

SDSA

Simulation & Dynamic Stability Analysis

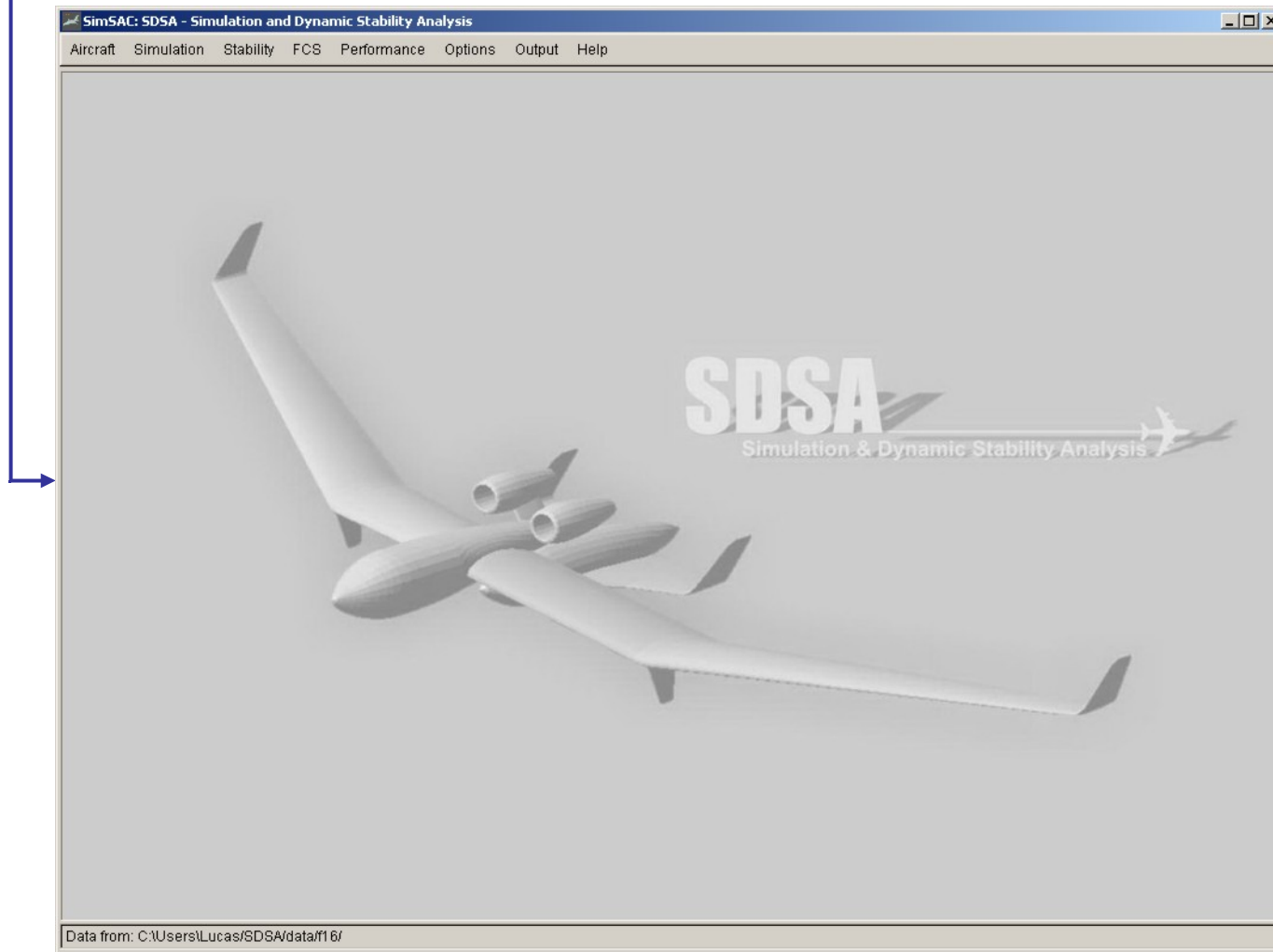


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The Faculty of Power and Aeronautical Engineering

