attitude=Euler Angles, Without GAFD, No Turn Coordination

Instrial Acceleration Vo.dor, Semeed Body Xxes Accelerations Xx, Yx, Xz (fr/eec ⁻¹) : 6.000 0.0000		ody Axes Output,Attitude=Euler Angles,Without GAFD, No Turn Coordination				
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<pre>! a high altitude to maximize orbit performance. At Max-Q and while flying at 2.5 Mach it ! experiences a strong wind shear that causes 4 deg of angle of attack. The vehicle has two side ! liquid oxygen rockets that can provide 320,000 (lb) of thrust each. The two fuel tanks, one ! on each side cause a significant amount of slosh disturbance. Body Axes Output,Attitude=Euler Angles,Without GAFD, No Turn Coordination Vehicle Mass (lb-sec^2/ft), Gravity Accelerat. (g) (ft/sec^2), Earth Radius (Re) (ft) : 8878.0 32.174 0.20896E+08 Moments and products of Inertias Ixx, Iyy, Izz, Ixy, Ixz, Iyz, in (lb-sec^2-ft) : 519500.0 1671000.0 2110000.0 0.000 CG location with respect to the Vehicle Reference Point, Xgg, Ygg, Zgg, in (feet) : -126.05 0.0000 0.007 Vehicle Mach Number, Velocity Vo (ft/sec), Dynamic Pressure (psf), Altitude (feet) : 2.5 2000.0 220.00 83000 Inertial Acceleration Vo_dot, Sensed Body Axes Accelerations Ax,Ay,Az (ft/sec^2) : 62.000 54.000 0.0000 0.0000 21.00 Angles of Attack and Sideslip (deg), alpha, beta rates (deg/sec) : 4.0000 0.0000 0.0000 0.0000 Vehicle Attitude Euler Angles, Phi_o,Thet_o,Psi_o (deg), Body Rates Po,Qo,Ro (deg/sec) : 0.0000 44.000 0.0000 0.0000 Wind Gust Vel wrt Vehi (Azim & Elev) angles (deg), or Force(lb), Torque(ft-lb), locat:xyz: Gust 45.0 45.0 Surface Reference Area (feet^2), Mean Aerodynamic Chord (ft), Wing Span in (feet) : 47.3 7.7000 7.7000 Aero Moment Reference Center (Xmrc,Ymrc,Zmrc) Location in (ft), {Partial_rho/ Partial_H} : -127.2 0.0000 0.0000 0.0000</pre>	CI Zi Zi ! TI E: E: FI Zi	REATE A NEW SYSTEM FROM AN OLD SYSTEM (Titles of the New and Old Systems) llu, Stage-1, Max-Q, Rigid Body Pitch rigid system is extracted from the coupled rigid system above RUNCATE OR REORDER THE SYSTEM INPUTS, STATES, AND OUTPUTS ktract Inputs: 1 2 5 ktract States: 3 4 7 ktract Outputs: 3 4 7 14 LIGHT VEHICLE INPUT DATA llu, Stage-1, Max-Q, 8 Flex Modes with Slosh				
Vehicle Mass (lb-sec^2/ft), Gravity Accelerat. (g) (ft/sec^2), Earth Radius (Re) (ft) : 8878.0 32.174 0.20896E+08 Moments and products of Inertias Ixx, Iyy, Izz, Ixy, Ixz, Iyz, in (lb-sec^2-ft) : 519500.0 1671000.0 2110000.0 0.000 CG location with respect to the Vehicle Reference Point, Xcg, Ycg, Zcg, in (feet) : -126.05 0.0000 0.007 Vehicle Mach Number, Velocity Vo (ft/sec), Dynamic Pressure (psf), Altitude (feet) : 2.5 2000.0 220.00 83000 Inertial Acceleration Vo_dot, Sensed Body Axes Accelerations Ax, Ay, Az (ft/sec^2) : 62.000 54.000 0.0000 0.0000 Angles of Attack and Sideslip (deg), alpha, beta rates (deg/sec) : 4.0000 0.0000 0.0000 0.0000 Vehicle Attitude Euler Angles, Phi_o, Thet_o, Psi_o (deg), Body Rates Po, Qo, Ro (deg/sec) : 0.0000 44.000 0.0000 0.0000 Wind Gust Vel wrt Vehi (Azim & Elev) angles (deg), or Force(lb), Torque(ft-lb), locat:xyz: Gust 45.0 45.0 Surface Reference Area (feet^2), Mean Aerodynamic Chord (tf), Wing Span in (feet) : 47.3 7.7000 7.7000 Aero Moment Reference Center (Xmrc, Xmrc, Zmrc) Location in (ft), {Partial_rho/ Partial_H} : -127.2 0.0000 0.0000 0.0000 Aero Force Coef/Deriv (l/deg), Along -X, {Cao,Ca_alf, PCa/PV, PCa/Ph, Ca_alfdot, Ca_q, Ca_bet}: 0.63 0.010 0.0001 0.0000	! ! ! !	a high altitude to maximize orbit performance. At Max-Q and while flying at 2.5 Mach it experiences a strong wind shear that causes 4 deg of angle of attack. The vehicle has tw liquid oxygen rockets that can provide 320,000 (lb) of thrust each. The two fuel tanks, on each side cause a significant amount of slosh disturbance.	vo side			
Moments and products of Inertias Ixx, Iyy, Izz, Ixy, Ixz, Iyz, in (lb-sec^2-ft) : 519500.0 1671000.0 2110000.0 0.000 CG location with respect to the Vehicle Reference Point, Xcg, Ycg, Zcg, in (feet) : -126.05 0.0000 0.007 Vehicle Mach Number, Velocity Vo (ft/sec), Dynamic Pressure (psf), Altitude (feet) : 2.5 2000.0 220.00 83000 Inertial Acceleration Vo_dot, Sensed Body Axes Accelerations Ax, Ay, Az (ft/sec^2) : 62.000 54.000 0.0000 210.000 Angles of Attack and Sideslip (deg), alpha, beta rates (deg/sec) : 4.0000 0.0000 0.0000 0.0000 Vehicle Attitude Euler Angles, Phi_o,Thet_o,Psi_o (deg), Body Rates Po,Qo,Ro (deg/sec) : 0.0000 44.000 0.0000 0.000 Wind Gust Vel wrt Vehi (Azim & Elev) angles (deg), or Force(lb), Torque(ft-lb), locat:xyz: Gust 45.0 45.0 Surface Reference Area (feet^2), Mean Aerodynamic Chord (ft), Wing Span in (feet) : 47.3 7.7000 7.7000 Aero Moment Reference Center (Xmrc,Ymrc,Zmrc) Location in (ft), {Partial_rho/Partial_H} : -127.2 0.0000 0.0000 0.0000 Aero Force Coef/Deriv (1/deg), Along -X, {Cao,Ca_alf,PCa/PV,PCa/Ph,Ca_alfdot,Ca_q,Ca_bet}: 0.63 0.01 0.0000 0.000	Bo	ody Axes Output,Attitude=Euler Angles,Without GAFD, No Turn Coordination				
Aero Force Coeff/Deriv (1/deg), Along Z, {Cz_o,Cz_alf,Cz_q,Cz_bet,PC2/Ph,Cz_alfdot,PC2/PV}: -1.1 -0.31 0.0000 0.000 Aero Moment Coeffic/Derivat (1/deg), Roll: {Clo, Cl_beta, Cl_betdot, Cl_p, Cl_r, Cl_alfa}: 0.0 -0.005 0.0000 0.000 Aero Moment Coeff/Deriv (1/deg), Pitch: {Cmo,Cm_alfa,Cm_alfdot,Cm_bet,Cm_q,PCm/PV,PCm/Ph}: 2.3 0.6 0.0000 0.000	M C V L L L L V V V V V V V V V V V V V V	<pre>oments and products of Inertias Ixx, Iyy, Izz, Ixy, Ixz, Iyz, in (lb-sec^2-ft) : 3 location with respect to the Vehicle Reference Point, Xcg, Ycg, Zcg, in (feet) : hicle Mach Number, Velocity Vo (ft/sec), Dynamic Pressure (psf), Altitude (feet) : nertial Acceleration Vo_dot, Sensed Body Axes Accelerations Ax,Ay,Az (ft/sec^2) : nelse of Attack and Sideslip (deg), alpha, beta rates (deg/sec) : hicle Attitude Euler Angles, Phi_o,Thet_o,Psi_o (deg), Body Rates Po,Qo,Ro (deg/sec) : ind Gust Vel wrt Vehi (Azim & Elev) angles (deg), or Force(lb), Torque(ft-lb), locat:xyz: urface Reference Area (feet^2), Mean Aerodynamic Chord (ft), Wing Span in (feet) : ero Moment Reference Center (Xmrc,Ymrc,Zmrc) Location in (ft), {Partial_rho/Partial_H} : ero Force Coef/Deriv(1/deg), Along -X, {Cao,Ca_alf,PCa/PV,PCa/Ph,Ca_alfdot,Ca_q,Ca_bet}; ero Moment Coeffic/Derivat (1/deg), Roll: {Clo, Cl_beta, Cl_betdot, Cl_p, Cl_alfa}; ero Moment Coeff/Deriv (1/deg), Pitch: {Cmo,Cm_alfa,Cm_alfdot,Cm_q,PCm/PV,PCm/Ph; </pre>	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	$\begin{array}{c} 1671000.0\\ 0.0000\\ 2000.0\\ 54.000\\ 0.0000\\ 44.000\\ 45.0\\ 7.7000\\ 0.0000\\ 0.0001\\ -0.06\\ -0.31\\ -0.005\\ 0.6\end{array}$	2110000.0 0.007 220.00 0.0000 0.0000 45.0 7.7000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000	0.0000 83000. 21.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
Number of Control Surfaces, With or No TWD (Tail-Wags-Dog and Hinge Moment Dynamics) ? : 0 NO TWD Number of Thruster Engines, Include or Not the Tail-Wags-Dog and Load-Torque Dynamics ? : 2 WITH TWD				ID		
Eng Mass (slug), Inertia about Gimbal (lb-sec^2-ft), Moment Arm, engine CG to gimbal (ft): 47.0 260.00 0.2	N				ng	
TVC Engine No: 2 (Gimbaling Throttling Single_Gimbal) : Right TVC Gimbaling	T E1 M E1 G	punting Angles wrt Vehicle (Dyn,Dzn), Maximum Deflections from Mount (Dymax,Dzmax) (deg): ng Mass (slug), Inertia about Gimbal (lb-sec^2-ft), Moment Arm, engine CG to gimbal (ft): imbal location with respect to the Vehicle Reference Axes, Xgimb, Ygimb, Zgimb, in (ft) :	47.0 -144.6	260.00 -8.7	0.2 0.0	5.0

Number of Gyros, (Attitude and Rate) Gyro No 1 Axis:(Pitch,Yaw,Roll), (Attitude, Rate, Accelerat), Sensor Location in (feet) : Roll Rate Gyro No 2 Axis:(Pitch,Yaw,Roll), (Attitude, Rate, Accelerat), Sensor Location in (feet) : Pitch Rate -102.000.00 0.00 Pitch Rate -102.00 0.00 0.00 Gyro No 3 Axis:(Pitch,Yaw,Roll), (Attitude, Rate, Accelerat), Sensor Location in (feet) : Yaw Rate -102.00 0.00 0.00 Number of Accelerometers, Along Axis: (x,y,z) Acceleromet No 1 Axis:(X,Y,Z), (Position, Velocity, Acceleration), Sensor Location (ft): Y-axis Accelerat. -102.00 0.00 Acceleromet No 2 Axis:(X,Y,Z), (Position, Velocity, Acceleration), Sensor Location (ft): Z-axis Accelerat. -102.00 0.00 0.00 0.00 Number of Vane Sensors, (Measuring Alpha or Beta) Number of Slosh Modes : 2 Rabit of bill holds (slug), Frequ Wy,Wz at lg (rad/s), Damping (zeta-y-z), Locat {Xsl,Ysl,Zsl} (ft): 350.0 2.31 2.31 0.001 0.001 -135.00 -8.7 Rght Tank (slug), Frequ Wy,Wz at lg (rad/s), Damping (zeta-y-z), Locat {Xsl,Ysl,Zsl} (ft): 350.0 2.31 2.31 0.001 0.001 -135.00 8.7 Number of Bending Modes : 8 Zulu, Stage-1, Max-Q, 8 Flex Modes, Pitch Modes SELECTED MODAL DATA AND LOCATIONS FOR THE PITCH MODES Zulu, Stage-1, Max-Q, 8 Flex Modes, Pitch Modes ! The pitch modes were selected by applying +Z forces at the two gimbals, (same direction at the ! left and right TVC). The pitch rotation was sensed at the IMU node. We included also modal data at the two TVC gimbals, the 3 roll, pitch, and yaw gyros, and the two (Ny and Nz) acceleromet. The modal data were scaled from the original Nastran output in (*.mod) file. We reverse the ! directions in the X and Z axes. The modal slopes were multiplied by 12 to be converted from ! (rad/inch) to (radians/foot). The modal masses were multiplied by 12 to be converted from ! (snails) to (slugs). Standard Nastran to GN&C units transformation (Default) MODE # 1/ 1, Frequency (rad/sec), Damping (zeta), Generalized Mass= 20.449 0.50000E-02 12.000 phi along X phi along Y phi along Z sigm about X sigm about Y sigm about Z DEFINITION OF LOCATIONS (NODES) Modal Data at the 2 Engines, (x,y,z)... -0.25060D-01 0.10089D-01 -0.48000D-03 0.23400D-04 -0.24816D-04 -0.12228D-02 0.25080D-01 0.10093D-01 -0.98000D-04 0.22764D-04 -0.21000D-04 -0.12233D-02 Node ID# Left (-y) Boster Gimbal Locat 35701 Right (+y) Boster Gimbal Locat 45701 Node ID# Modal Data at the 3 Gyros . -0.13080D-05 0.23100D-01 0.18520D-03 -0.60120D-04 0.17244D-04 0.36600D-02 -0.13080D-05 0.23100D-01 0.18520D-03 -0.60120D-04 0.17244D-04 0.36600D-02 -0.13080D-05 0.23100D-01 0.18520D-03 -0.60120D-04 0.17244D-04 0.36600D-02 Nav Base (IMU , Accelerom) 95602 Nav Base (IMU , Accelerom) Nav Base (IMU , Accelerom) 95602 95602 Node ID# Modal Data at the 2 Accelerometers, along $(x,y,z)\ldots$ Nav Base (IMU , Accelerom) Nav Base (IMU , Accelerom) -0.13080D-05 0.23100D-01 0.18520D-03 -0.13080D-05 0.23100D-01 0.18520D-03 95602 95602 Node ID# Modal Data at the 2 Slosh Masses... Left Booster Liquid Oxygen Sl 81602 Right Booster Liquid Oxygen Sl 88603 -0.90090D-02 0.51000D-02 0.26000D-03 -0.33480D-05 0.24360D-04 0.26904D-02 0.90170D-02 0.50960D-02 0.34470D-03 -0.40680D-05 -0.83160D-05 0.26904D-02 Node TD# Modal Data at the Disturbance Point 95602 Nav Base (IMU , Accelerom) -0.13080D-05 0.23100D-01 0.18520D-03 -0.60120D-04 0.17244D-04 0.36600D-02 MODE # 2/ 2, Frequency (rad/sec), Damping (zeta), Generalized Mass= 22.271 0.50000E-02 12.000 phi along X phi along Y phi along Z sigm about X sigm about Y sigm about Z DEFINITION OF LOCATIONS (NODES) Node ID# Modal Data at the 2 Engines, (x,y,z)... Left (-y) Boster Gimbal Locat 35701 Right (+y) Boster Gimbal Locat 45701 0.26580D-03 0.57370D-04 0.25310D-01 0.12300D-03 -0.19884D-02 -0.15852D-04 0.41850D-03 0.88360D-04 0.25260D-01 0.11760D-03 -0.19872D-02 -0.18912D-04 Node TD# Modal Data at the 3 Gyros . Nav Base (IMU , Accelerom) 95602
 0.43500D-03
 0.45400D-03
 -0.10500D-01
 0.43200D-05
 -0.23088D-02

 0.43500D-03
 0.45400D-03
 -0.10500D-01
 0.43200D-05
 -0.23088D-02

 0.43500D-03
 0.45400D-03
 -0.10500D-01
 0.43200D-05
 -0.23088D-02

 0.43500D-03
 0.45400D-03
 -0.10500D-01
 0.43200D-05
 -0.23088D-02
 0 546000-04 Nav Base (IMU , Accelerom) 95602 0.54600D-04 Nav Base (IMU , Accelerom) 95602 0.54600D-04 Node ID# Modal Data at the 2 Accelerometers, along (x,y,z)... 0.43500D-03 0.45400D-03 -0.10500D-01 0.43500D-03 0.45400D-03 -0.10500D-01 95602 Nav Base (IMU , Accelerom) Nav Base (IMU , Accelerom) 95602 Node TD# Modal Data at the 2 Slosh Masses.. Left Booster Liquid Oxygen Sl 81602 Right Booster Liquid Oxygen Sl 88603 -0.12800D-03 0.12550D-03 -0.24500D-01 -0.32760D-04 -0.11892D-02 0.13236D-04 0.15130D-03 0.28260D-03 -0.24510D-01 0.37200D-04 -0.81360D-03 0.70200D-04 Node ID# Modal Data at the Disturbance Point 0.43500D-03 0.45400D-03 -0.10500D-01 0.43200D-05 -0.23088D-02 0.54600D-04 Nav Base (IMU , Accelerom) 95602 _____ CREATE A NEW SYSTEM FROM AN OLD SYSTEM... (Titles of the New and Old Systems) Zulu, Stage-1, Max-Q, 8 Flex Modes with Slosh, Pitch Axis Zulu, Stage-1, Max-Q, 8 Flex Modes with Slosh ! Pitch flexible system is extracted from the coupled system above ! to be used in Matlab/Simulink Simulations TRUNCATE OR REORDER THE SYSTEM INPUTS, STATES, AND OUTPUTS

 Extract Inputs:
 1
 2
 3
 4
 9

 Extract States:
 3
 4
 7
 11
 12
 13
 14
 15
 16
 17
 18
 19
 20
 21
 22
 23
 24
 25
 26
 27
 29
 31
 33

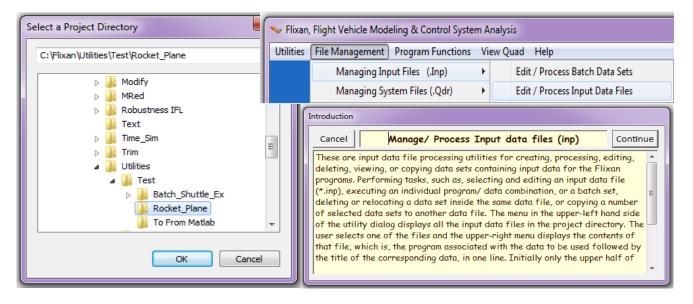
 Extract Outputs:
 3
 4
 7
 13
 16
 17
 18
 19
 20
 21
 22
 23
 24
 25
 26
 27
 29
 31
 33

SYSTEM OF TRANSFER FUNCTIONS ... Alpha Estimator ! This filter estimates the angle of attack in (radians) from the accelerometer measurement and ! the gimbal deflection angle. It basically solves the normal force equation for alpha. The ! inputs are (a) Nz measurement from the accelerometer, (b) Pitch rate to counteract against the ! rotational component picked up by the accelerometer, (c) gimbal deflection to estimate the ! normal component of thrust. The washout filter differentiates the rate gyro signal at low ! frequencies. Continuous TF. Block # 1 Integrator Order of Numer, Denom= 0 1 1.0 Numer 0.0 Denom 1.0 0.0 TF. Block # 2 Washout Filter Order of Numer, Denom= 1 1 Numer 280.0 0.0 Denom 1.0 10.0 Block #, from Input #, Gain 11-8878.000{TF: 1, Integrator } from {Nz Acceleration}12-464000.0{TF: 1, Integrator } from {Gimbal Deflection}231.0{TF: 2, Washout Filt} from {Pitch Rate Gyro} Outpt #, from Block #, Gain 1 1 0.1745000E-01 {System Output 1 } from {TF: 1, Integrator } Block #, from Block #, Gain 1 1 -3225.860 {TF: 1, Integrator } from {TF: 1, Integrator } 1 2 -8878.0 {TF: 1, Integrator } from {TF: 2, Washout Filt} Definitions of Inputs = 3 Nz Acceleration (ft/sec^2) Gimbal Deflection, Delta (rad) Pitch Rate Gyro, q-flex (rad/sec) Definitions of Outputs = 1 Alpha Estimate in (radians) _____ SYSTEM OF TRANSFER FUNCTIONS ... Pitch Flight Control System ! This is the state-feedback pitch FCS with filters and actuator combined ! The attitude, pitch rate and gamma come from the vehicle subsystem. The ! angle of attack comes from the alpha estimator. The output goes to the ! vehicle gimbal deflection input. Continuous TF. Block # 1 Gamma Integrat Order of Numer, Denom= 0 1 Numer 0.0 1.0 Denom 1.0 0.0 TF. Block # 2 Low-Pass Filter Order of Numer, Denom= 0 2 Numer 0.0 0.0 324.0 Denom 1.0 19.8 324.0 TF. Block # 3 Actuator Order of Numer, Denom= 0 1 Numer 0.0 63 0 Denom 1.0 63.0 Block #, from Input #, Gain 2 1 0.85 2 2 0.5 {TF: 2, Filter} from {Theta Error}
{TF: 2, Filter} from {Pitch Rate Gyro} 0.012 2 3 1 4 {TF: 2, Filter} from {Alpha} {TF: 1, Integrator} from {Gamma Error} Outpt #, from Block #, Gain 1 3 1.0 {Gimbal Deflect} from {TF: 3, Actuator} . Block #, from Block #, Gain 3 2 1.0 2 1 0.04375 {TF: 3, Actuator} from {TF: 2, Filter} {TF: 2, Filter} from {TF: 1, Gamma Integral} {TF: 3, Actuator} from {TF: 2, Filter} Definitions of Inputs = 4 Theta error (Theta-Thetcom) (rad) Pitch rate gyro (rad/sec) Alpha (rad) Gamma error (Gamma-Gamcom) (rad) Definitions of Outputs = 1 Gimbal Deflection (radians)

INTERCONNECTION OF SYSTEMS Pitch Closed-Loop System ! Closed-Loop System obtained using the Flixan system building utilities ! to be used for Simulations Titles of Systems to be Combined Title 1 Zulu, Stage-1, Max-Q, 8 Flex Modes with Slosh, Pitch Axis Title 2 Alpha Estimator Title 3 Pitch Flight Control System SYSTEM INPUTS TO SUBSYSTEM 3 Pitch Flight Control System System Input 1 to Subsystem 3, Input 1, Gain= -1.0000 System Input 2 to Subsystem 3, Input 4, Gain= -1.0000 Theta Command Gamma Command System Input 3 to Subsystem 1, Input 5, Gain= 1.0000 Wind Gust (ft/sec) SYSTEM OUTPUTS FROM SUBSYSTEM 1 Zulu, Stage-1, Max-Q, 8 Flex Modes with Slosh System Output 1 from Subsystem 1, Output 1, Gain= 1.0000 Theta System Output 2 from Subsystem 1, Output 4, Gain= 1.0000 System Output 3 from Subsystem 1, Output 3, Gain= 1.0000 g-flex (rate gyro) Alpha System Output5 from Subsystem1, Output1, Gain=1.0000System Output5 from Subsystem1, Output3, Gain=-1.0000System Output6 from Subsystem1, Output5, Gain=1.0000 Gamma= Theta -Alpha Nz accelerom SYSTEM OUTPUTS FROM SUBSYSTEM 2 Alpha Estimator System Output 4 from Subsystem 2, Output 1, Gain= 1.0000 Alpha-Hat System Output 7 from Subsystem 3, Output 1, Gain= 1.0000 Gimbal deflect (rad) SUBSYSTEM NO 1 GOES TO SUBSYSTEM NO 3 Vehicle to Controller Subsystem 1, Output 1 to Subsystem 3, Input 1, Gain= 1.0000 Attitude Theta Subsystem 1, Output 4 to Subsystem 3, Input 2, Gain= 1.0000 Subsystem 1, Output 1 to Subsystem 3, Input 4, Gain= 1.0000 a-flex Gamma= Theta Subsystem 1, Output 3 to Subsystem 3, Input 4, Gain= -1.0000 -Alpha SUBSYSTEM NO 1 GOES TO SUBSYSTEM NO 2 Vehicle to Estimator Subsystem 1, Output 4 to Subsystem 2, Input 3, Gain= 1.0000 Subsystem 1, Output 5 to Subsystem 2, Input 1, Gain= 1.0000 q-flex Nz SUBSYSTEM NO 2 GOES TO SUBSYSTEM NO 3 Estimator to Controller Subsystem 2, Output 1 to Subsystem 3, Input 3, Gain= 1.0000 Alpha-Estimate SUBSYSTEM NO 3 GOES TO SUBSYSTEM NO 1 Gimbal to Vehicle Subsystem 3, Output 1 to Subsystem 1, Input 1, Gain= 1.0000 Subsystem 3, Output 1 to Subsystem 1, Input 2, Gain= 1.0000 Pitch Gimbal-1 Pitch Gimbal-2 SUBSYSTEM NO 3 GOES TO SUBSYSTEM NO 2 Gimbal to Estimator Subsystem 3, Output 1 to Subsystem 2, Input 2, Gain= 1.0000 Pitch Gimbal Definitions of Inputs = 3 Theta Command (rad) Gamma Command (rad) Wind Gust Veloc. (ft/sec) Definitions of Outputs = 7 Theta (rad) Pitch Rate (rad/sec) Alpha (rad) Alpha Estimate (rad) Gamma (rad) Normal Accelerometer, Nz (ft/sec^2) Gimbal Deflection (rad) _____ CONVERT TO MATLAB FORMAT (Title, System/Matrix, m-filename) Zulu, Stage-1, Max-Q, Rigid Body, Pitch Axis System Vehi_Pitch_rb _____ CONVERT TO MATLAB FORMAT (Title, System/Matrix, m-filename) Zulu, Stage-1, Max-Q, 8 Flex Modes with Slosh, Pitch Axis System Vehi_Pitch_SFlx _____ _____ CONVERT TO MATLAB FORMAT (Title, System/Matrix, m-filename) Alpha Estimator System Estimator _____ CONVERT TO MATLAB FORMAT (Title, System/Matrix, m-filename) Pitch Flight Control System System pitch_fcs _____ _____ Flixan uses two separate utility programs for managing input data files: a utility for managing the sets within an input file, and a utility for creating, editing, and processing batch sets in an input file.

6.1.1 Input File Manager Utility

The input file manager utility is used for preparing and processing input files that have an extension (.Inp). For example, editing, deleting or relocating data-sets inside the file, or copying data-sets to another file. Editing or viewing user comments. Individual data-sets and batch sets can also be processed from the file manager utility. Batch sets are useful for fast processing of the entire input file instead of interactively. Initially interactive processing is useful when setting up the modeling structure and the functions to be performed. When the process is debugged, a batch data-set can be created for the next reprocessing, which may be another flight condition or a parameter modification, etc. To run the input file managing utility you must first start Flixan and select a project directory. From the Flixan main menu select "*File Management*", then "*Manage Input Files*" and then "*Edit/Process Input Data*".



The file manager utility dialog is shown below. You must first select the input file to be processed. The menu on the left side of this dialog shows all the input filenames having extension (.Inp) located in the selected folder: " $C:\Flixan\Utilities\Test\Rocket_Plane$ ". In this case choose the file "RocketPlane-RB.Inp" and click on "Select Input File". The menu on the right will then show the titles of all data-sets located in this file. The type of the data-set also appears on the left side of each title to identify the Flixan utility that will process each set. For example: "Flight Vehicle", "Actuator", "Mixing Logic", "Transfer Function Data", "Batch Data", etc. The utility performs several file management functions, such as, deleting unused sets or relocating them to other positions inside this file, processing the data-sets by running the corresponding Flixan program or copying a number of selected data-sets to another input file. The user can also edit the selected input file. The user defined comments associated with each set appear in the beige field below the menus. These are the user comment lines that begin with an (!). The data-set title must first be selected in the menu and then click on "View Data-Set Comments" button which displays the user comments. They can also be edited or new comments be entered in this field if the original set did not include any.

Process Input Data Files			
Point to an Input Data Fi	lename and Click on		Exit
"Select Input File"		The following Input Data Sets are in File: RocketPlane_RB.Inp	
RocketPlane_RB.Inp	Select Input File	Run Batch Mode : Batch Set for Creating Rocket-Plane Control Design Models	*
RocketPlane_RB.Inp		Flight Vehicle : Rocket Plane at Mach=0.85, Q=150, Rigid Body	
	Edit Input File	Flight Vehicle : Rocket Plane at Mach=0.85, Q=150, Rigid Body (for computing the lateral mixing m Mixing Matrix : Pitch axis Mixing Matrix for Rocket-Plane [Kpitmix: Q-dot, Ax] Mixing Matrix : Coupled axes Mixing Matrix for Rocket-Plane [K4axmix: PQR-dot, Ax]	matrix K
	Process/ View Input Data	Mixing Matrix : Lateral axes Mixing Matrix for Rocket-Plane [Klat: PR-dot] Transf-Functions : First Order Gust Lag	
	Delete Data Sets in File	Transf-Functions : Integrator System Modificat : Rocket Plane at Mach=0.85, Q=150, Rigid Body, Pitch Axis System Modificat : Pitch Design Model	
	Relocate Data Set in File	System Connection: Pitch Design Model with Alpha Integral (2-inputs, 4-states) System Modificat : Pitch Design Model with Alpha Integral (1-input, 4-states) System Modificat : Rocket Plane at Mach=0.85, Q=150, Rigid Body, Lateral Axes	E
	Copy Set to Another File	System Modificat : Lateral Design Model System Connection: Lateral Design Model with p-Integral (4-states)	
	View Data-Set Comments	To Matlab Format : Rocket Plane at Mach=0.85, Q=150, Rigid Body To Matlab Format : Rocket Plane at Mach=0.85, Q=150, Rigid Body, Pitch Axis To Matlab Format : Pitch Design Model with Alpha Integral (1-input, 4-states) To Matlab Format : Rocket Plane at Mach=0.85, Q=150, Rigid Body, Lateral Axes	
		To Matlab Format : Lateral Design Model with p-Integral (4-states)	
		To Matlab Format : Pitch axis Mixing Matrix for Rocket-Plane [Kpitmix: Q-dot, Ax]	
		To Matlab Format : Coupled axes Mixing Matrix for Rocket-Plane [K4axmix: PQR-dot, Ax]	-
Comments, Data-Set User	• Notes		
		lane. It has five control surfaces, 2 flaps, 2 rudders, and a body-flap. It also has a fixed engine with variable thrust for spea rned off. It will be used to create state-space models for control design.	ed A

To process, for example, one of the data sets highlighted on the right menu, which in this case we select a rigid-body rocket-plane flight vehicle model. Click on "*View Comments*" to see the user notes in the comments field below, and then click on "*Process/ View Input Data*" to process the set. The flight vehicle program dialog comes up where the user can view or modify the data, and then click on "Run" to process the vehicle data. In this case the system already exists in the systems file and we cancel the processing.