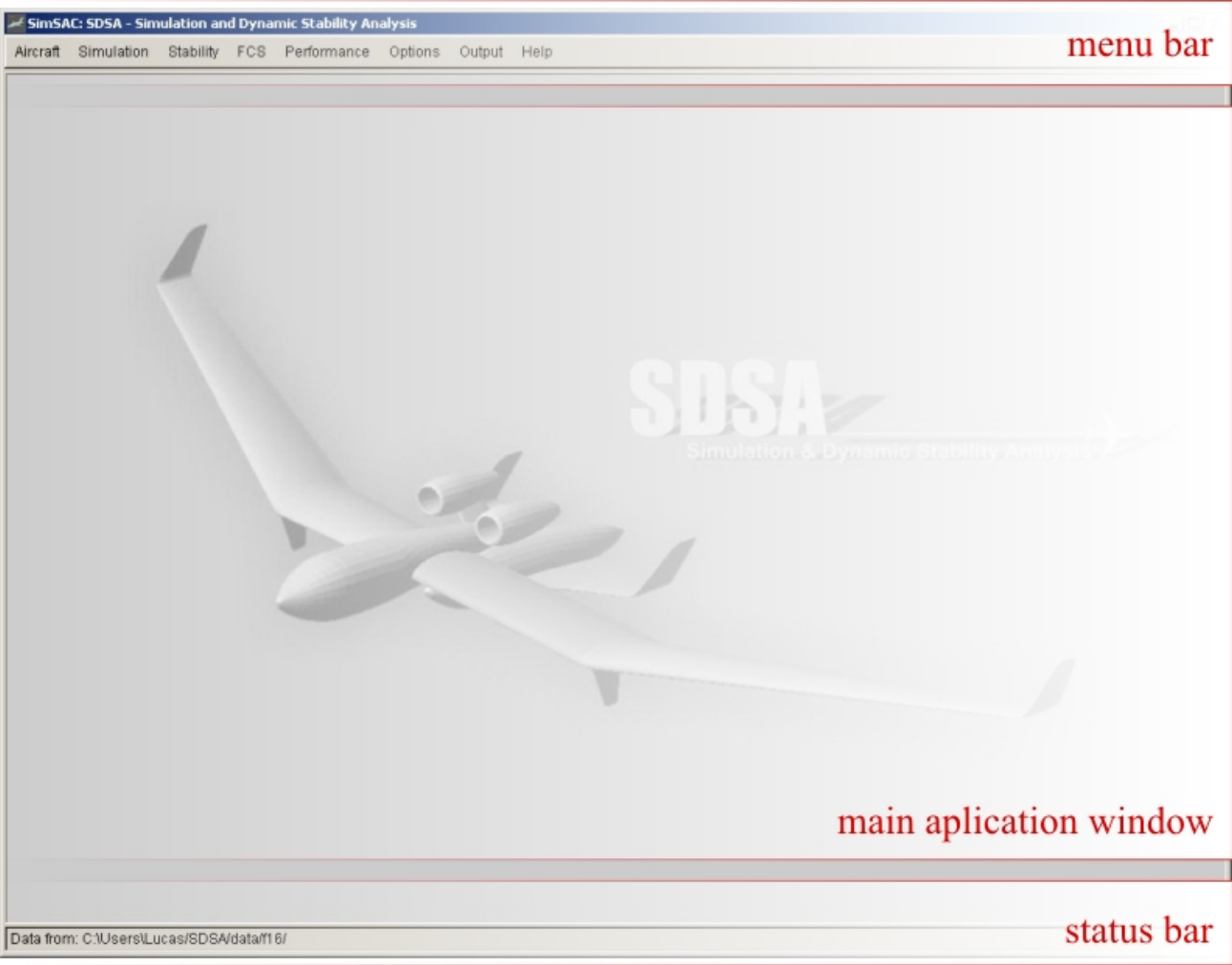
REVIEW

MAIN GUI WINDOW

Present SDSA Design

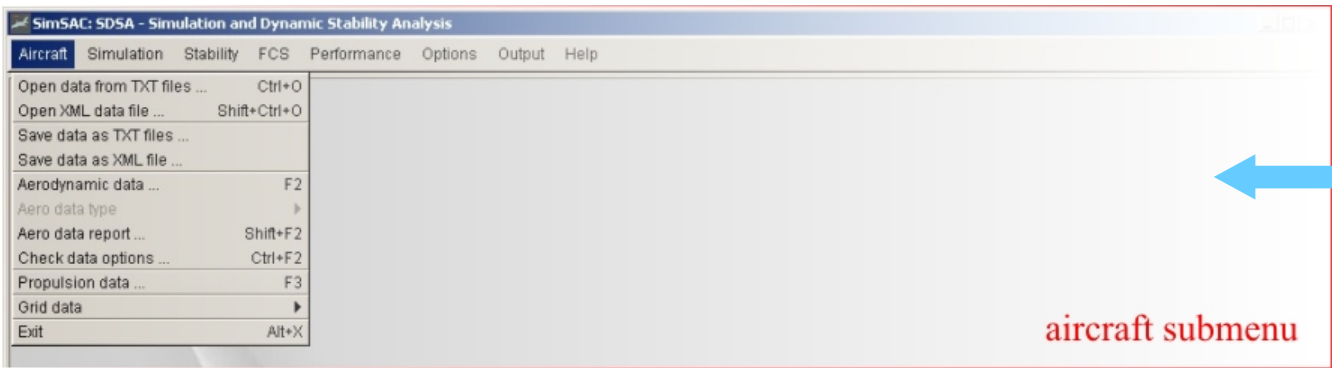


MAIN GUI WINDOW division

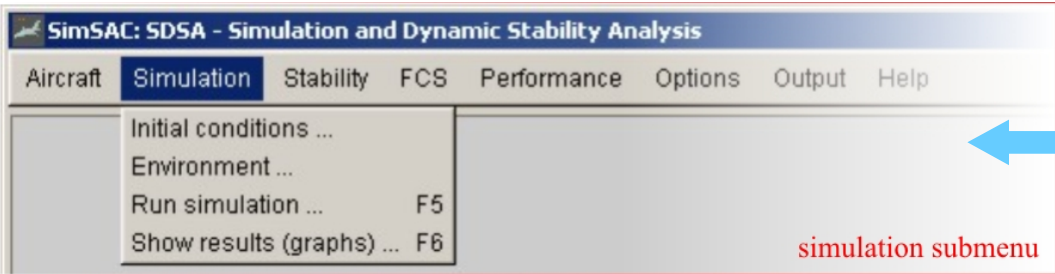


- Menu bar
- Main application window
- Status bar

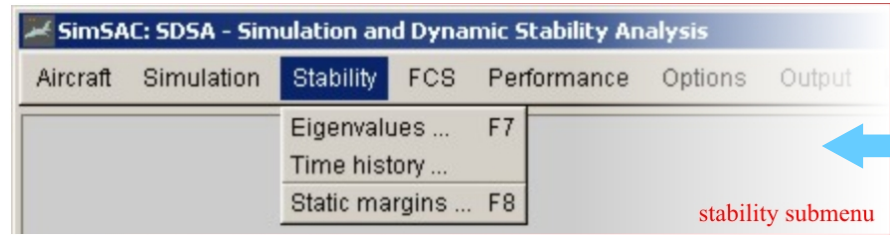
NEW SUBMENUS description



Aircraft - SUBMENU



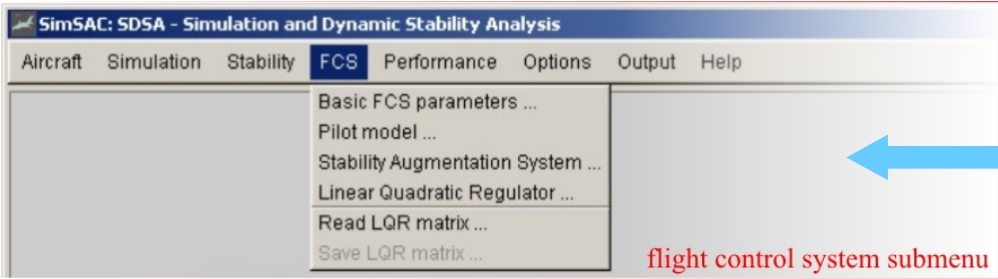
Simulation - SUBMENU



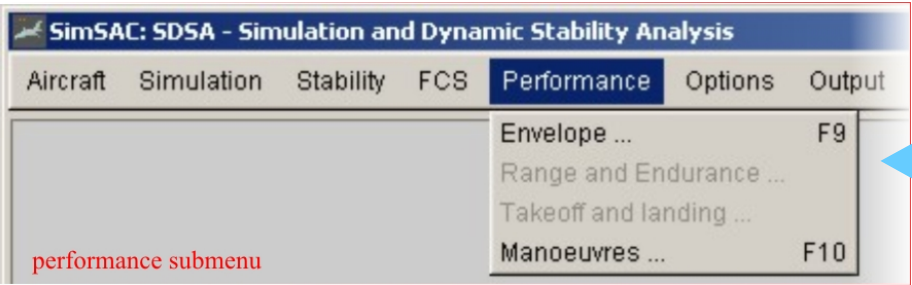
Stability - SUBMENU

SDSA menu bar is divided now into 8 submenus. Each submenu has individual button groups.

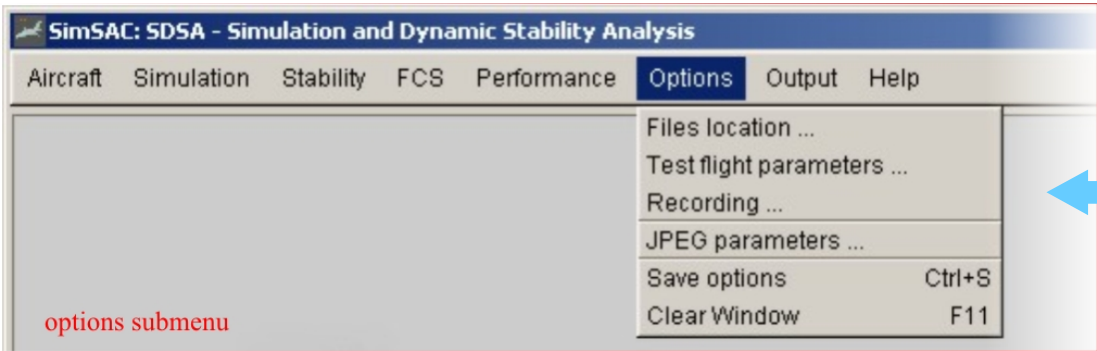
NEW SUBMENUS description



FCS Flight Control System - SUBMENU



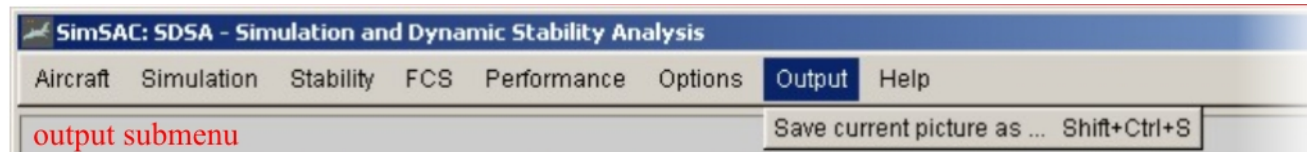
Performance - SUBMENU



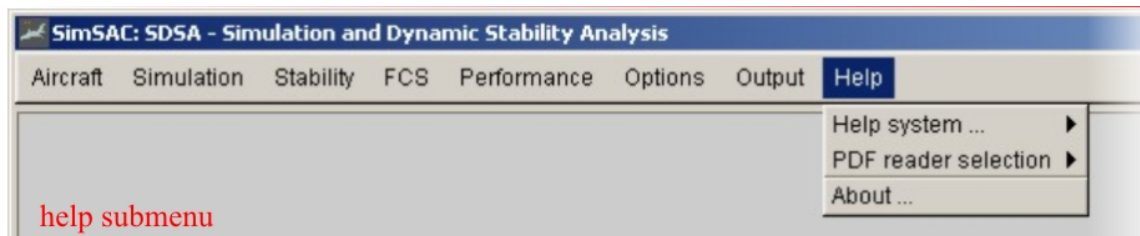
Options - SUBMENU

SDSA menu bar is divided now into 8 submenus. Each submenu has individual button groups.

NEW SUBMENU description



Output - **NEW SUBMENU**



About - SUBMENU

SDSA menu bar is divided now into 8 submenus. Each submenu has individual button groups.

AIRCRAFT submenu

Aircraft	
Open data from TXT files ...	Ctrl+O
Open XML data file ...	Shift+Ctrl+O
Save data as TXT files ...	
Save data as XML file ...	
Aerodynamic data ...	F2
Aero data type	▶
Aero data report ...	Shift+F2
Check data options ...	Ctrl+F2
Propulsion data ...	F3
Grid data	▶
Exit	Alt+X

Ctrl+O – to OPEN flight data TXT files ...

Shift+Ctrl+O – to OPEN flight data XML file ...

F2 – to review input AERODYNAMIC DATA ...

Shift+F2 – to display AERO DATA REPORT ...

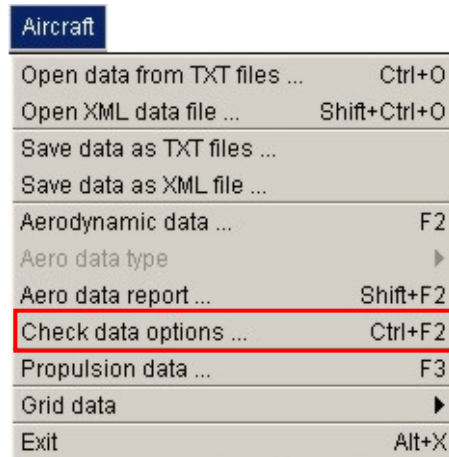
Ctrl+F2 – Check data options window ...

F3 – to open the PROPULSION DATA window ...

Alt+X – to EXIT the program ...

By clicking each of the submenu buttons, user can activate the appropriate SDSA feature.

AIRCRAFT submenu Check data options... (Ctrl+F2) external window



Check data options

Derivatives with respect to the airplane's state	min	max
Side force derivative with respect to sideslip angle [1/rad]	-2.00	0
Rolling moment derivative with respect to sideslip angle [1/rad]	-0.50	0.50
Yawing moment derivative with respect to sideslip angle [1/rad]	0	0.50
Lift force derivative with respect to pitch rate [1/rad]	-5.00	-0.50
Pitching moment derivative with respect to pitch rate [1/rad]	-15.00	-0.50
Lift force derivative with respect to Alpha dot [1/rad]	-2.00	0
Pitching moment derivative with respect to Alpha dot [1/rad]	-4.00	0
Rolling moment derivative with respect to roll rate [1/rad]	-0.90	-0.10
Rolling moment derivative with respect to yaw rate [1/rad]	-0.50	0.80
Yawing moment derivative with respect to roll rate [1/rad]	-0.500	0.500
Yawing moment derivative with respect to yaw rate [1/rad]	-1.000	-0.005

Derivatives with respect to the control surfaces deflection	min	max
Lift force derivative with respect to elevator deflection [1/rad]	0	4.00
Pitching moment derivative with respect to elevator deflection [1/rad]	-3.00	0
Rolling moment derivative with respect to ailerons deflection [1/rad]	-1.50	0
Rolling moment derivative with respect to rudder deflection [1/rad]	-0.10	0.10
Yawing moment derivative with respect to rudder deflection [1/rad]	-0.50	0
Side force derivative with respect to rudder deflection [1/rad]	0	1.00

OK Apply Cancel

Before start, user should define the SDSA derivative min/max values (range) with respect to: the airplane's state & the control surfaces deflection.