Flight Vehicle Parameters				
Vehicle System Title Rocket Plane at Mach=0.85, Q=150, Rigid Body				Edit Input File Exit
Number of Vehicle Effectors	Number of Sensors	Modeling Options (FI	ags)	Update Data Run
Gimbaling Engines or Jets. UITH TWD Include Tail-Wags-Dog?	Gyros 0	Body Axes Include	oordination ? e Turn Coordin	Save in File
Rotating Control Surfaces. 5 WITH TWD Include Tail-Wags-Dog? 5 WITHOUT TWD	Acceleromet 0	Stability Axes	ut Turn Coordin	
Reaction Momentum Control Devices	Aero Vanes 0	Aero-Elasticity Options Attitude	e Angles Angles	Number of Modes Structure Bending 0
Single Include a 3-axes Gimbal 0 Stabilized Double No CMGs? Gimbal CMG System?	External 0 Torques	Flex Coupl. data only Integra	als of Rates Attitude	Fuel Sloshing:
Reaction Wheels Single Gimbal CMGs Double Gimbal	CMG System Slewing App	endages Gyros Accelerometer	Aero Sensors F	uel Slosh Flex Modes User Notes
Mass Properties Trajectory Data Gust/Aero Parar	met. Aero Force Coeffs	Aero Moment Coeffs Control S	Cannot Save	×
Vehicle Mass Properties				
Moments/ Products of Inertia (slg-ft^2)	ation of Center of Gravity (ft)			Plane at Mach=0.85, Q=150, Rigid Body stem name is already in systems file
Ixx 1098.000 Ixy 0.000000 Xo	g -15.16700	Vehicle Mass in (slugs)		you like to Save it under a different Name?
lyy 10933.00 lxz 123.7500 Yo	g 0.000000	Accelerat. due to Gravity (ft/sec^		
lzz 11290.00 lyz 0.000000 Zo	cg 0.4670000	Earth Radius (Re) in (feet)		OK Cancel

This example also includes a batch set on the top for processing the entire file in batch mode rather than interactively. Batch is a much faster way of processing the already created input files. Return to the file manager dialog and select the first title which is the batch set, and click on "*Process / View Input Data*", to process the batch data. Say "Yes" to recreate the already existing systems file "*RocketPlane-RB.Qdr*". The batch processes the individual data-sets located in the input file. A display comes up showing the individual set titles highlighted as they are being processed. It is used for monitoring the batch process in case of errors.

ilename and Click on "S		The following Input Data Sets are in File: RocketPlane_RB.Inp
RocketPlane_RB.Inp	Select Input File	Run Batch Mode : Batch Set for Creating Rocket-Plane Control Design Models Flight Vehicle : Rocket Plane at Mach=0.95. 0=150. Rigid Body
ocketPlane_RB.Inp		Flight Vehicle : Rocket Flane at Mach=0.05, Q=150, Rigid Body Flight Vehicle : Rocket Flane at Mach=0.85, Q=150, Rigid Body (for computing the lateral mixing matrix Klat
	Edit Input File	Mixing Matrix : Pitch axis Mixing Matrix for Rocket-Plane [Kpitmix: Q-dot, Ax]
		Mixing Matrix : Coupled axes Mixing Matrix for Rocket-Plane [K4axmix: PQR-dot, Ax]
	Process/View Input Data	Mixing Matrix : Lateral axes Mixing Matrix for Rocket-Plane [Klat: PR-dot]
	Process/ view input butu	Transf-Functions : First Order Gust Lag
	Delete Data Sets in File	Transf-Functions : Integrator System Modificat : Rocket Plane at Mach=0.85, Q=150, Rigid Body, Pitch Axis
	Delete Data Sets in File	System Modificat : Pitch Design Model
		System Connection: Pitch Design Model with Alpha Integral (2-inputs 4-states)
	Relocate Data Set in File	System Modificat : Pitch Design Model with Alpha Integral (1-i Replace Systems File?
		System Modificat : Rocket Plane at Mach=0.85, Q=150, Rigid Bod
	Copy Set to Another File	System Modificat : Lateral Design Model
		System Connection: Lateral Design Model with p-Integral (4-sta To Matlab Format : Rocket Plane at Mach=0.85, Q=150, Rigid Bod The systems filename: RocketPlane_RB.Qdr
	View Data-Set Comments	To Matlab Format : Rocket Plane at Mach=0.85, Q=150, Rigid Bod
		To Matlab Format : Pitch Design Model with Alpha Integral (1-1
		To Matlab Format : Rocket Plane at Mach=0.85, Q=150, Rigid Bod
		To Matlab Format : Lateral Design Model with p-Integral (4-sta
		To Matlab Format : Pitch axis Mixing Matrix for Rocket-Plane [Yes No
		To Matlab Format : Coupled axes Mixing Matrix for Rocket-Plane
mments, Data-Set Us	ser Notes	
nie hatch eat ie wead	to create nitch and lateral or	ontrol design models for the rocket-plane vehicle. It creates also simulation models and converts them into Matlab format to be used in
mulink	to create pitch and lateral co	Introl design models for the rocket-plane venicle. If creates also simulation models and converts them into Matiab format to be used in

ename and Click on "Sel	ect Input File"	The following Input Data Sets are in File: RocketPlane_RB.Inp	Exit
ocketPlane_RB.Inp	Select Input File	Run Batch Mode : Batch Set for Creating Rocket-Plane Control Design Models Flight Vehicle : Rocket Plane at Mach=0.85, Q=150, Rigid Body	
Bate	ch Mode Execution	el mixing m	atrix Klat
17: 14: 17: 17: 17: 17: 17: 17: 17: 17: 17: 17	light Vehicle : Rock ixing Matrix : Pitc ransf-Functions : Fire ransf-Functions : Inte ystem Modificat : Rock ystem Modificat : Pitc ystem Modificat : Pitc ystem Modificat : Rock ixing Matrix : Coup ixing Matrix : Late	agrator tet Plane at Mach=0.85, Q=150, Rigid Body, Pitch Axis th Design Model th Design Model with Alpha Integral (2-inputs, 4-states) th Design Model with Alpha Integral (1-input, 4-states) tet Plane at Mach=0.85, Q=150, Rigid Body, Lateral Axes Died axes Mixing Matrix for Rocket-Plane [K4axmix: PQR-dot, Ax] eral axes Mixing Matrix for Rocket-Plane [K1at: PR-dot] eral Design Model	
nments, Data-Set	o Matlab Format : Rock o Matlab Format : Rock o Matlab Format : Pitc o Matlab Format : Rock o Matlab Format : Late	<pre>ral Design Model with p-Integral (4-states) tet Plane at Mach=0.85, Q=150, Rigid Body tet Plane at Mach=0.85, Q=150, Rigid Body, Pitch Axis th Design Model with Alpha Integral (1-input, 4-states) tet Plane at Mach=0.85, Q=150, Rigid Body, Lateral Axes ral Design Model with p-Integral (4-states)</pre>	
his batch set is us mulink	o Matlab Format : Pitc	ch axis Mixing Matrix for Rocket-Plane [Kpitmix: Q-dot, Ax]	be used in

The "Delete Data Sets in File" button is used to delete selected items from the right menu in case you want to remove some older and unused data sets. You may also relocate some the data-sets to a different position inside the input data file by using the "Relocate Data Set in File" button. The file manager utility can also be used to copy selected data-sets from one input file to another. Return to the utility dialog and reselect the input filename. Initially only the upper half of the dialog is visible. The lower half appears only when you click on "Copy Set to Another File". This button allows you to copy the highlighted data sets from the original file to another input data file that is defined in the lower left menu. After highlighting the data sets to be copied from the original file using the upper-right menu, click on the "Copy to Another File" button and the dialog displays two additional menus at the bottom. Use the lower-left menu to enter or to select a destination filename in a similar manner as the original filename from the upper-left menu.

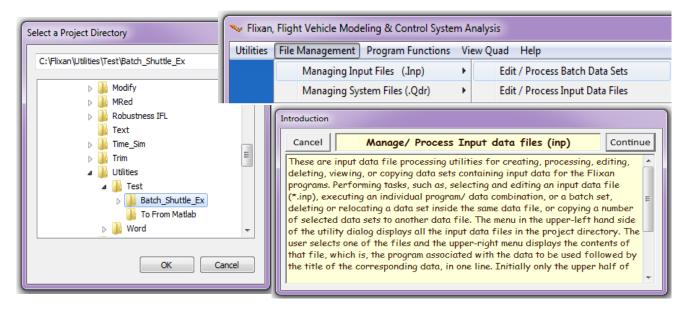
Managing Input Data Files			
To Manage an Input Data Filename and Click on "Sel		The following Input Data Sets are in File: RocketPlane_RB.Inp	Exit
RocketPlane_RB.Inp RocketPlane_RB.Inp	Select Input File	Run Batch Mode : Batch Set for Creating Rocket-Plane Control Design Models Flight Vehicle : Rocket Plane at Mach=0.85, Q=150, Rigid Body	Â
	Edit Input File	Flight Vehicle : Rocket Plane at Mach=0.85, Q=150, Rigid Body (For computing the lateral mixing matri Mixing Matrix : Fitch axis Mixing Matrix for Rocket-Plane [Kpitmix: Q-dot, Ax] Mixing Matrix : Coupled axes Mixing Matrix for Rocket-Plane (K4axmix: PQR-dot, Ax)	x Klat
	Process/ View Input Data	Mixing Matrix : Lateral axes Mixing Matrix for Rocket-Plane (Klat: PR-dot) Transf-Functions : First Order Gust Lag	
	Delete Data Sets in File	Transf-Functions : Integrator System Modificat : Rocket Plane at Mach=0.85, Q=150, Rigid Body, Pitch Axis System Modificat : Pitch Design Model	
	Relocate Data Set in File	System Connection: Pitch Design Model with Alpha Integral (2-inputs, 4-states) System Modificat : Pitch Design Model with Alpha Integral (1-input, 4-states) System Modificat : Rocket Plane at Machel 0.85, Q=150, Rigid Body, Lateral Axes	E
	Copy Set to Another File	System Modificat : Lateral Design Model System Connection: Lateral Design Model with p-Integral (4-states)	
	View Data-Set Comments	To Matlab Format : Rocket Plane at Mach=0.85, Q=150, Rigid Body To Matlab Format : Rocket Plane at Mach=0.85, Q=150, Rigid Body, Pitch Axis To Matlab Format : Pitch Design Model with Alpha Integral (1-input, 4-states)	
Comments, Data-Set User		To Matlab Format : Rocket Plane at Mach=0.85, Q=150, Rigid Body, Lateral Axes To Matlab Format : Lateral Design Model with p-Integral (4-states) To Matlab Format : Pitch axis Mixing Matrix for Rocket-Plane [Kpitmix: Q-dot, Ax] To Matlab Format : Coupled axes Mixing Matrix for Rocket-Plane [K4axmix: PQR-dot, Ax]	-
			*
To Copy Sets to another I			
Filename and Click on "Sel Rocket_2.Inp RocketPlane_RB.Inp NewFile.Inp	lect Destinat Input File" Select Destin. Input File Edit Destination File Copy the Selected Sets	The following data sets will be copied in destination file: Rocket_2.Inp Run Batch Mode : Batch Set for Creating Rocket-Plane Control Design Models Flight Vehicle : Rocket Plane at Mach=0.85, Q=150, Rigid Body Flight Vehicle : Rocket Plane at Mach=0.85, Q=150, Rigid Body (for computing the lateral mixing matri Mixing Matrix : Pitch axis Mixing Matrix for Rocket-Plane [Kpitmix: Q-dot, Ax] Mixing Matrix : Coupled axes Mixing Matrix for Rocket-Plane [Kdaxmix: PQR-dot, Ax] Mixing Matrix : Lateral axes Mixing Matrix for Rocket-Plane [Klat: PR-dot] Transf-Functions : First Order Gust Lag Transf-Functions : Integrator System Modificat : Pitch Design Model System Modificat : Pitch Design Model with Alpha Integral (2-inputs, 4-states) System Modificat : Rocket Plane at Mach=0.85, Q=150, Rigid Body, Lateral Axes System Modificat : Rocket Plane at Mach=0.85, Q=150, Rigid Body, Lateral Axes System Modificat : Rocket Plane at Mach=0.85, Q=150, Rigid Body, Lateral Axes System Modificat : Lateral Design Model with Alpha Integral (4-states)	x Klat)

In this case we type-in a new filename: "*Rocket_2.Inp*" in the field above the menu and click on "*Select Destination Input File*". The display on the bottom right shows the titles of the data-sets that will be copied from the original file to the new file. Click on the "*Copy the Selected Sets*" and the new data will be copied to the second file. The total contents of the second file are now shown in the lower-right display. Click on any button and the file managing dialog returns to its original size. Now the newly created filename "*Rocket_2.Inp*" is included in the left menu. You may select it and process it using the batch, the same way as the original file.