It is the best way to avoid mistakes and check the input data before simulation computation starts (Aerodynamic data report Shift+F2... submenu option) for ex. incorrect derivatives sign or abnormal values etc.).

AIRCRAFT submenu Aerodynamic Data... (F2) internal window

Aircraft

Open data from TXT files ... Ctrl+O

Open XML data file ... Shift+Ctrl+O

Save data as TXT files ...

Save data as XML file ...

Aerodynamic data ... F2

Aero data type

Aero data report ... Shift+F2

Check data options ... Ctrl+F2

Propulsion data ... F3

Grid data

Exit Alt+X

Aerodynamic data selection

Lift coefficient versus AoA & Mach number

Drag coefficient versus AoA & Mach number

Pitching moment coefficient versus AoA & Mach number

Max. angle of attack versus Mach number

Side force derivative with respect to sideslip angle versus Mach number

Rolling moment derivative with respect to sideslip angle versus AoA & Mach number

Yawing moment derivative with respect to sideslip angle versus Mach number

Lift derivative with respect to pitch rate versus Mach number

Pitching moment derivative with respect to pitch rate versus Mach number

Pitching moment derivative with respect to Alpha dot versus Mach number

Rolling moment derivative with respect to roll rate versus Mach number

Rolling moment derivative with respect to yaw rate versus Mach number

Yawing moment derivative with respect to roll rate versus AoA & Mach number

Yawing moment derivative with respect to yaw rate Mach number

Lift derivative with respect to elevator deflection versus Mach number

Pitching moment derivative with respect to elevator deflection versus Mach number

Rolling moment derivative with respect to ailerons deflection versus Mach number

Side force derivative with respect to rudder deflection versus Mach number

Rolling moment derivative with respect to rudder deflection versus AoA & Mach number

Yawing moment derivative with respect to rudder deflection versus Mach number

SimSAC: SDSA - Simulation and Dynamic Stability Analysis

Aircraft Simulation Stability FCS Performance Options Output Help

Review data from: C:/Users/Lucas/SDSA/data/f1 6/

Select aerodynamic data: Lift coefficient versus AoA

Select "X" variable: Angle of Attack

Select "Y" variable: Mach

Active Aero data: 1st 2nd Both

X var range: 0.1 1.5

Y var range: -5.0 20.0

X axis grid Y axis grid Legend Default

Data from: C:/Users/Lucas/SDSA/data/f1 6/

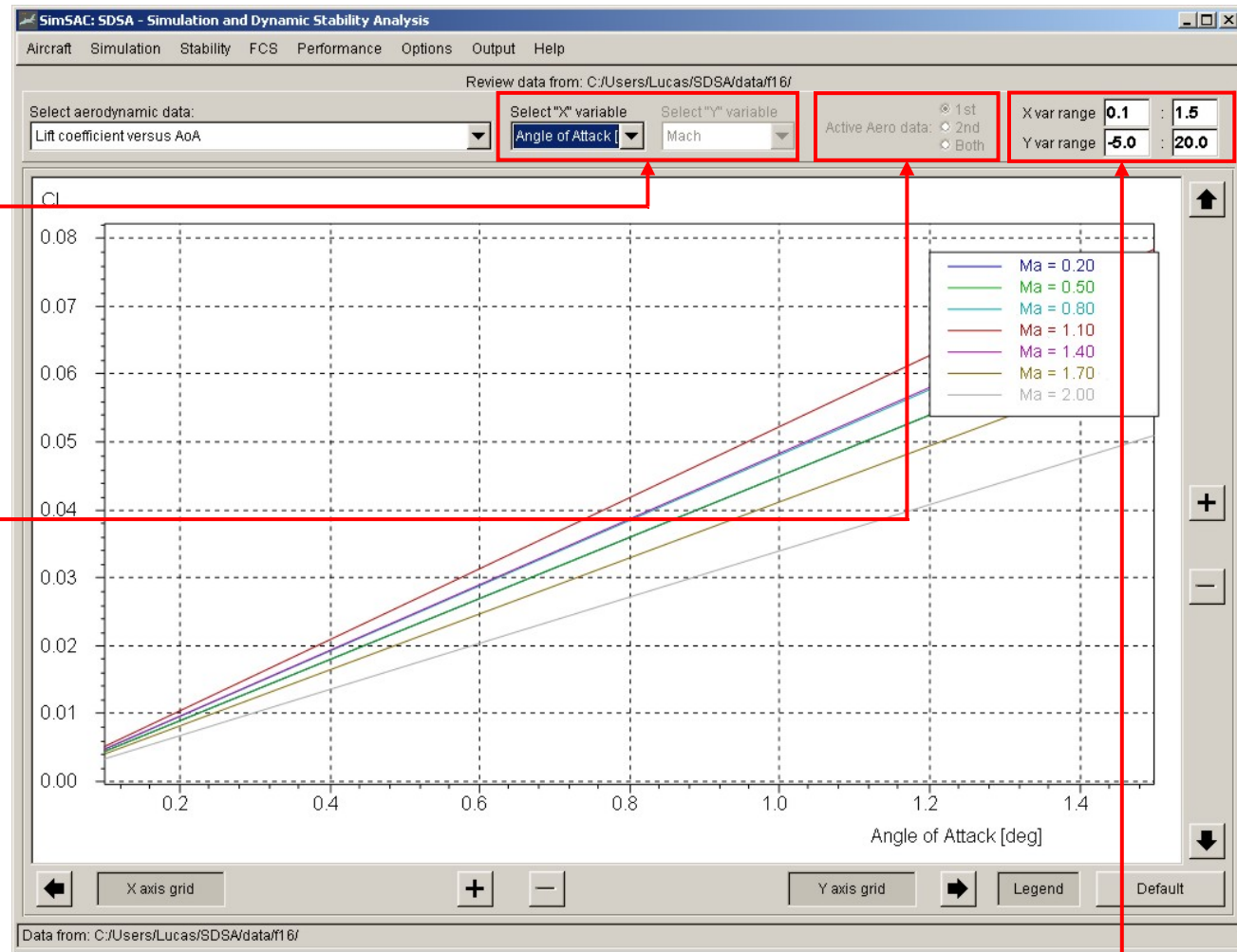
This feature enables user to review and check the SDSA input data!