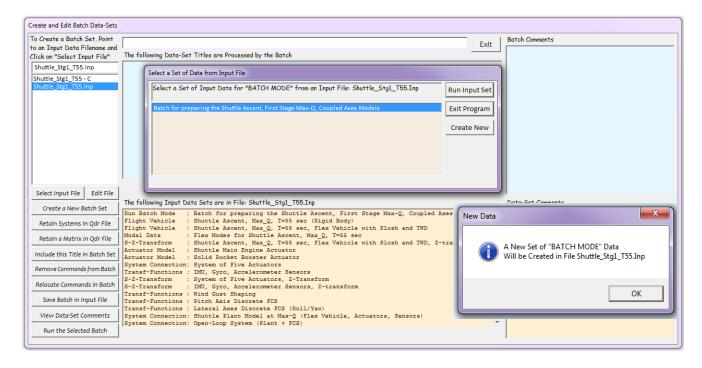
ect Input File" Select Input File Edit Input File Process/View Input Data	The following Input Data Sets are in File: RocketPlane_RB.Inp Run Batch Mode : Batch Set for Creating Rocket-Plane Control Design Models Flight Vehicle : Rocket Plane at Mach=0.85, Q=150, Rigid Body Flight Vehicle : Rocket Plane at Mach=0.85, Q=150, Rigid Body (for computing the lateral mixing matrix for Rocket-Plane (Kpinxi: Q=dot, Ax) Mixing Matrix : Coupled axes Mixing Matrix for Rocket-Plane (Kfaxmix: Q=dot, Ax) Mixing Matrix : Lateral axes Mixing Matrix for Rocket-Plane (Kfaxmix: PQR=dot, Ax) Mixing Matrix : Lateral axes Mixing Matrix for Rocket-Plane (Klat: PR=dot)	Exit
Edit Input File Process/View Input Data	Flight Vehicle : Rocket Plane at Mach=0.85, Q=150, Rigid Body Flight Vehicle : Rocket Plane at Mach=0.85, Q=150, Rigid Body (for computing the lateral mixing matr Mixing Matrix : Pitch axis Mixing Matrix for Rocket-Plane (Kpitmix: Q-dot, Ax) Mixing Matrix : Coupled axes Mixing Matrix for Rocket-Plane (Klat: PQR-dot, Ax) Mixing Matrix : Lateral axes Mixing Matrix for Rocket-Plane (Klat: PP-dot)	rix Klat
Process/ View Input Data	Mixing Matrix : Pitch axis Mixing Matrix for Rocket-Plane (Kpithix: Q-dot, Ax) Mixing Matrix : Coupled axes Mixing Matrix for Rocket-Plane (K4axmix: PQR-dot, Ax) Mixing Matrix : Lateral axes Mixing Matrix for Rocket-Plane (Klat: PR-dot)	
Delete Detu S. L. S. S.	Transf-Functions : First Order Gust Lag Transf-Functions : Integrator	
Delete Data Sets in File	System Modificat : Rocket Plane at Mach=0.85, Q=150, Rigid Body, Pitch Axis System Modificat : Pitch Design Model	
Relocate Data Set in File	System Connection: Pitch Design Model with Alpha Integral (2-input, 4-states) System Modificat : Pitch Design Model with Alpha Integral (1-input, 4-states) System Modificat : Rocket Plane at Mach=0.85, Q=150, Rigid Body, Lateral Axes	
Copy Set to Another File	System Modificat : Lateral Design Model System Connection: Lateral Design Model with p-Integral (4-states)	
View Data-Set Comments	To Matlab Format : Rocket Plane at Mach=0.85, Q=150, Migid Body, Pitch Axis To Matlab Format : Rocket Plane at Mach=0.85, Q=150, Rigid Body, Pitch Axis To Matlab Format : Pitch Design Model with Alpha Integral (1-input, 4-states) To Matlab Format : Rocket Plane at Mach=0.85, Q=150, Rigid Body, Lateral Axes To Matlab Format : Lateral Design Model with p-Integral (4-states) To Matlab Format : Pitch axis Mixing Matrix for Rocket-Plane [Kpitmix: Q-dot, Ax] To Matlab Format : Coupled axes Mixing Matrix for Rocket-Plane [K4axmix: PQR-dot, Ax]	
Notes	,	
Edit Destination File	Flight Vehicle : Rocket Plane at Mach=0.85, Q=150, Rigid Body Flight Vehicle : Rocket Plane at Mach=0.85, Q=150, Rigid Body (for computing the lateral mixing matrix Mixing Matrix : Pitch axis Mixing Matrix for Rocket-Plane [Kpitmix: Q-dot, Ax] Mixing Matrix : Coupled axes Mixing Matrix for Rocket-Plane [Kfaxmix: PQR-dot, Ax] Mixing Matrix : Lateral axes Mixing Matrix for Rocket-Plane [Klat: PR-dot] Transf-Functions : First Order Gust Lag Transf-Functions : Integrator System Modificat : Rocket Plane at Mach=0.85, Q=150, Rigid Body, Pitch Axis System Modificat : Rocket Plane at Mach=0.85, Q=150, Rigid Body, Pitch Axis System Connection: Pitch Design Model with Alpha Integral (2-inputs, 4-states) System Modificat : Lateral Design Model with Alpha Integral (1-input, 4-states) System Modificat : Lateral Design Model System Connection: Lateral Design Model with p-Integral (4-states)	rix Klat
	The following Input Nata Sets are in File: Dacket 2 Inp	Exit
	Run Batch Mode : Batch Set for Creating Rocket-Plane Control Design Models	
·	ateral mixing matr	rix Klat
t Vehicle : Rocket P y Matrix : Pitch aw F-Functions : First Or f-Functions : Integrat a Modificat : Pitch De a Modificat : Pitch De a Modificat : Rocket P y Matrix : Coupled y Matrix : Lateral Modificat : Lateral	<pre>Plane at Mach=0.85, Q=150, Rigid Body (for computing the lateral mixing matrix K1: der Gust Lag or Plane at Mach=0.85, Q=150, Rigid Body, Pitch Axis sign Model sign Model with Alpha Integral (2-inputs, 4-states) sign Model with Alpha Integral (1-input, 4-states) Plane at Mach=0.85, Q=150, Rigid Body, Lateral Axes axes Mixing Matrix for Rocket-Plane [K4at: PR=dot]</pre>	
	View Data-Set Comments View Data-Set Comments Notes File, choose destination ect Destinat Input File" Select Destin. Input File Edit Destination File Copy the Selected Sets File, Point to the lect Input File" Select Input File Select Input File Vehicle : Rocket P Vehicle : Pitch De Modificat : Pitch De Modificat : Rocket P Modificat : Coupled Modificat : Rocket P Matrix : Lateral	View DataSetComments System Connection: Encess) Backge Models with Dipleterysi (detacle) View DataSetComments For Matlab Format : Rocket Diame at Mach-0.8; Q=160, Bigid Body, Dista Mais To Matlab Format : Dick Diame at Mach-0.8; Q=160, Bigid Body To Matlab Format : Leteral Design Model with Julia Integral (1-input, d-states) To Matlab Format : Leteral Design Model with Pintegral (d-states) To Matlab Format : Leteral Design Model with Pintegral (d-states) Notes Select Destino Input File" The following data sets are now in destination file: Rocket 2 Inp To Matlab Format : Dick Mais Maining Matrix for Rocket-Dane [Riamain: PQD-dot, Ax] Select Destino Input File" The following data sets are now in destination file: Rocket 2 Inp To Matlab Format : Dicket Bias for Constant Destates Materia Bias Destable Setting Matrix : Coupled axes Mixing Matrix for Rocket-Dane [Riamain: PQD-dot, Ax] Copy the Select Disk Input File Edit Destino File Disk Matrix : Coupled axes Mixing Matrix for Rocket-Dane [Riamain: PQD-dot, Ax] Hixing Matrix : Coupled axes Mixing Matrix for Rocket-Dane [Riamain: PQD-dot, Ax] Hixing Matrix : Coupled axes Mixing Matrix for Rocket-Dane [Riamain: PQD-dot, Ax] Hixing Matrix : Discerations = Fires Order Guas Lag Transf-Vunctions : Fires Order Guas Lag Transf-Vunctions : Dische Plane at Mach-0.8; Q=160, Rigid Body, Disch Axis Pytem Modificat: Dische Plane at Mach-0.8; Q=160, Rigid Body, Disch Axis Pytem Modificat: Dische Plane at Mach-0.8; Q=160, Rigid Body, Disch Axis Pytem Modificat: Dische Plane at Mach-0.8; Q=160, Rigid Body, Disch Axis Pytem Modificat: Dische Plane at Mach-0.8; Q=160, Rigid Body File, Point to the Ext Input File The following Input Data Sets are in File: Rocket_Zing

6.1.2 Utility for Creating, Editing and Managing Batch Data-Sets

Batch sets are important for quickly processing input data files and a batch set utility is included in Flixan for creating and managing batch sets. A batch is a set of input instructions that coordinate non-interactive processing of data-sets within an input file by Flixan utilities. This is in contrast with the interactive processing that uses menus, dialogs, and graphics. The batch manager is a utility that is not only used to create new batch sets but also to modify existing data-sets and to save them under a different title in the input data file (.Inp). Batch sets are typically created for future applications after the modeling process has already been debugged interactively. To create a set of batch commands you must first plan the data processing sequence and debug one process at a time by running each data-set/ utility combination interactively, to make sure that they can be processed successfully without any errors caused by erroneous input data. When the individual steps are successfully tested, then you can use the batch utility to create a batch that will process the individual steps faster. The following is an example of creating and running a batch using the batch editor. You must first select the directory that includes at least one input data file (.Inp). In this case choose folder: "C:\Flixan\Utilities\Test\ Batch_Shuttle_Ex". Then go to Flixan main menu, click on "File Management", then "Manage Input Files", and "Edit/ Process Batch Data Sets".



This will open the batch editor dialog shown below. From the filename selection menu on the left side select the input file "*Shuttle_Stg1_T55.Inp*" and click "*Select Input File*". This input file already includes previously created data-sets ready to be processed by Flixan programs. The individual sets are either created interactively by Flixan or copied from other input files using a text editor. The menu at the bottom of this dialog shows the titles of all the data sets which are included in this file. The corresponding utility program is also shown on the left side of each title. At this point the program expects the user to either create a new batch or to modify an already existing batch. In this case the file already contains a batch set and the editor prompts the user to either select the existing batch title from a menu or to create a new batch. In this case we respond with "*Create New*" batch. We must then enter a new title for the new batch to be created: "*New Batch for the Shuttle Ascent Example*". The light blue menu at the top of the dialog will eventually show the accumulated batch commands that will be included in this batch and processed by the batch processor. Titles from the yellow menu at the bottom are gradually selected and included in the batch, one or more items at a time by clicking on "*Include Title in Batch Set*".



The light blue display on the upper right shows the user comments for the selected batch set. When starting a new batch the user must type-in the batch notes in this field, describing the function and the purpose of this batch. The notes will appear as comment lines in the new batch set in the (.Inp) file after saving it. The buttons in the lower left corner are for various editing functions. When you click on "*Retain a System in Qdr File*" or "*Retain a Matrix in Qdr*", as shown below, the program will save some of the systems and matrices from the old systems file to the new systems file. The systems filename is typically the same as the input file but with a different extension (.Qdr). The file is recreated every time you process the batch, so in order to preserve some of the old systems and matrices you must include "*Retain*" statements in the batch.

Create a Batch Set, Point	New Batch for Shuttle Ascent Example Exit	Batch Comments
an Input Data Filename and k on "Select Input File"	The following Data-Set Titles are Processed by the Batch	This batch set creates Space Shuttle Ascent models at Max Dynamic Pressure which occurs 55 seconds after
nuttle_Stg1_T55.Inp		lift-off. A rigid-body model is created and a flexible
uttle_Stg1_T55 - C uttle_Stg1_T55.inp	Select Multiple State-Space Systems from File	model with 29 mixed symmetric and anti-symmetric fle modes. Fuel sloshing for the External Tank is also
ottie_stgr_rbb.mp	Select a number of Systems from File: Shuttle_Stg1_T55.Qdr	included in the flex model and the tail-wags-dog option
	Shuttle Main Engine Actuator	turned on. Two actuator models are created,
elect Input File Edit File	Shuttle Ascent, Max_Q, T=55 sec, Flex Vehicle with Slosh and TWD Pitch Axis Discrete FCS Lateral Axes Discrete FCS Unid Gust Shaping System of Flve Actuators IMU, Gyro, Accelerometer Sensors Shuttle Plant Model at Max-Q, T=55 sec, Flex Vehicle, Actuators, Sensors) Shuttle Ascent, Max_Q, T=55 sec, Flex Vehicle with Slosh and TWD, Z-transform	
· · · · · · · · · · · · · · · · · · ·	The foll	Data-Set Comments
Create a New Batch Set	Run Ba	
Retain Systems in Qdr File	Flight Flight Select One or More System Titles and then click on "Select" Cancel Select	
Retain a Matrix in Qdr File	Modal	
clude this Title in Batch Set	Actuator Model : Shuttle Main Engine Actuator Actuator Model : Solid Rocket Booster Actuator	
emove Commands from Batch	System Connection: System of Five Actuators Transf-Functions : IMU, Gyro, Accelerometer Sensors	
	S-2-Transform : System of Five Actuators, 2-Transform S-2-Transform : IMU, Gyco, Accelerometer Sensors, 2-transform Transf-Turctions : Wind Gust Shaping	
Save Batch in Input File	Transf-Functions : Wind Gust Shaping Transf-Functions : Pitch Axis Discrete FCS Transf-Functions : Lateral Axee Discrete FCS (Roll/Yaw)	
View Data-Set Comments	System Connection: Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) System Connection: Open-Loop System (Plant + FCS)	

Create and Edit Batch Data-Sets			
To Create a Batch Set, Point to an Input Data Filename and Click on "Select Input File"	New Batch for Shuttle Ascent Example The following Data-Set Titles are Processed by the Batch	Exit	Batch Comments This batch set creates Space Shuttle Ascent models at Max Dynamic Pressure which occurs 55 seconds after
Shuttle_Stg1_T55.Inp Shuttle_Stg1_T55 - C Shuttle_Stg1_T55.Inp	Retain System : Shuttle Main Engine Actuator Retain System : Solid Rocket Booster Actuator		lift-off. A rigid-body model is created and a flexible model with 29 mixed symmetric and anti-symmetric flex modes. Fuel sloshing for the External Tank is also
	Select a Gain Matrix		included in the flex model and the tail-wags-dog option is turned on. Two actuator models are created.
	Select one of the following Matrices from Systems File: Shuttle_Stg1_T55.Qdr Sel	ect Matrix	
	TVC : Shuttle Stage-1 TVC Matrix at Max-Q	Cancel	
	Vie	ew Matrix	
Select Input File Edit File			Data-Set Comments
Create a New Batch Set Retain Systems in Qdr File	Run Batch Mode : Batch for preparing the Shuttle Ascent, First Stage Max-Q, Coupled Axes Mov Flight Vehicle : Shuttle Ascent, Max Q, T=55 sec (Rigid Body)	dels 🔺	
Retain a Matrix in Qdr File	Flight Vehicle : Shuttle Ascent, Max_Q, T=55 sec, Flex Vehicle with Slosh and TWD Modal Data : Flex Modes for Shuttle Ascent, Max_Q, T=55 sec S-2-Transform : Shuttle Ascent, Max_Q, T=55 sec, Flex Vehicle with Slosh and TWD, Z-transf.		
Include this Title in Batch Set	Actuator Model : Shuttle Main Engine Actuator Actuator Model : Shuttle Main Engine Actuator	orm E	
Remove Commands from Batch	System Connection: System of Five Actuators Transf-Functions : IMU, Gyro, Accelerometer Sensors		
Relocate Commands in Batch	S-2-Transform : System of Five Actuators, Z-Transform S-2-Transform : IMU, Gyro, Accelerometer Sensors, Z-transform Transf-Functions : Wind Gust Shaping		
Save Batch in Input File	lransf-runctions : wind Gust Snaping Transf-Functions : Pitch Axis Discrete FCS Transf-Functions : Lateral Axes Discrete FCS (Roll/Yaw)		
View Data-Set Comments	System Connection: Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) System Connection: Open-Loop System (Plant + FCS)	-	
Run the Selected Batch			

When you click on "*Retain Systems*.." or "*Retain a Matrix*.." buttons, selection menus come up showing the existing systems or matrices in the old systems file. From the menus, the user selects some of the systems or matrices to be retained in the new systems file. Obviously, only a few of them are needed. Most of them are re-created. The corresponding statements will be added in the light blue batch commands list on the top. There are also buttons for deleting some of the already existing batch commands and for relocating them within the batch. There is also a "*Run the Selected Batch*" button for testing the batch while editing, and either before or after saving it. You may start, for example, with a few commands in the batch and test them, add some more and test them again, and so on until the batch set is complete. In the following dialog we select four data-set titles from the lower menu and include them in the batch set.

To Create a Barch Set, Pioint to on Tiput Data Filemen and [Lick on "Sector Tiput Data Filemen and [Shuttle_Stg1_T55:rc] New Batch for Shuttle Ascent Example Exit Batch Comments Shuttle_Stg1_T55:rc] Reason System : Shutch Batch Bootzer Actuator Reason System Connection: System of Five Actuators, First Stage Max-Q, Coupled Axes Model Reason System Connection: System of Five Actuators Reason System Connection: System of Five Actuators Reason System Connection: System of Five Actuators System Connection: System of Five Actuators Reason System Single Actuators Reasons STransform : System of Five Actuators Reasons STransform : System of Five Actuators Reasons System Connection: System of Five Actuators Reasons System Connection: System Of Five Actuators Reasons System Connection: System Of Five Actuators Re	Create and Edit Batch Data-Sets		
Shuttle_Stg1_T55-C Patain Matrix : Shuttle Stage-1 TVC Matrix at Max-Q model with 29 mixed symmetric and anti-symmetric flex modes. Fuel solving for the External Tank is also included in the fall-wags-dog option is turned on. Two actuator models are created. Select Input File Edit File The following Data-Sets are in Input File: Shuttle_Stg1_T55.Inp Data-Set Comments Select Input File Edit File Run Batch Mode : E atch for preparing the Setup tank in Matrix 10 d/r File Data-Set Comments Retain Matrix In d/r File Retain Matrix In d/r File Mode Set Retain Systems (model : Shuttle Ancent, Max_Q, TeSE sec, Files Watchels with Elosh and TWD Data-Set Comments Retain Matrix In d/r File Mode Rote : E Batch Boder Anter, Max_Q, TeSE sec, Files Watchels with Elosh and TWD Data-Set Comments Retain Matrix In d/r File Mode Rote : State Modes for Tive Modes i : Shuttle Ancent, Max_Q, TeSE sec, Files Watchels with Elosh and TWD Data-Set Comments Retain Matrix In d/r File Mode Rote : State Modes for Tive Modes i : Shuttle Modes in the Title Matrix in Max (Max Coll action of Tive Matrix in Max (Max Coll action in Shuttle Ancent, Max_Q, TeSE sec, Files Watchels with Elosh and TWD Mode Set Comments Remove Commands from Batch Sovements : Shuttle Modes into Tive Ancentor Sovements : Shuttle Mode into Tive Ancentor Sove Batch Iniput File Sovement : State Rotes for Tive Ancentors : State Rotes for Matrix action : State Rotes for Matrix into Rote	to an Input Data Filename and Click on "Select Input File"	The following Data-Set Titles are Processed by the Batch Retain System : Shuttle Main Engine Actuator	This batch set creates Space Shuttle Ascent models at Max Dynamic Pressure which occurs 55 seconds after lift-off. A rigid-body model is created and a flexible
Greate a New Batch Set The following Data-Sets are in Input File: Shuttle_Stgl_T55.Inp Data-Set Comments Greate a New Batch Set Run Batch Mode : Batch for preparing the Shuttle Ascent, First Stage Max-Q, Coupled Axes Models A Retain Systems in Qdr File Filefit Vehicle : Shuttle Ascent, Max_Q, T=55 sec, Flax Vehicle with Stoh and TWD A Retain Addrix in Qdr File Shuttle Ascent, Max_Q, T=55 sec, Flax Vehicle with Stoh and TWD E Include this Title in Batch Set Actuator Model : Shuttle Ascent, Max_Q, T=55 sec, Flax Vehicle with Stosh and TWD, Z-transform E Remove Commands from Batch System Connection: System of Five Actuators System of Five Actuators, Z-transform E Relocate Commands in Batch S-2-Transform : System of Five Actuators, Z-transform System Connection: System of Five Actuators, Z-transform E Save Batch in Input File Transf-Functions : Wind Quest Shaping Transform System Connection: Shuttle Interfore State Sta			modes. Fuel sloshing for the External Tank is also included in the flex model and the tail-wags-dog option is
Create a New Batch Set Run Batch Mode : Batch for preparing the Shuttle Ascent, First Stage Max-Q, Coupled Axes Models Retain Systems in Qdr File Flight Vehicle : Shuttle Ascent, Max Q, T=55 sec, Hiad Body) Flight Vehicle : Shuttle Ascent, Max Q, T=55 sec, Flex Vehicle with Slohh and TWD Modal Data : Flex Modes for Shuttle Ascent, Max Q, T=55 sec S-Z-Transform : Shuttle Ascent, Max Q, T=55 sec, Flex Vehicle with Slohh and TWD Actuator Model : Shuttle Ascent, Max Q, T=55 sec Batch Hole His Title in Batch Set Actuator Model : Shuttle Ascent, Max Q, T=55 sec System Grometation: System of Five Actuators System Connection: System of Five Actuators System Strike Ascent, Strike Ascents, Z-Transform Remove Commands from Batch Relocate Commands In Batch S-2-Transform : IMU, Gyro, Accelerometer Sensors S-2-Transform : System of Five Actuators, 2-Transform Transf-Functions : Wind Gust Shaping Transf-Functions : Pitch Axis Discrete 7CS (201/Yaw) Yiew Data-Set Comments System of Functions : Lateral Axes Discrete 7CS (201/Yaw) System Connection: Shuttle Platent Macq (Flex Vehicle, Actuators, Sensors)	Select Input File Edit File	The following News Code and in Tanna File, Churcher Card, TEE Tan	Note Cat Comments
Retain Systems in Qdr File Filight Vehicle : Shuttle Ascent, Max Q, T=55 sec (Figui Body) Retain a Matrix in Qdr File Filex Modes for Shuttle Ascent, Max Q, T=55 sec, Fiex Vehicle with Slosh and TWD Modal Data : Flex Modes for Shuttle Ascent, Max Q, T=55 sec, Fiex Vehicle with Slosh and TWD Include this Title in Batch Set Shuttle Ascent, Max Q, T=55 sec, Fiex Vehicle with Slosh and TWD, Z-transform Actuator Model Shuttle Ascent, Max Q, T=55 sec, Fiex Vehicle with Slosh and TWD, Z-transform Actuator Model Shuttle Ascent, Max Q, T=55 sec, Fiex Vehicle with Slosh and TWD, Z-transform Actuator Model Solit Rocket Booster Actuator System of Five Actuators System of Five Actuators, Z-Transform Relocate Commands from Batch System of Five Actuators, Z-Transform S-Z-Transform IMU, Gyro, Accelerometer Sensors S-Z-Transform IMU, Gyro, Accelerometer Sensors, Z-transform Save Batch in Input File Transf-Functions : Wind Guest Shaping Transf-Functions INcluse Toto View Data-Set Comments System of Funct Max P (Filex Vehicle, Actuators, Sensors)	Create a New Batch Set		Data-Set Comments
Retain & Madrix in Qdr File S-2-Transform Shuttle Ascent, Max Q, T=65 sec, Flex Vehicle with Slosh and TWD, Z-transform Include this Title in Batch Set Actuator Model : Solid Rocket Booster Actuator Actuator Model : Solid Rocket Booster Actuator Remove Commands from Batch System Connection: System of Five Actuators Relocate Commands from Batch System of Five Actuators, Z-transform Save Batch in Input File Transf-Functions : Wind Quest Shaping Save Batch in Input File Transf-Functions : Lateral Axes Discrete FCS View Date-Set Comments System Connection: Shuttle Plant Mac Q (Flex Vehicle, Actuators, Sensors)	Retain Systems in Qdr File	Flight Vehicle : Shuttle Ascent, Max 2 , T=55 sec, Flex Vehicle with Slosh and TWD	
Include this Title in Batch Set Accuator Model : Solid Bocket Booster Accuator Remove Commands from Batch System of Five Actuators Relocate Commands in Batch System of Five Actuators, Z-transform : System of Five Actuators, Z-transform Save Batch in Input File Transf-Functions : Wind Gust Shaping Transf-Functions : Litteral Xxes Discrete TCS Transf-Functions : Lateral Xxes Discrete TCS View Date-Set Comments System of File Actuators (Coll/Yaw)	Retain a Matrix in Qdr File	S-Z-Transform : Shuttle Ascent, Max_Q, T=55 sec, Flex Vehicle with Slosh and TWD, Z-transform	E
Remove Commands from Batch Transf-Functions : IMU, Gyro, Accelerometer Sensors S-2-Transform : System of Five Actuators, 2-Transform S-2-Transform : System of Five Actuators, 2-Transform Save Batch in Input File Transf-Functions : Wind Gust Shaping Transf-Functions : Discrete TCS Transf-Functions : Lateral Axes Discrete TCS (Poll/Yav) View Data-Set Comments System of Functions : Suttle Platen March (Flex Vehicle, Actuators, Sensors)	Include this Title in Batch Set	Actuator Model : Solid Rocket Booster Actuator	
Relocate Commands in Batch S-Z-Transform IMU, Gyro, Accelerometer Sensors, Z-transform Save Batch in Input File Transf-Functions : Wind Gust Shaping View Data-Set Comments Functions : Lateral Axes Discrete FCS View Data-Set Comments System Connection: Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors)	Remove Commands from Batch	Transf-Functions : IMU, Gyro, Accelerometer Sensors	
Save Batch in Input File Transf-Functions : Pitch Axis Discrete FCS View Data-Set Comments System Connection: Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors)	Relocate Commands in Batch	S-Z-Transform : IMU, Gyro, Accelerometer Sensors, Z-transform	
View Data-Set Comments System Connection: Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors)	Save Batch in Input File	Transf-Functions : Pitch Axis Discrete FCS	
	View Data-Set Comments	System Connection: Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors)	-
Run the Selected Batch	Run the Selected Batch	Joysvem connection. Open body System (Fiend + Fos)	

When the batch is tested successfully you may save it in the data file by clicking on the "Save Batch in Input File". The new set of instructions will be saved at the bottom of the input data file under the new title and the new comments. The lower-left yellow menu shows the titles and processes of the data-sets located in the input file (.Inp). The user comments of the individual data-sets can also be displayed and modified using the yellow display located in the lower-right corner of the dialog. You must first select the title of the data-set from the lower-left yellow menu and the corresponding comment lines (!) will appear in the yellow field on the lower-right. This is useful when the analyst is checking the various sets of data included in the input data file. The "Edit File" button us used for editing the entire input file, as shown below.

o Create a Batch Set, Point o an Input Data Filename and	New Batch for Shuttle Ascent Example	Exit	Batch Comments This batch set creates Space Shuttle Ascent models at
lick on "Select Input File" Shuttle_Stg1_T55.Inp	The following Data-Set Titles are Processed by the Batch S-Z-Transform : Discrete Shuttle Plant Model at Max-Q (Flex Vehicle, Actuat	ors Sensors)	Max Dynamic Pressure which occurs 55 seconds after
Shutte_stg1_TS5.PC Shutte_stg1_TS5.C	System Connection: Open-Loop System (Plant + FCS) To Matlab Format : Shuttle Stage-1 TVC Matrix at Max-Q To Matlab Format : Shuttle Ascent, Max Q, T=55 sec (Rigid Body) To Matlab Format : Shuttle Asine Engine Actuator To Matlab Format : Solid Rocket Booster Actuator To Matlab Format : Solid Rocket Booster Actuator To Matlab Format : Lateral Axes Discrete FCS To Matlab Format : Lateral Axes Discrete FCS (Roll/Yaw) To Matlab Format : System of Five Actuators To Matlab Format : Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sens To Matlab Format : Shuttle Plant Model at Max-Q (Flex Vehicle with Slosh an To Matlab Format : Shuttle Plant Model at Max-Q (Flex Vehicle Actuators, Sens To Matlab Format : Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Actuat To Matlab Format : System of Five Actuators, Z-Transform To Matlab Format : System of Five Actuators, Z-transform To Matlab Format : System (Flant + FCS)	d TWD ors) d TWD, Z-transform =	Iift-off. A rigid-body model is created and a flexible model with 29 mixed symmetric and anti-symmetric flex modes. Fuel sloshing for the External Tank is also included in the flex model and the tail-wags-dag option turned on. Two actuator models are created, an SSME and an SRB, and they are combined together to form a system of 5 actuators, one for each engine. The sensor dynamics are also included. The pitch and lateral flight control systems are contructed in the z-domain with 40 msec sampling period.
Select Input File Edit File			
Create a New Batch Set	The following Data-Sets are in Input File: Shuttle_Stg1_T55.Inp Run Batch Mode : Batch for preparing the Shuttle Ascent, First Stage Max-0		
Retain Systems in Qdr File	Flight Vehicle : Shuttle Ascent, Max Q, T=55 sec (Rigid Body) Flight Vehicle : Shuttle Ascent, Max Q, T=55 sec, Flex Vehicle with Slosh		
Retain a Matrix in Qdr File	Modal Data : Flex Modes for Shuttle Ascent, Max Q, T=55 sec S-Z-Transform : Shuttle Ascent, Max Q, T=55 sec, Flex Vehicle with Slosh	The New Batch Data-Set New Batch for Shuttle Ascent Exa	ample
nclude this Title in Batch Set	Actuator Model : Shuttle Main Engine Actuator Actuator Model : Solid Rocket Booster Actuator	was saved in file: Shuttle_Stg1_T	55.Inp
Remove Commands from Batch	System Connection: System of Five Actuators Transf-Functions : IMU, Gyro, Accelerometer Sensors		
Relocate Commands in Batch	S-Z-Transform : System of Five Actuators, Z-Transform S-Z-Transform : IMU, Gyro, Accelerometer Sensors, Z-transform		ОК
Save Batch in Input File	Transf-Functions : Wind Gust Shaping Transf-Functions : Pitch Axis Discrete FCS		
View Data-Set Comments	Transf-Functions : Lateral Axes Discrete FCS (Roll/Yaw) System Connection: Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sens	ors)	
Run the Selected Batch	System Connection: Open-Loop System (Plant + FCS)	·	

BATCH MODE INSTRUCTIONS New Batch for Shuttle Ascent Example

New Batch for Shuttle Ascent Example ? This batch set creates Space Shuttle Ascent models at Max Dynamic Pressure which occurs 55 ? seconds after lift-off. A rigid-body model is created and a flexible model with 29 mixed ? symmetric and anti-symmetric flex modes. Fuel sloshing for the External Tank is also included in ? the flex model and the tail-wags-dog option is turned on. Two actuator models are created, an ? SSME and an SRB, and they are combined together to form a system of 5 actuators, one for each ? engine. The sensor dynamics are also included. The pitch and lateral flight control systems are ? contructed in the z-domain with 40 msec sampling period. Retain System Retain System : Shuttle Main Engine Actuator : Solid Rocket Booster Actuator Retain Matrix Flight Vehicle Flight Vehicle Transf-Functions South Notect Booster Actatus
 Shuttle Stage-1 TUC Matrix at Max-Q
 Shuttle Ascent, Max_Q, T=55 sec (Rigid Body)
 Shuttle Ascent, Max_Q, T=55 sec, Flex Uehicle with Slosh and TWD
 Pitch Axis Discrete FCS Transf-Functions : Lateral Axes Discrete FCS (Roll/Yaw) System Connections : Transf-Functions : Transf-Functions : System Connection: System of Five Actuators Supervised of Tree Relations INU, Gyro, Accelerometer Sensors Wind Gust Shaping Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) System Connection: Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) S-2-Transform : System of Five Actuators, Z-Transform S-2-Transform : IMU, Gyro, Accelerometer Sensors, Z-transform S-2-Transform : Shuttle Ascent, Max_Q, T=55 sec, Flex Vehicle with Slosh and TWD, Z-transform S-2-Transform : Discrete Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) System Connection: Open-Loop System (Plant + FCS) To Matlab Format : Shuttle Ascent, Max_Q, T=55 sec, Rigid Body) To Matlab Format : Shuttle Ascent, Max_Q, T=55 sec, Rigid Body) To Matlab Format : Shuttle Ascent, Max_Q, T=55 sec, Flex Vehicle with Slosh and TWD To Matlab Format : Shuttle Main Engine Actuator To Matlab Format : Shuttle Main Engine Actuator To Matlah Format Solid Rocket Booster Actuator To Matlab Format Pitch Axis Discrete FCS To Matlab Format : Lateral Axes Discrete FCS (Roll/Yaw) To Matlab Format System of Five Actuators Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) To Matlab Format Shuttle Ascent, Max_Q, T=55 sec, Flex Vehicle with Slosh and TWD, Z-transform Discrete Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) To Matlab Format To Matlab Format System of Five Actuators, Z-Transform IMU, Gyro, Accelerometer Sensors, Z-transform To Matlab Format To Matlab Format To Matlab Format : Open-Loop System (Plant + FCS)

Create a Batch Set, Point	New Batch for Shuttle Ascent Example	Exit	Batch Comments
an Input Data Filename and sk on "Select Input File"	The following Data-Set Titles are Processed by the Batch	Exit	This batch set creates Space Shuttle Ascent models at
nuttle Stg1 T55.inp	Retain System : Shuttle Main Engine Actuator		Max Dynamic Pressure which occurs 55 seconds after
	Potain System - Colid Bookat Popatar Actuator	-	lift-off. A rigid-body model is created and a flexible
uttle_Stg1_T55 Batch Mod	e Execution		model with 29 mixed symmetric and anti-symmetric fle modes. Fuel sloshing for the External Tank is also
Retain	System : Shuttle Main Engine Actuator		included in the flex model and the tail-wags-dog option
Retain		A I	turned on. Two actuator models are created, an SSME
	Matrix : Shutle Stage-1 TVC Matrix at Max-Q		and an SRB, and they are combined together to form a
	Vehicle : Shuttle Ascent, Max Q, T=55 sec (Rigid Body)		
	Vehicle : Shuttle Ascent, Max Q, T=55 sec, Flex Vehicle with Slosh and TWD		system of 5 actuators, one for each engine. The senso
	Functions : Ditch Axis Discrete FCS		dynamics are also included. The pitch and lateral fligh
	Functions : Lateral Axes Discrete FCS (Roll/Yaw)		control systems are contructed in the z-domain with 4
	Connection: System of Five Actuators	=	msec sampling period.
	Functions : IMU, Gyro, Accelerometer Sensors		insec sumpring period.
	Functions : Wind Gust Shaping		
	Connection: Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors)		
	s Some State of Five Actuators, 2-Transform		
	Inform : IMU, Gyro, Accelerameter Sensors, Z-transform		
	: Shuttle Ascent, Max Q, T=55 sec, Flex Vehicle with Slosh and TWD, Z-transform		
S-Z-Tra			
	Connection: Open-Loop System (Plant + FCS)		Data-Set Comments
	ab Format : Shuttle Starge-1 TVC Matrix at Max-Q		
	ab Format : Shuttle Ascent, Max Q. T=55 sec (Rigid Body)	_	
	ab Format : Shuttle Ascent, Mar.Q. T=55 sec. Flex Vehicle with Slosh and TWD		
	ab Format : Shuttle Main Engine Actuator	-	
Retain a Matrix	ab Format . Shutte Main Engine Adduator		
clude this Title	Actuator Model : Solid Kocket Booster Actuator		/
	System Connection: System of Five Actuators		
emove Commands from Batch	Transf-Functions : IMU, Gyro, Accelerometer Sensors		
	S-Z-Transform : System of Five Actuators, Z-Transform		
elocate Commands in Batch	S-Z-Transform : IMU, Gyro, Accelerometer Sensors, Z-transform		
Save Batch in Input File	Transf-Functions : Wind Gust Shaping Transf-Functions : Pitch Axis Discrete FCS		
Save Succir in input File	Transf-Functions : Pitch Axis Discrete FCS Transf-Functions : Lateral Axes Discrete FCS (Roll/Yaw)		
View Data-Set Comments	System Connection: Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors)		
Run the Selected Batch	System Connection: Open-Loop System (Plant + FCS)	÷	

When you click on "*Run the Selected Batch*" the program will process the selected batch set, create new systems and matrices, and save them in systems file "*Shuttle_Stg1_T55.Qdr*". A display momentarily pop-up, while the program is processing the input file, showing the set that is currently being processed. This is mainly for debugging purposes and for locating the problem in case of an error.