AIRCRAFT submenu Aerodynamic Data... (F2) internal window

X & Y variable
selection (for ex.
Mach number or
Angle of Attack)

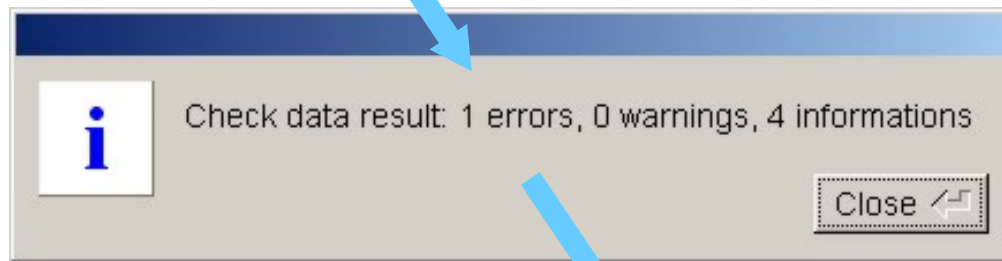
NEW - Active Aero
data... user can
select and display
1st or 2nd or both
aero data sets on
review graph
window (if such aero
data is available)

X and Y variable
range (input window)

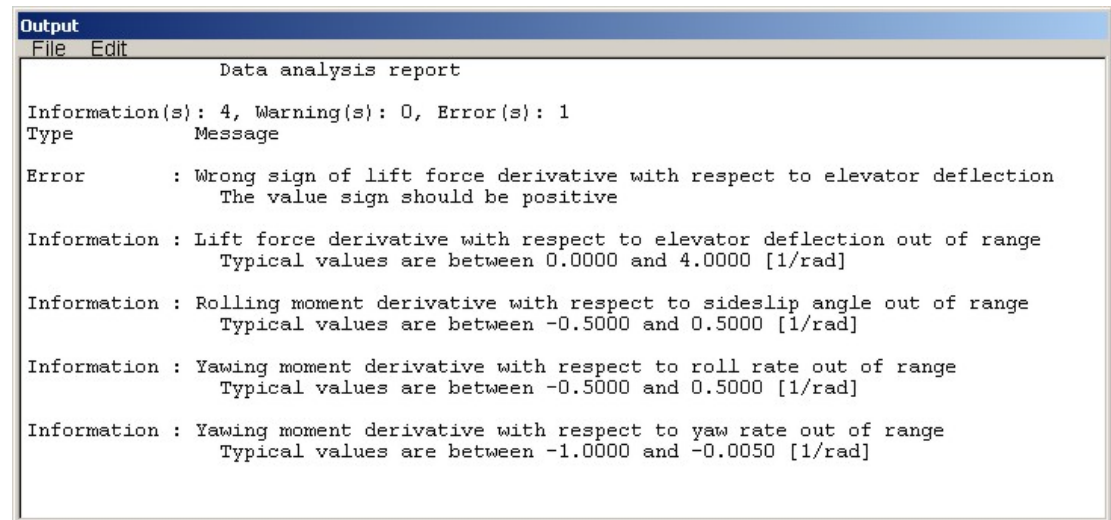


AIRCRAFT submenu Aero Data Report... (Shift+F2) **NEW menu feature !**

Aero data report ... Activates the data validation function



Input data validation takes only few seconds. When the verification process is finished, data analysis report is ready to display.



AIRCRAFT submenu Propulsion Data... (F3) internal window

Aircraft

Open data from TXT files ...
Ctrl+O

Open XML data file ...
Shift+Ctrl+O

Save data as TXT files ...

Save data as XML file ...

Aerodynamic data ...
F2

Aero data type
▶

Aero data report ...
Shift+F2

Check data options ...
Ctrl+F2

Propulsion data ...
F3

Grid data
▶

Exit
Alt+X

Propulsion Data window enables user to define propulsion configuration for the aircraft. User can also load saved thrust or propulsion data.

If it is necessary we can completely turn off the propulsion.

SimSAC: SDSA - Simulation and Dynamic Stability Analysis

Aircraft Simulation Stability FCS Performance Options Output Help

Propulsion configuration file:
C:/Users/Lucas/SDSA/data/f16/power.cfg
Load Save (as)

Thrust file:
C:/Users/Lucas/SDSA/data/f16/thrust.cfg
Load Save (as)

Thrust graph parameters:
Compute thrust Show thrust
Altitude range: H min [m] 0 H max [m] 0 H step [m] 0
Airspeed range (Ma): Ma min 0.00 Ma max 0.00 Ma step 0.00

Propulsion data
NO propulsion External data Defined above

Engines
Number of Engines: 1
☐ Symmetrical configuration.
(Engines are the same)

Propulsion configuration
Engines Type:
☒ turbo prop
☐ turbo jet
☐ piston propeller
☐ turbo fan
Propeller
Maximum power [kW]: 0
Altitude power factor: 0.00
Engine factor:
min 0.08 , max 0.25
Typical values: from 0.12 to 0.16
Jet
Maximum thrust (H=0, Ma=0) [N]: 0
Altitude thrust factor: 0.00
By-pass ratio: 0.0 : 0.0
Default Apply

Engine No 1
Coordinates in BC system [m]
X: 7.00 Y: 0 Z: 0
Angles of incidence [deg]
α: 0 β: 0
Max shaft angular velocity [rad/s]
Ω1: 3000.00 Ω2: 3000.00
Moments of inertia [kg m2]
Jx1: 110.00 Jx2: 107.00
Time constant [-]
T1: 1.50 T2: 2.00
Throttle [%] 10.0
Thrust [kN] 10.0