6.1.3 Processing the new Batch Using the File Manager

This newly created batch can also be processed via the file manager utility. From the Flixan main menu select "*Edit/ Process Input Data*", then from the file manager dialog select the input file "*Shuttle_Stg1_T55.Inp*", and find the newly created batch set "*New Batch for Shuttle Ascent Example*" which is originally located at the bottom of the file. Highlight this batch set and relocate it closer to the top, right below the original batch, as shown.

Select a Project Directory	💊 Flixan, Flight Vehicle Modeling & Control System Analysis
C:\Flixan\Utilities\Test\Batch_Shuttle_Ex	Utilities File Management Program Functions View Quad Help
	Managing Input Files (.Inp) Edit / Process Batch Data Sets
Modify MRed	Managing System Files (.Qdr) Edit / Process Input Data Files
▶ Bacculo P	
📕 Text	
D J Time_Sim D III D IIII D III D IIII D III D IIIII D IIII D IIIII D IIII D IIII D IIII D IIII D IIIII D IIII D IIII D IIII D IIII D IIIII D IIII D IIII D IIII D IIII D IIIII D IIII D IIII D IIII D IIIII D IIIIII	E
↓ ↓ Utilities	
a 🔒 Test	
▷ 퉲 Batch_Shuttle_Ex	
To From Matlab	
⊵ 🁑 Word	
ОК	Cancel
Process Input Data Files	
Point to an Input Data Filename and Click on "Select Input File" The	following Input Data Sets are in File: Shuttle_Stg1_T55.Inp
Shuttle_Stg1_T55.Inp	Transform : IMU, Gyro, Accelerometer Sensors, 2-transform .
Shuttle_Stg1_T55 - C	sf-Functions : Wind Gust Shaping sf-Functions : Pitch Axis Discrete FCS
Edit input File	sf-Functions : Lateral Axes Discrete FCS (Roll/Yaw) em Connection: Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors)
	em Connection: Open-Loop System (Plant + FCS) Transform : Discrete Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors)
	atlab Format : Shuttle Stage-1 TVC Matrix at Max-Q atlab Format : Shuttle Ascent, Max_Q, T=55 sec (Rigid Body)
To M	atlab Format : Shuttle Ascent, Max_Q, T=55 sec, Flex Vehicle with Slosh and TWD atlab Format : Shuttle Main Engine Actuator
To M	atlab Format : Solid Rocket Booster Actuator atlab Format : Pitch Axis Discrete FCS
	atlab Format : Lateral Axes Discrete FCS (Roll/Yaw) atlab Format : System of Five Actuators
	atlab Format : Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) atlab Format : Shuttle Ascent, Max_Q, T=55 sec, Flex Vehicle with Slosh and TWD, Z-transform
	atlab Format : Discrete Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) atlab Format : System of Five Actuators, Z-Transform
	atlab Format : IMU, Gyro, Accelerometer Sensors, Z-transform atlab Format : Open-Loop System (Plant + FCS)
Comments, Data-Set User Nates	Batch Mode : New Batch for Shuttle Ascent Example
This batch set creates Relocate Data Set in Input File	reconds after lift-off. A rigid-body model is created and a flexible model with 29 mixed
symmetric and anti-sym	mber 2 - from the Top OK the flex model and the tail-wags-dog option is turned on. Two actuator models are
engine deflections (dy), and tor yow detlections (dz). The s	ensor aynamics are also included. The pitch and lateral flight control systems are contructed in the z-domain with 40 msec
the steel to be a start to be a start of the	ombined together to create a coupled continuous plant model which is also discretized at 40 msec. The created systems are

Then go to the menu on the right and select the new batch title, as shown below. Also click on "*View Data-Set Comments*" to be able to read the batch comments at the bottom of the dialog. Then click on "*Process/View Input Data*" to process the batch.

elect Input File"		The following data sets are now in input file: Shuttle_Stg1_T55.Inp —	
huttle_Stg1_T55.Inp	Select Input File	Run Batch Mode : Batch for preparing the Shuttle Ascent, First Stage Max-Q, Coupled Axes Models Run Batch Mode : New Batch for Shuttle Ascent Example	
nuttle_Stg1_T55 - C nuttle_Stg1_T55.Inp	Edit Input File	Flight Vehicle : Shuttle Ascent, Max_Q, T=55 sec (Rigid Body) Flight Vehicle : Shuttle Ascent, Max_Q, T=55 sec, Flex Vehicle with Slosh and TWD Modal Data : Flex Modes for Shuttle Ascent, Max Q, T=55 sec	
	Process/ View Input Data	S-Z-Transform : Shuttle Ascent, Max_Q, T=55 sec, Flex Vehicle with Slosh and TWD, Z-transform Actuator Model : Shuttle Main Engine Actuator Actuator Model : Solid Rocket Booster Actuator	
	Delete Data Sets in File	System Connection: System of Five Actuators Transf-Functions : IMU, Gyro, Accelerometer Sensors	
	Relocate Data Set in File	S-Z-Transform : System of Five Actuators, Z-Transform S-Z-Transform : IMU, Gyro, Accelerometer Sensors, Z-transform Transf-Functions : Wind Gust Shaping	
	Copy Set to Another File	Transf-Functions : Pitch Axis Discrete FCS Transf-Functions : Lateral Axes Discrete FCS (Roll/Yaw)	
	View Data-Set Comments	System Connection: Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) System Connection: Open-Loop System (Plant + FCS) S-Z-Transform : Discrete Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) To Matlab Format : Shuttle Stage-1 TVC Matrix at Max-Q	
		To Matlab Format : Shuttle Ascent, MaxQ, T=55 sec (Rigid Body) To Matlab Format : Shuttle Ascent, MaxQ, T=55 sec, Flex Vehicle with Slosh and TWD To Matlab Format : Shuttle Main Engine Actuator	
nments, Data-Set Us	er Notes		
mmetric and anti-syn reated, an SSME and	nmetric flex modes. Fuel slost	s at Max Dynamic Pressure which occurs 55 seconds after lift-off. A rigid-body model is created and a flexible model with 29 mix ning for the External Tank is also included in the flex model and the tail-wags-dog option is turned on. Two actuator models are ed together to form a system of 5 actuators, one for each engine. The sensor dynamics are also included. The pitch and lateral flig h 40 msec sampling nerind.	

elect Input File"	The following data sets are now in input file: Shuttle_Stg1_T55.Inp		_
nuttle_Stg1_T55.Inp	Dun Ratch Mode · Ratch for preparing the Shuttle Agrent First Stage May-O Coupled Av	Models	_
uttle_Stg1_T55 - C	Batch Mode Execution		
uttle_Stg1_T55.Inp		-	
	Retain System : Shuttle Main Engine Actuator		
	Retain System : Solid Rocket Booster Actuator	nsform	
_	Retain Matrix : Shuttle Stage-1 TVC Matrix at Max-Q		
	Flight Vehicle : Shuttle Ascent, Max_Q, T=55 sec (Rigid Body)		
	Flight Vehicle : Shuttle Ascent, Max_Q, T=55 sec, Flex Vehicle with Slosh and TWD		
_	Transf-Functions : Pitch Axis Discrete FCS		
_	Transf-Functions : Lateral Axes Discrete FCS (Roll/Yaw)		
	System Connection: System of Five Actuators		
	Transf-Functions : IMU, Cyro, Accelerometer Sensors		
_	Transf-Functions : Wind Gust Shaping		
	System Connection: Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors)		
	S-Z-Transform : System of Five Actuators, Z-Transform S-Z-Transform : IMU, Gyro, Accelerometer Sensors, Z-transform		
_	S-2-Transform : Shuttle Ascent, Max Q. T=55 sec. Flex Vehicle with Slosh and TWD, Z-transform		
	S-2-Transform : Discrete Shuttle Plant Model at Max-Q (Flex Vehicle Actuators, Sensors)	b	
	System Connection: Open-Loop System (Plant #0001 at Max 0 (Field Venicite, Actuators, Sensors)		
_	To Matlab Format Sphericology system (Filmt + Fils)		
_	To Matlab Format : Shuttle Ascent, Max Q, T=55 sec (Right Body)		
_	To Matlab Format : Shuttle Ascent, Mar Q, T=55 sec. Flex Vehicle with Slosh and TWD		
nments, Data-Set U			
			_
is batch set creates		el with 29 mixed	
mmetric and anti-syn	metric tlex modes. Fuel sloshing for the External lank is also included in the flex model and the fail-wags-dog option is turned on. I wo actu	ator models are	
anted on COME and	l an SRB, and they are combined together to form a system of 5 actuators, one for each engine. The sensor dynamics are also included. The pit	oh and latonal flicht	

The new batch is then processed by Flixan and the new systems are saved in file: "Shuttle_Stg1-T55.Inp".

6.2 System Files (.Qdr)

A systems file consists of state-space systems and single matrices which are generated by Flixan programs and utilities, similar to the file below. Each system or matrix has a title followed by comment lines below the title. Single matrices also have a short name in addition to the title. You must avoid using: A, B, C, D, for single matrix names because they are reserved for state-space system matrices. Input and output definitions are also included below the matrix or system data.

```
GAIN MATRIX FOR ...
Shuttle Stage-1 TVC Matrix at Max-Q
! Converts the Roll, Pitch, and Yaw FCS Demands to Pitch and Yaw Engine Deflections
                     Size = 10 X 3
Matrix TVC
        1-Roll
                      2-Pitch
                                      3-Yaw
  1-dy1 0.0
                      1.28
                                     0.0
  2-dy2 -0.2518
                     1.28
                                     0.0
                 1.28
1.28
0.6
0.0
0.0
0.0
0.0
0.0
0.0
  3-dy3 0.2518
                     1.28
0.6
                                     0.0
  4-dy4 -0.35
                                     0.0
  5-dy5 0.35
                                     0.0
  6-dz1 -0.189
                                     0.61
  7-dz2 0.0
                                     0.61
  8-dz3 0.0
                                     0.61
  9-dz4 0.0
                                     0.43
 10-dz5 0.0
                      0.0
                                     0.43
            _____
                                           _____
Definitions of Matrix Inputs (Columns): 3
DP_TVC Roll FCS Demand About X Axis
DQ_TVC Pitch FCS Demand About Y Axis
DR_TVC Yaw
        FCS Demand About Z Axis
Definitions of Matrix Outputs (Rows):
                               10
Dy_engine 1 Centr SSME Pitch Deflection (rad)
Dy_engine 2 Left SSME Pitch Deflection (rad)
Dy_engine 3 Right SSME Pitch Deflection (rad)
Dy_engine 4 Left SRB Pitch Deflection (rad)
Dy engine 5 Right SRB Pitch Deflection (rad)
Dz_engine 1 Centr SSME Yaw Deflection (rad)
Dz_engine 2 Left SSME Yaw Deflection (rad)
Dz_engine 3 Right SSME Yaw Deflection (rad)
Dz_engine 4 Left SRB Yaw Deflection (rad)
Dz_engine 5 Right SRB Yaw Deflection (rad)
STATE-SPACE SYSTEM ...
Shuttle Main Engine Actuator
! Shuttle Main Engine Actuator Without Compensator Using the Hydraulic Actuator Model Type (B)
Number of Inputs, States, Outputs, Sample Time dT (for discrete)= 2 4
                                                          3
                                                               0.0000
Matrices: (A,B,C,D)
                    Size = 4 X 4
Matrix A
                                      3-Column
        1-Column
                      2-Column
                                                     4-Column
  1-Row -0.521007765548E+02 -0.116700557842E+02 -0.109601849353E+02 -0.203189376000E+01
  2-Row -0.53950000000E+02 -0.142437261803E+02 -0.133773030730E+02 0.00000000000E+00
  -----
                 Size = 4 \times 2
Matrix B
        1-Column
                       2-Column
  1-Row 0.402237129840E+02 0.0000000000E+00
  2-Row 0.490945000000E+02 0.00000000000E+00
3-Row 0.00000000000E+00 0.00000000000E+00
  -----
                   Size = 3 \times 4
Matrix C
                       2-Column
        1-Column
                                      3-Column
                                                     4-Column
  -----
                Size = 3 X 2
Matrix D
                      2-Column
        1-Column
  2-Row 0.00000000000E+00 0.0000000000E+00
  3-Row 0.00000000000E+00 0.221434898140E-03
```

```
Definition of System Variables
Inputs =
        2
     Nozzle Deflection Command (Delta_com) (rad)
     Load-Torque at the Gimbal, (Tl) (ft-lb)
Outputs =
         3
     Nozzle Gimbal Rotation (Delta) (rad)
     Nozzle Gimbal Rate (Delta-dot) (rad/sec)
     Gimbal Accelerat. (Delta-dot-dot) (rad/sec^2)
States =
        4
     Differ. Pressure Feedback (DPF) (ft-lb)
     Piston Displacement (Xr)
                               (feet)
     Engine Gimbal Rotation (Delta) (rad)
     Engine Gimbal Rate (Delta-dot) (rad/sec)
_____
                                       _____
Gain Matrix for ...
Pitch axis Mixing Matrix for Rocket-Plane [Kpitmix: Q-dot, Ax]
! Mixing Logic Matrix for the rocket-plane in the pitch axis. It converts the pitch and
! axial acceleration demands to five aero-surface deflections and engine thrust variation
                Size = 6 X 2
Matrix Kpitmix
      1-Column
                      2-Column
  1-Row -0.488779040922E-01 0.982582014775E-01
  2-Row -0.291806701836E-01 -0.310962189063E-02
  3-Row -0.291806701836E-01 -0.310962189063E-02
  4-Row -0.127295123699E+00 0.117463289448E-03
  5-Row -0.127295123699E+00 0.117463289448E-03
6-Row -0.370557557847E-01 0.137897247667E-02
    -----
                                                 _____
Definitions of Matrix Inputs (Columns):
                                 2
Q-dot Pitch Accel Demand About Y Axis
Ax Forward Accel Demand Along X Axis
Definitions of Matrix Outputs (Rows):
                                 б
Output: 1 Delta(throttle) of Engine No: 1
Output: 2 Control Surface: 1 Deflection (radians)
Output: 3 Control Surface: 2 Deflection (radians)
Output: 4 Control Surface: 3 Deflection (radians)
Output: 5 Control Surface: 4 Deflection (radians)
Output: 6 Control Surface: 5 Deflection (radians)
_____
STATE-SPACE SYSTEM ...
First Order Gust Lag
! A low-pass filter 0.5 (rad/sec) to smooth out the input gust
Number of Inputs, States, Outputs, Sample Time dT (for discrete)= 1 1 1 0.0000
Matrices: (A,B,C,D)
                     Size = 1 X 1
Matrix A
        1-Column
  1-Row -0.50000000000E+00
    _____
Matrix B
                     Size = 1 X 1
        1-Column
  1-Row 0.1000000000E+01
_____
                                  _____
Matrix C
                    Size = 1 X 1
        1-Column
  1-Row 0.50000000000E+00
_____
                           _____
                     Size = 1 X 1
Matrix D
        1-Column
  1-Row 0.00000000000E+00
_____
Definition of System Variables
Inputs = 1
 1 Input No: 1
States = 1
 1 State No: 1
Outputs = 1
 1 Output No: 1
                     _____
```

STATE-SPACE SYSTEM ... Pitch Design Model ! The pitch axis control design model is extracted from the coupled rigid-body model. The ! wind-gust input is not used. The states and outputs are: (theta, q, and alpha) Number of Inputs, States, Outputs, Sample Time dT (for discrete)= 6 3 3 0.0000 Matrices: (A,B,C,D) Matrix A Size = 3 X 3 2-Column 1-Column 3-Column 3-Row 0.533570410077E-08 0.997318761156E+00 -0.303460356762E+00 _____ Size = 3 X 6 Matrix B 1-Column 2-Column 3-Column 4-Column 5-Column 6-Column 2-Row -0.383726824856E-01 -0.873361046148E+00 -0.873361046148E+00 -0.363483208593E+01 -3-Row -0.149738604708E-03 -0.251044848966E-01 -0.251044848966E-01 -0.214350479379E-01 -_____ Matrix C Size = 3 X 3 1-Column 2-Column 3-Column 1-Row 0.1000000000E+01 0.0000000000E+00 0.000000000E+00 _____ Size = 3 X 6 Matrix D 2-Column 1-Column 3-Column 4-Column 5-Column 6-Column _____ Definition of System Variables 6 Inputs = 1 Throttle Input dTh/Th for Engine No 1 (-) Aero Surface No 1 Deflection (radians) (radians) 3 Aero Surface No 2 Deflection 4 Aero Surface No 3 Deflection (radians) 5 Aero Surface No 4 Deflection (radians) 6 Aero Surface No 5 Deflection (radians) States = 31 Pitch Attitude (theta-rigid) (radians) Pitch Rate (q -rigid) (rad/sec) Angle of attack (alfa-rigid) (radians) 2 Pitch Rate 3 Outputs = 3 1 Pitch Attitude (thet-123) (radians) 2 Pitch Rate (q-body) (rad/sec) 3 Angle of attack, alfa, (radians) _____ STATE-SPACE SYSTEM ... Pitch Design Model with Alpha Integral (2-inputs, 4-states) ! The pitch axis control design model is augmented with the integral of the angle of attack for ! H-infinity design. The states and outputs are: (theta, q, alpha, and alpha-integral). The ! inputs to the design model are reduced to two by pre-multiplying it with the mixing matrix ! (Kpitmix) Number of Inputs, States, Outputs, Sample Time dT (for discrete)= 2 4 4 0 0000 Matrices: (A,B,C,D) Size = 4×4 Matrix A 1-Column 2-Column 3-Column 4-Column 3-Row 0.533570410077E-08 0.997318761156E+00 -0.303460356762E+00 0.00000000000E+00 ------Size = 4×2 Matrix B 2-Column 1-Column 3-Row 0.702100385268E-02 0.132980916263E-03 4-Row 0.00000000000E+00 0.0000000000E+00 _____

```
Size = 4 \times 4
Matrix C
      1-Column
                 2-Column
                               3-Column
                                            4-Column

        1-Row
        0.10000000000E+01
        0.000000000E+00
        0.0000000000E+00
        0.0000000000E+00

        2-Row
        0.0000000000E+00
        0.1000000000E+01
        0.0000000000E+00
        0.0000000000E+00

 ------
              Size = 4 X 2
Matrix D
                  2-Column
      1-Column
 4-Row 0.000000000000E+00 0.0000000000E+00
 _____
Definition of System Variables
Tnputs = 2
 1 Pitch Acceleration
 2 Axial Acceleration
      4
States =
 1 State No: 1
  2 State No: 2
 3 State No: 3
4 State No: 4
Outputs = 4
 1Pitch Attitude(theta-rigid)(radians)2Pitch Rate(q -rigid)(rad/sec)
               (q-rigid) (rad/sec)
(alpha) (radians)
 3 Angle of attack (alpha)
                        (rad-sec)
 4 Alpha Integral
               _____
_____
STATE-SPACE SYSTEM ...
Pitch Design Model with Alpha Integral (1-input, 4-states)
! Eliminate the second input (Ax acceleration) from the pitch design model
Number of Inputs, States, Outputs, Sample Time dT (for discrete)= 1 4 4 0.0000
Matrices: (A,B,C,D)
                 Size = 4 \times 4
Matrix A
                   2-Column
                               3-Column
      1-Column
                                            4-Column
 2-Row 0.00000000000E+00 -0.301385824515E+00 -0.398388623235E+01 0.00000000000E+00
 3-Row 0.533570410077E-08 0.997318761156E+00 -0.303460356762E+00 0.00000000000E+00
 _____
                Size = 4 X 1
Matrix B
      1-Column
 2-Row 0.999912364254E+00
 3-Row 0.702100385268E-02
 4-Row 0.00000000000E+00
_____
                            _____
              Size = 4 X 4
2-Column
Matrix C
      1-Column
                                3-Column
                                             4-Column
 -----
Matrix D
                Size = 4 X 1
      1-Column
 2-Row 0.0000000000E+00
 3-Row 0.00000000000E+00
 4-Row 0.00000000000E+00
_____
                       _____
Definition of System Variables
Inputs = 1
 1 Pitch Acceleration
States = 4
 1 State No: 1
 2 State No: 2
3 State No: 3
                                124
```

```
Outputs = 4
  1 Pitch Attitude
                     (theta-rigid) (radians)
                    (q-rigid) (rad/sec)
(alpha) (radians)
  2 Pitch Rate
  3 Angle of attack (alpha)
  4 Alpha Integral
                                   (rad-sec)
_____
                                                 _____
                     _____
Gain Matrix for ...
Coupled axes Mixing Matrix for Rocket-Plane [K4axmix: PQR-dot, Ax]
! This mixing logic uses all five control surfaces and the variable throttling engine to achieve
! roll, pitch, yaw attitude control plus axial (Ax) acceleration control
Matrix K4axmix Size = 6 X 4
         1-Column
                          2-Column
                                             3-Column
                                                               4-Column
  2-Row 0.321285869960E-01 -0.291806701836E-01 0.176524775014E+00 -0.310962189063E-02
  3-Row -0.321285869960E-01 -0.291806701836E-01 -0.176524775014E+00 -0.310962189063E-02
  4-Row 0.878975586914E-02 -0.127295123699E+00 -0.123043886641E+00 0.117463289448E-03
  5-Row -0.878975586914E-02 -0.127295123699E+00 0.123043886641E+00 0.117463289448E-03
  -----
Definitions of Matrix Inputs (Columns):
                                     - 4
P-dot Roll Accel Demand About X Axis
Q-dot Pitch Accel Demand About Y Axis
R-dot Yaw Accel Demand About Z Axis
Ax Forward Accel Demand Along X Axis
Definitions of Matrix Outputs (Rows):
                                      6
Output: 1 Delta(throttle) of Engine No: 1
Output: 2 Control Surface: 1 Deflection (radians)
Output: 3 Control Surface: 2 Deflection (radians)
Output: 4 Control Surface: 3 Deflection (radians)
Output: 5 Control Surface: 4 Deflection (radians)
Output: 6 Control Surface: 5 Deflection (radians)
Gain Matrix for ...
Lateral axes Mixing Matrix for Rocket-Plane [Klat: PR-dot]
! This mixing logic uses only four control surfaces for lateral (roll and yaw) control. It is
! based on a separate vehicle model which does not use the engine and the body-flap
                     Size = 4 X 2
Matrix Klat
         1-Column
                          2-Column
  1-Row 0.321285869960E-01 0.176524775014E+00
2-Row -0.321285869960E-01 -0.176524775014E+00
  3-Row 0.878975586914E-02 -0.123043886641E+00
  4-Row -0.878975586914E-02 0.123043886641E+00
                                               _____
  _____
Definitions of Matrix Inputs (Columns): 2
P-dot Roll Accel Demand About X Axis
R-dot Yaw Accel Demand About Z Axis
Definitions of Matrix Outputs (Rows):
Output: 1 Control Surface: 1 Deflection (radians)
Output: 2 Control Surface: 2 Deflection (radians)
Output: 3 Control Surface: 3 Deflection (radians)
Output: 4 Control Surface: 4 Deflection (radians)
_____
STATE-SPACE SYSTEM ...
Lateral Design Model
! A further simplified lateral axes rigid-body model is extracted from the coupled rigid-body
! model to be used for LQR control design. It consists of three states: (p, r, and beta)
Number of Inputs, States, Outputs, Sample Time dT (for discrete)= 4 3 3 0.0000
Matrices: (A,B,C,D)
                        Size = 3 X 3
Matrix A
         1-Column
                          2-Column
                                            3-Column
  1-Row -0.571243257881E+00 0.588055221219E+00 -0.184398767835E+02
  2-Row 0.198513239863E-01 -0.198692970677E+00 0.142318779813E+00
  3-Row 0.349050142074E-01 -0.998225203528E+00 -0.101044964581E+00
_____
                                                                     _____
              Size = 3 X 4
Matrix B
                          2-Column
         1-Column
                                             3-Column
                                                               4-Column
  1-Row 0.111759819563E+02 -0.111759819563E+02 0.160336238937E+02 -0.160336238937E+02
  2-Row 0.798367964709E+00 -0.798367964709E+00 -0.291807761069E+01 0.291807761069E+01
  3-Row -0.102729036961E-01 0.102729036961E-01 0.197449806024E-01 -0.197449806024E-01
```