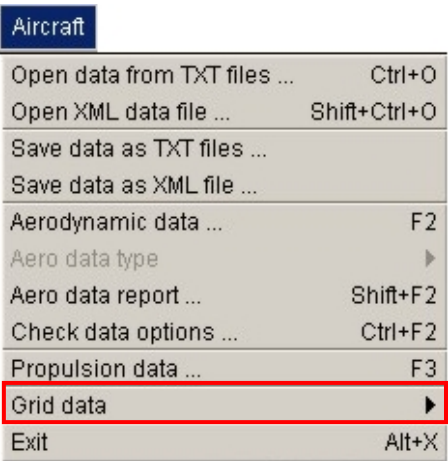
Engine No 2
Coordinates in BC system [m]
X: 0 Y: 0 Z: 0
Angles of incidence [deg]
α: 0 β: 0
Max shaft angular velocity [rad/s]
Ω1: 0 Ω2: 0
Moments of inertia [kg m2]
Jx1: 0 Jx2: 0
Time constant [-]
T1: 0 T2: 0
Throttle [%] 10.0
Thrust [kN] 10.0

Engine No 3
Coordinates in BC system [m]
X: 0 Y: 0 Z: 0
Angles of incidence [deg]
α: 0 β: 0
Max shaft angular velocity [rad/s]
Ω1: 0 Ω2: 0
Moments of inertia [kg m2]
Jx1: 0 Jx2: 0
Time constant [-]
T1: 0 T2: 0
Throttle [%] 10.0
Thrust [kN] 10.0

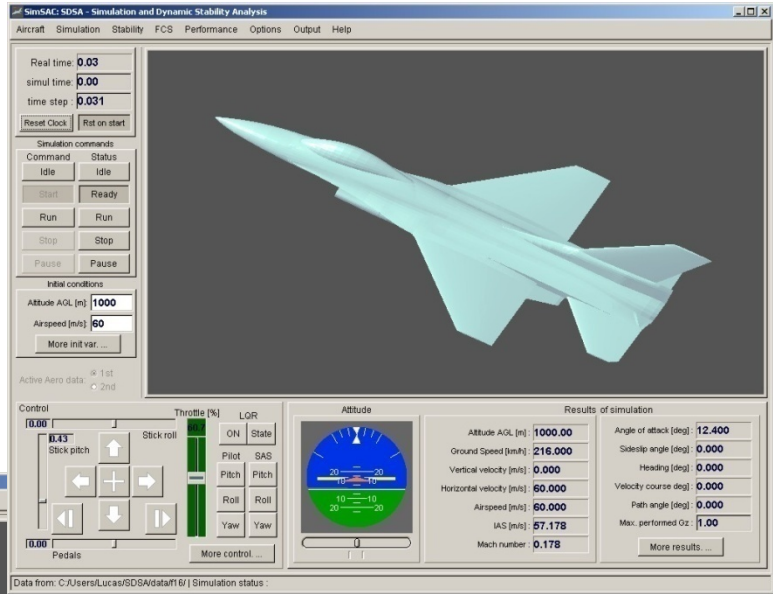
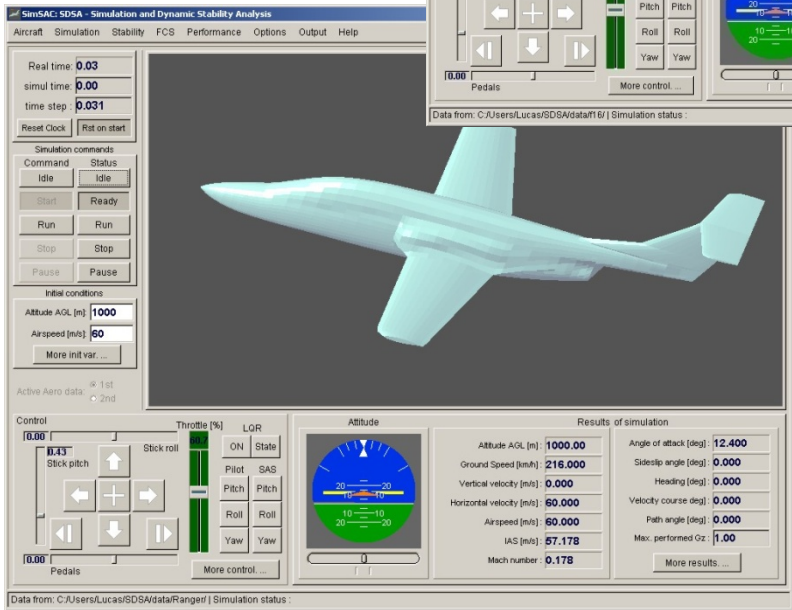
Engine No 4
Coordinates in BC system [m]
X: 0 Y: 0 Z: 0
Angles of incidence [deg]
α: 0 β: 0
Max shaft angular velocity [rad/s]
Ω1: 0 Ω2: 0
Moments of inertia [kg m2]
Jx1: 0 Jx2: 0
Time constant [-]
T1: 0 T2: 0
Throttle [%] 10.0
Thrust [kN] 10.0

Data from: C:/Users/Lucas/SDSA/data/f16/

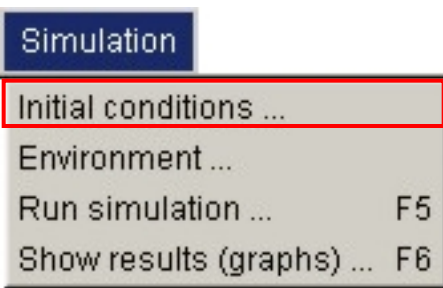
AIRCRAFT submenu Grid Data... Option selection **NEW FEATURE!**



User can select from the Default to Custom selected grid to being displayed during the simulation process.



SIMULATION submenu Initial conditions... external setup window



Initial conditions... It is the best way to setup the initial position and flight values for the current simulation process.

Setup

Initial values

Altitude AGL [m]:
6000

Airspeed [m/s]:
250

Heading [deg]:
0

Path angle [deg]:
0

Roll angle [deg]:
0

Ground Start

Engine ON

Initial position

Predefined coordinates
South Pole

Longitude
DEG 0 E
MIN 0
SEC 0
HDR 0 W

Latitude
DEG 90 N
MIN 0
SEC 0
HDR 0 S

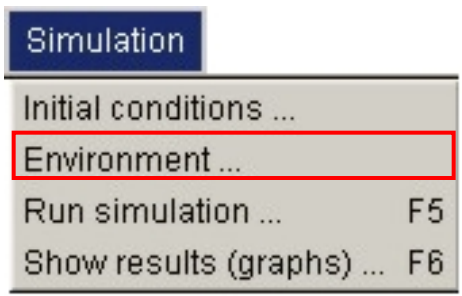
Configuration

Fuel initial state: FULL HALF MIN Fuel value: 0

Payload initial state: FULL HALF MIN Payload value: 0

OK Apply Cancel

SIMULATION submenu Environment... external setup window



Environment... It is the best way to setup the flight environment parameters: wind course/shear air temperature etc.

Environment

Initial values

Air temperature [C]: 15.00

Air pressure [Pa]: 101325

Global Wind Control

Wind course [deg]: 0

Wind speed (horiz.) [m/s]: 0

Wind speed (vert.) [m/s]: 0

Current state (in the aircraft position)

Air temperature [C]: 15.00

Air pressure [Pa]: 101325

Air density [kg/m3]: 1.2248

Speed of sound [m/s]: 340.3

WIND (local coordiantes)

0 0 0

x y z

Switches:

GROUND EFFECT

Runway condition: DRY WET ICE

Wind Shear ☐ Turbulence: NONE LIGHT MEDIUM EXTREME

Wind Shear - parameters

Coordinates of the windshear root

Longitude

DEG MIN SEC HDR

0 0 0 0

E W

Latitude

DEG MIN SEC HDR

0 0 0 0

N S

Altitude ASL of WS bottom [m]: 0

Height of WS [m]: 0

Airspeed in the root [m/s]: 0

Diameter [m]: 0

OK

Apply

Cancel

SIMULATION submenu Run simulation... internal simulation window

Simulation

Initial conditions ...
Environment ...
Run simulation ... F5
Show results (graphs) ... F6

Run simulation... (F5)
This is the artificial control panel, where user can start / stop aircraft simulation and control / observe the desirable parameters / results.

SimSAC: SDSA - Simulation and Dynamic Stability Analysis

Aircraft Simulation Stability FCS Performance Options Output Help

Real time: 0.03
simul time: 0.00
time step: 0.031
Reset Clock Rst on start

Simulation commands
Command Status
Idle Idle
Start Ready
Run Run
Stop Stop
Pause Pause

Initial conditions
Altitude AGL [m]: 1000
Airspeed [m/s]: 60
More init var. ...

Active Aero data: 1st 2nd

Control
0.00
0.43
Stick roll
Stick pitch
Pedals
More control. ...

Throttle [%]
0.7
LQR
ON State
Pilot SAS
Pitch Pitch
Roll Roll
Yaw Yaw
More control. ...

Attitude
0
20 10 0 10 20
20 10 0 10 20

Results of simulation
Altitude AGL [m]: 1000.00
Ground Speed [km/h]: 216.000
Vertical velocity [m/s]: 0.000
Horizontal velocity [m/s]: 60.000
Airspeed [m/s]: 60.000
IAS [m/s]: 57.178
Mach number: 0.178
Angle of attack [deg]: 12.400
Sideslip angle [deg]: 0.000
Heading [deg]: 0.000
Velocity course [deg]: 0.000
Path angle [deg]: 0.000
Max. performed Gz: 1.00
More results. ...

Data from: C:/Users/Lucas/SDSA/data/Ranger/ | Simulation status :

14.05.09

16

SIMULATION submenu Run simulation... internal simulation window

Simulation...
control panel

Real time: 0.03
simul time: 0.00
time step : 0.031

Reset Clock Rst on start

Simulation commands

Command	Status
Idle	Idle
Start	Ready
Run	Run
Stop	Stop
Pause	Pause

New - Active
Aero Data...
selection panel

SimSAC: SDSA - Simulation and Dynamic Stability Analysis

Aircraft Simulation Stability FCS Performance Options Output Help

Real time: 0.03
simul time: 0.00
time step : 0.031

Reset Clock Rst on start

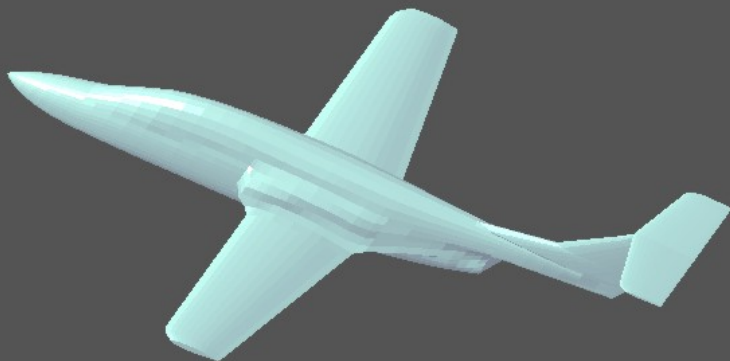
Simulation commands

Command	Status
Idle	Idle
Start	Ready
Run	Run
Stop	Stop
Pause	Pause

Initial conditions

Altitude AGL [m]: 1000
Airspeed [m/s]: 60
More init var. ...

Active Aero data: ☒ 1st ☐ 2nd



Control

Throttle [%] 60.7

Stick roll: 0.43

Stick pitch: 0.00

Pedals: 0.00

More control. ...