4 State No: 4

```
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```

Size = 3×3 Matrix C 2-Column 1-Column 3-Column
 1-Row
 0.10000000000E+01
 0.000000000E+00
 0.0000000000E+00

 2-Row
 0.0000000000E+00
 0.1000000000E+01
 0.0000000000E+00
 _____ _____ Size = 3 X 4 Matrix D 2-Column 1-Column 3-Column 4-Column _____ Definition of System Variables Inputs = 4 1 Aero Surface No 1 Deflection (radians) Aero Surface No2 Deflection(radians)Aero Surface No3 Deflection(radians) 2 3 Aero Surface No 3 Deflection (radians)4 Aero Surface No 4 Deflection (radians) States = 3 Roll Rate(p -rigid)(rad/sec)Yaw Rate(r -rigid)(rad/sec) 1 Roll Rate 3 Angle of sideslip (beta-rigid) (radians) Outputs = 3 (rad/sec) 1 Roll Rate (p-body) 2 Yaw Bate (r-body) Yaw Rate (r-body) (rad/sec) 3 Angle of sideslip, beta, (radian) _____ STATE-SPACE SYSTEM ... Lateral Design Model with p-Integral (4-states) ! The Lateral Axes control design model is augmented with the integral of roll rate. The states ! for LQR design are: (p,r, beta, and p-Integral) Number of Inputs, States, Outputs, Sample Time dT (for discrete)= 2 4 4 0.0000 Matrices: (A,B,C,D) Size = 4 X 4Matrix A 2-Column 3-Column 1-Column 4-Column 1-Row -0.571243257881E+00 0.588055221219E+00 -0.184398767835E+02 0.000000000000E+00 2-Row 0.198513239863E-01 -0.198692970677E+00 0.142318779813E+00 0.00000000000E+00 3-Row 0.349050142074E-01 -0.998225203528E+00 -0.101044964581E+00 0.0000000000E+00 Size = 4 X 2 Matrix B 2-Column 1-Column 1-Row 0.100000029654E+01 -0.340084894157E-05 2-Row 0.248960760822E-05 0.999966672176E+00 3-Row -0.313000641931E-03 -0.848584233733E-02 4-Row 0.000000000000E+00 0.00000000000E+00 _____ Size = 4 X 4Matrix C 2-Column 3-Column 1-Column 4-Column
 1-Row
 0.1000000000E+01
 0.000000000E+00
 0.000000000E+00
 0.000000000E+00

 2-Row
 0.000000000E+00
 0.1000000000E+01
 0.000000000E+01
 0.000000000E+00
 _____ _____ Size = 4 X 2 Matrix D 2-Column 1-Column 3-Row 0.00000000000E+00 0.0000000000E+00 _____ Definition of System Variables Inputs = 2 Aileron Deflection (rad)
 Rudder Deflection (rad) Outputs = 4 (p-body) 1 Roll Rate 2 Yaw Pott (rad/sec) Yaw Rate (r-body) (rad/sec) 3 Angle of sideslip, beta, (radian) (rad) 4 p-Integral -----

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6.2.1 Managing System Files

The systems file management utility is used for organizing system files and it is similar to the input data file management utility. Maintaining organized system files by introducing comments, labeling the system inputs, states, and output variables, keeping the systems and matrices in a sequential order, and deleting the unused older versions is a very attractive feature for documenting the analysis. The comments, notes and name-lists of the system variables are useful for remembering details, especially when you have to discontinue the analysis for a period of time and resume it later in the future. To get to the systems manager utility, the user must first select the project directory, and from the Flixan main menu select: "*File Management*", "*Managing System Files (Qdr)*", and "*Edit/ View/ Copy System Files*", as shown below.

Size Flixan, Flight Vehicle Modeling & Control System Analysis					
Utilities File Management Program Functions			View Quad Help		
	Managing Input Files (.Inp)	►			
	Managing System Files (.Qdr)	۲	Create a New Matrix in System File		
			Create a New State-Space System		
			Edit/ View/ Copy System Files		
			Read Ascii Files from Matlab		
		-	Export Flixan Systems to Matlab		

The systems file manager dialog is shown below. The menu on the left side shows the system files which are located in the project directory. The user selects a filename, for example, "*Shuttle_Stg1_T55.Qdr*", and clicks on "*Select Systems File*". The menu on the right will then display the titles of the systems or single matrices which are saved in the systems file, as shown below. The user is then able to perform several operations on this file using the dialog buttons. For example, delete some of the systems or matrices which are no longer used, move them to a different location within the file, and edit the systems file using a Flixan provided text editor. The repositioning of each item is defined relative to the top of the file. The "*View/ Modify Systems*" button is used to display the state-space system or matrix using color coded graphics, including tables of the system inputs, states, outputs, and display the user comments or notes that describe the system or the gain matrix. The state variable definitions and comments can be modified using the interactive dialogs.

To Select a Systems File Point to a Filename Ind Click on "Select Systems File"	The following systems or matrices are in this file	Exit
Shuttle_Stg1_T55.Qdr Big_Matrices.qdr Modif3.Qdr Modif3.Qdr RocketPlane_RB.Qdr Shuttle_Stg1_T55.Qdr T800.Qdr Temp5.Qdr Zulu_MaxQ_Latr.Qdr Relocate a System in File Copy to Another .Qdr File	Matrix TVC: Shuttle Stage-1 TVC Matrix at Max-Q State System: Shuttle Main Engine Actuator State System: Shuttle Ascent, Max_Q, T=55 sec, Rigid Body) State System: Shuttle Ascent, Max_Q, T=55 sec, Flex Vehicle with Slosh and TWD State System: Pitch Axis Discrete FCS State System: Lateral Axes Discrete FCS (Roll/Yaw) State System: IMID Gust Shaping State System: Nind Gust Shaping State System: Shuttle Piant Model at Max-Q (Flex Vehicle, Actuators, Sensors) State System: Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) State System: Discrete Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) State System: Discrete Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) State System: Discrete Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) State System: Discrete Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) State System: Discrete Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) State System: Discrete Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) State System: Discrete Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) State System: Discrete Shuttle Plant Hodel at Max-Q (Flex Vehicle, Actuators, Sensors) State System: Discrete Shuttle Plant Hodel at Max-Q (Flex Vehicle, Actuators, Sensors) State System: Dyro, Accelerometer Sensors, Z-transform State System: Open-Loop System (Plant + FCS)	

The "Copy to Another .Qdr File" button is used to copy a group of systems and single matrices to another systems file. You must first select from the right menu all the systems and matrices to copy from the original file and click on "Copy to Another .Qdr File" button. The lower part of the dialog opens up showing two additional menus and buttons. From the lower-left menu select the destination systems file. In this case we select the empty file "NewFile.Qdr" and click on "Select Destination File". The selected systems and matrices from the top-right menu will now appear in the lower-right display, but they are not copied yet. Click on "Copy Selected Systems" and the selected items will be copied to file "NewFile.Qdr". If the destination file is not empty but already includes some previous systems, these items will be preserved in this file after the transfer. The new items will be added at the bottom of the file and the lower-right display will show both old and new. Click on "Close" and the dialog will return to its original size showing only the top part.

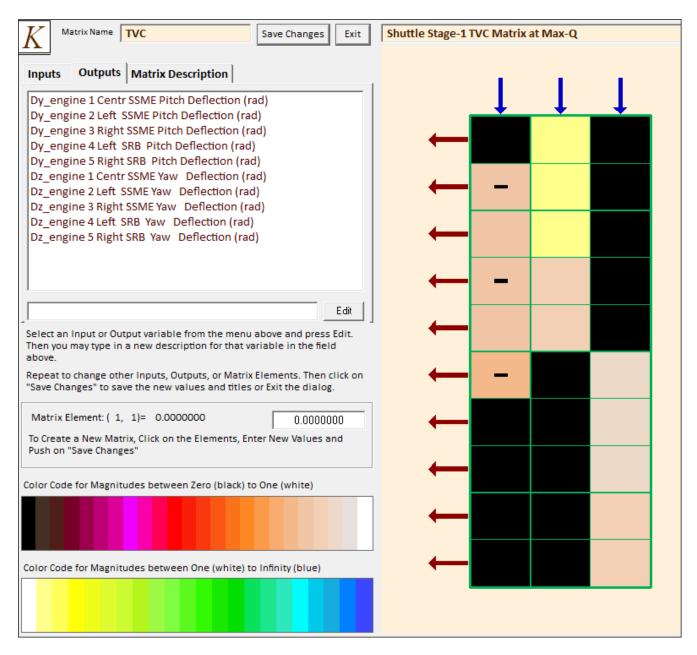
iew and Manage System I	Files		
To Select a Systems File and Click on "Select Syst		The following Systems or Matrices are in Systems File: Shuttle_Stg1_T55.Qdr	Exit
Shuttle_Stg1_T55.Qdr	Select Systems File	Matrix TVC: Shuttle Stage-1 TVC Matrix at Max-Q State System: Shuttle Main Engine Actuator	
Big_Matrices.qdr Modif3.Qdr Modif3o.Qdr	Edit Systems File	State System: Solid Rocket Booster Actuator State System: Shutle Ascent, Max_Q, T=55 sec (Rigid Body) State System: Shutle Ascent, Max Q, T=55 sec, Flex Vehicle with Slosh and TWD	
RocketPlane_RB.Qdr Shuttle_Stg1_T55.Qdr T800.Qdr	View / Modify Systems	State System: Pitch Axis Discrete FCS State System: Lateral Axes Discrete FCS (Roll/Yaw) State System: Wind Gust Shaping	
Temp5.Qdr Zulu_MaxQ_Latr.Qdr	Delete Systems in File	State System: System of Five Actuators State System: IMU, Gyzo, Accelerometer Sensors	
20.2Hox4_cont.col	Relocate a System in File	State System: Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors) State System: Shuttle Ascent, Max_Q, T=55 sec, Flex Vehicle with Slosh and TWD, Z-transform State System: Discrete Shuttle Plant Model at Max-Q (Flex Vehicle, Actuators, Sensors)	
	Copy to Another .Qdr File	State System: System of Five Actuators, Z-Transform State System: NWU, Gyro, Accelerometer Sensors, Z-transform State System: Open-Loop System (Plant + FCS)	
o Copy Systems or Mati ile and Click on "Select	rices, Choose the Destinat Destination File"	The following systems are now in the destination file NewFile.Qdr	Clo
lewFile.Qdr		Matrix TVC: Shuttle Stage-1 TVC Matrix at Max-Q	
ig_Matrices.qdr Iodif3.Qdr Iodif30.Qdr ocketPlane_RB.Qdr	Edit Destination File	State System: IMU, Gyro, Accelerometer Sensors State System: IMU, Gyro, Accelerometer Sensors, Z-transform State System: Open-Loop System (Plant + FCS)	
ihuttle_Stg1_T55.Qdr 800.Qdr emp5.Qdr ulu_MaxQ_Latr.Qdr lewFile.Qdr	Copy Selected Systems		
		1	

View or Modify Systems: The "*View/ Modify System*" button is used to graphically display a system or a single matrix using color coded graphics. Each matrix element appears as a small square of different colors. This is a convenient way for visualizing large matrices because the color coding provides an indication the magnitude of each element, which in general is a sufficient information, rather than reading the actual numbers. Numbers with high positive exponent gravitate toward the green, blue, and cyan regions of the color spectrum. Numbers with high negative exponent gravitate toward the orange, red, and brown regions. Zeros are black. Ones are bright white. Negative numbers have the minus (-) sign in front of the colored square. The actual value of each element can be read in the field located below the tabs by pointing the cursor on the matrix element and clicking the left mouse button. The matrix element values can also be changed by entering data using this field. The system display dialog also includes four tabs that provide additional information about the system. The comments tab displays comments or user notes about the system. There are also tabs that show the

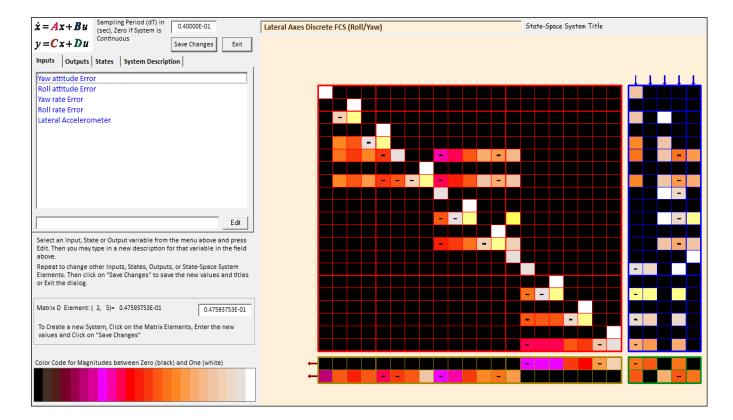
system inputs, states, and output variables. There are similar tabs for single matrices. In addition to modifying the matrix elements, the variable definitions or comments can also be modified using this dialog. The new system, however, must be saved under a new title. The first system below is a lateral vehicle with four inputs and three outputs. The display shows the user comments. The second example shows a Shuttle main engine actuator. The display tab shows definitions of the state variables. The bottom display is pointing at matrix element B(1,1) that has a value of 40.22.

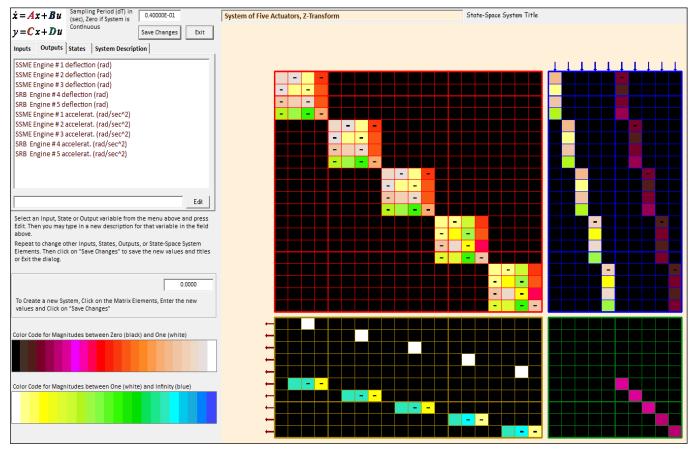
$\dot{\mathbf{x}} = \mathbf{A}\mathbf{x} + \mathbf{B}\mathbf{u}$ (sec), Zero if System is 0.0000	Lateral Design Model	State-Space System Title
y = Cx + Du Continuous Save Changes Exit Inputs Outputs States System Description		
A further simplified lateral axes rigid-body model is extracted from the coupled rigid-body model to be used for LQR control design. It consists of three states: (p, r, and beta)		
Select an Input, State or Output variable from the menu above and press Edit. Then you may type in a new description for that variable in the field above. Repeat to change other Inputs, States, Outputs, or State-Space System Elements. Then click on "Save Changes" to save the new values and titles or Exit the dialog. 0.0000 To Create a new System, Click on the Matrix Elements, Enter the new values and Click on "Save Changes"		
x = Ax + Du (sec), Zero if System is 0.0000 y = Cx + Du Continuous Save Changes Exit Inputs Outputs States System Description Exit Differ. Pressure Feedback (DPF) (ft-1b) Piston Displacement (Xr) (feet) Engine Gimbal Rotation (Delta) (rad) Engine Gimbal Rate (Delta-dot) (rad/sec)		State-Space System Title
Edit. Then you may type in a new description for that variable in the field above. Repeat to change other inputs, States, Outputs, or State-Space System Elements. Then click on "Save Changes" to save the new values and title or Exit the dialog. Matrix B Element: (1, 1)= 40.223713 40.223713 To Create a new System, Click on the Matrix Elements, Enter the new values and Click on "Save Changes" Color Code for Magnitudes between Zero (black) and One (white) Color Code for Magnitudes between One (white) and Infinity (blue)		

The figure below shows a Shuttle TVC matrix which transforms the roll, pitch and yaw acceleration demands to pitch and yaw deflections for the 5 engines. The matrix name and title are shown on the top and they can be modified and saved to a different name and title. Every time you change something using this dialog, for example, a matrix element, the input-output definitions, the comments, the matrix name or title, you must remember to save the changes by clicking the "*Save Changes*" button. When the modifications are complete, click on the "*Exit*" button, and the new data will be saved as a separate system or matrix in the same systems file. You must remember to change the system or matrix title, otherwise, the modifications will not be accepted using the same title. You can later delete the old system or matrix and rename the new one, if you wish.



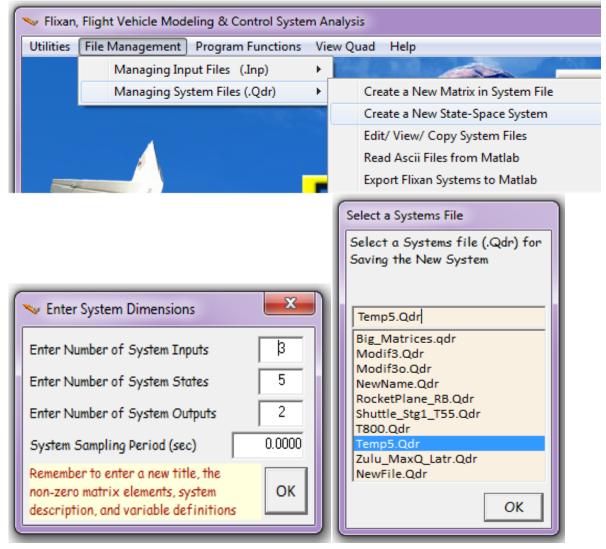
The following figures show two additional discrete systems sampled at 40 msec. A Shuttle lateral flight control system where the tab is showing its inputs, and a system of five actuators, three SSME and two SRB in block diagonal form. The second system's tab is showing the outputs.





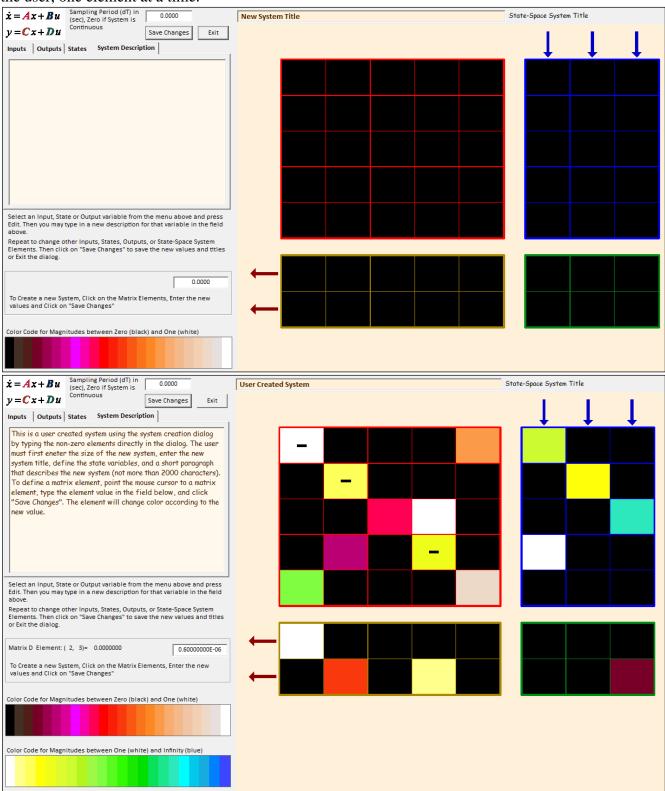
6.2.2 Creating a New System or a Matrix

The Flixan program also includes utilities for creating a new state-space system or a new matrix from scratch by entering the data using dialogs and then saving the system or matrix in a systems file (.Qdr). After selecting the project directory, from the Flixan main menu select "*File Management*", then "*Manage System Files*", and then "*Create a New State-Space System*" or "*Create a New Matrix*". For a new system the following dialog appears asking the user to define the number of the new system inputs, states, and outputs, and also the sampling period if the system is discrete described in terms of state-space difference equations. Otherwise, for a continuous system the sampling period is set to zero. In this case we arbitrarily define a system with 3 inputs, 2 outputs, and 5 states. The next menu shows the system files already existing in the current directory. A filename must be selected to save the new system or matrix. To create a new file the user must select "NewFile.Qdr". In this example, however, we select an existing systems file "*Temp5.Qdr*".



At this point a dialog appears that helps the user define the new system. Initially the four state-space matrices (A, B, C, D) are empty. The matrix element numbers are not yet entered and the element squares are black. In the upper hand left side of the dialog there a field with four tabs used for defining the new system's input, state, and output variables, and also for entering user comments about the system. The sizes of the four (A, B, C, D) matrices on the right are defined by the number of inputs,

states, and outputs. Their elements are initially set to zero (black) and they are ready to be painted by the user, one element at a time.



The user must point the cursor at a matrix element, click the mouse button to select the element, enter the value of the selected element in the field below the tabs, and click on the "Save Changes" button.

The matrix element then changes colors depending on the magnitude of the element. Small magnitude elements appear in brown, dark-red region, and large magnitude elements appear in the green and cyan regions. Ones appear in bright white, zeros are black, and there is a range of colors in between as a function of magnitude. Negative numbers appear with a minus sign in front of the matrix element.

The user must also enter the new system title in the title field on the top, a short description of the new system (less than 2000 characters long) in the system description tab, and also define the system input, state and output variables using the corresponding tabs. A default initial system title "*New System Title*" appears in the title field. This title must be changed to something different, "*User Created System*", is used in this example, and click on "*Save Changes*" button. When defining the system variables, initially the inputs, states, and outputs assume default titles, such as, "Input No: 1", etc, "State No: 1", etc, "Output No: 1", etc. These titles can be changed to something more descriptive. To rename the inputs, for example, the user must go to the Inputs tab in the dialog, select one of the inputs, and press "Edit". The original default label appears at the bottom of the inputs list, where it can be modified to something more descriptive, for example: "*Rudder Control Surface deflection in (deg)*". When the input relabeling is complete the user must click on "*Save Changes*" before selecting the state or output tab variables to rename. When all system definitions are complete the new system appears similar to the one shown in the second figure. The system is now ready to be saved in the systems file.

Click on "Exit" and the following dialog comes up asking about saving this new system in file. If the answer is "Yes" the new system will be saved in the bottom of file "*Temp5.Qdr*" in this example, and it will appear as shown in the next page.

Save Sy	stem?		
?	Would you like to User Created Sy:	save the modified stem	d System?
	Yes	No	

STATE-SPACE SYSTEM ...

User Created System

! This is a user created system using the system creation dialog by typing the non-zero elements ! directly in the dialog. The user must first eneter the size of the new system, enter the new ! system title, define the state variables, and a short paragraph that describes the new system ! (not more than 2000 characters). To define a matrix element, point the mouse cursor to a matrix ! element, type the element value in the field below, and click "Save Changes". The element will ! change color according to the new value. Number of Inputs, States, Outputs, Sample Time dT (for discrete)= 3 5 2 0.0000 Matrices: (A,B,C,D) Matrix A Size = 5 X 5 1-Column 2-Column 3-Column 4-Column 5-Column _____ Size = 5 X 3 Matrix B 1-Column 2-Column 3-Column 1-Row 0.11000000000E+02 0.0000000000E+00 0.0000000000E+00 2-Row 0.00000000000E+00 0.3000000000E+01 0.00000000000E+00
 4-Row
 0.1000000000E+01
 0.000000000E+00
 0.000000000E+00

 5-Row
 0.0000000000E+00
 0.00000000E+00
 0.000000000E+00
 _____ _____ Size = 2 X 5 Matrix C 1-Column 2-Column 3-Column 4-Column 5-Column Size = 2 X 3 Matrix D 1-Column 2-Column 3-Column _____ _____ _____ Definition of System Variables Inputs = 3 1 Input No: 1

2 Input No: 2 3 Input No: 3 States = 5 1 State No: 1 2 State No: 2 3 State No: 3 4 State No: 4 5 State No: 5 Outputs = 2 1 Output No: 1 2 Output No: 2