LQR

ON	State
Pilot	SAS
Pitch	Pitch
Roll	Roll
Yaw	Yaw

Attitude



Results of simulation

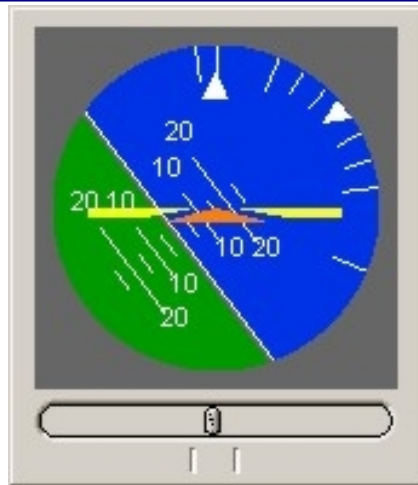
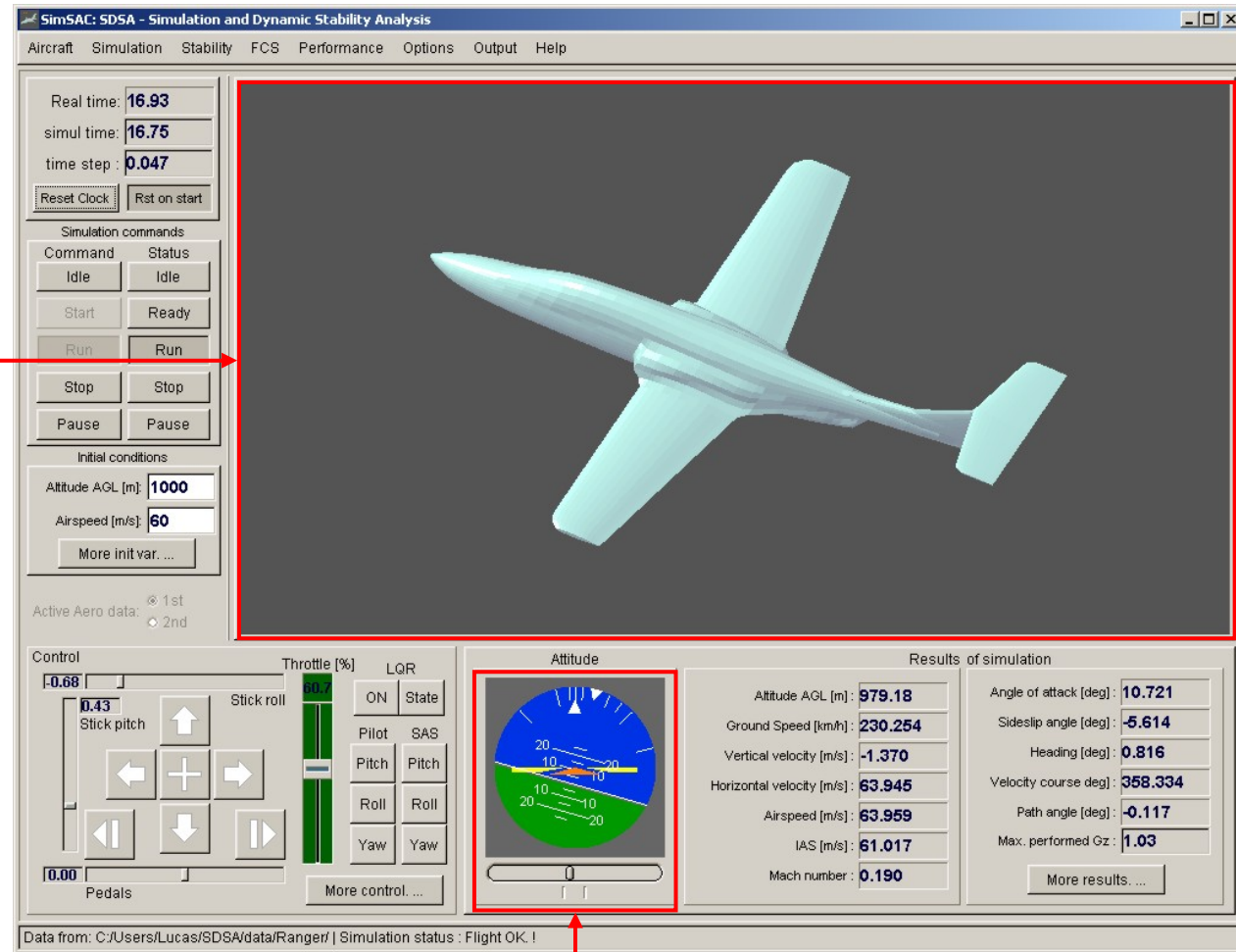
Altitude AGL [m]	1000.00	Angle of attack [deg]	12.400
Ground Speed [km/h]	216.000	Sideslip angle [deg]	0.000
Vertical velocity [m/s]	0.000	Heading [deg]	0.000
Horizontal velocity [m/s]	60.000	Velocity course [deg]	0.000
Airspeed [m/s]	60.000	Path angle [deg]	0.000
IAS [m/s]	57.178	Max. performed Gz	1.00
Mach number	0.178		

More results. ...

Data from: C:/Users/Lucas/SDSA/data/Ranger/ | Simulation status :

Spacious 3D
visualization window

HIS horizontal situation indicator



SIMULATION submenu Run simulation... internal simulation window

Control... panel

Control

0.00

Stick pitch

0.43

Stick roll

60.7

Throttle [%]

LQR

ON

State

Pilot

SAS

Pitch

Pitch

Roll

Roll

Yaw

Yaw

0.00

Pedals

More control. ...

More results ... ext. window

Results of simulation

State vector

WGS coordiantes

Coordinates [m]

Attitude angles [deg]

U: 43.538

V: 2.322

W: 54.634

P: -0.034

Q: -0.103

R: 0.019

Fi: 13.8007

Theta: -15.9843

Psi: 29.7613

Latitude: -89.8164

Longitude: -18.3335

Altitude: 2878.754

X: 19478.17

Y: -6454.44

Z: -6359598.19

Fi WGS: 13.7058

Theta WGS: -16.1437

Psi WGS: 11.4540

GX: 0.277

GY: -0.043

GZ: 0.869

"G" force

Close

SimSAC: SDSA - Simulation and Dynamic Stability Analysis

Aircraft

Simulation

Stability

FCS

Performance

Options

Output

Help

Real time: 16.93

simul time: 16.75

time step: 0.047

Reset Clock

Ret on start

Simulation commands

Command

Status

Idle

Idle

Start

Ready

Run

Run

Stop

Stop

Pause

Pause

Initial conditions

Altitude AGL [m]: 1000

Airspeed [m/s]: 60

More init var.

Active Aero data: 1st 2nd

Control

Throttle [%]

LQR

ON

State

Pilot

SAS

Pitch

Pitch

Roll

Roll

Yaw

Yaw

0.00

Pedals

More control. ...

Altitude

Attitude

Results of simulation

Altitude AGL [m]: 979.18

Ground Speed [km/h]: 230.254

Vertical velocity [m/s]: -1.370

Horizontal velocity [m/s]: 63.945

Airspeed [m/s]: 63.959

IAS [m/s]: 61.017

Mach number: 0.190

Angle of attack [deg]: 10.721

Sideslip angle [deg]: -5.614

Heading [deg]: 0.816

Velocity course deg: 358.334

Path angle [deg]: -0.117

Max. performed Gz: 1.03

More results. ...

Data from: C:/Users/Lucas/SDSA\data/Ranger/ | Simulation status: Flight OK !

SIMULATION submenu Run simulation... internal simulation window

More initial variables...
ext. window

More control... ext. window

Control

Elevator [deg]: -1.01
Ailerones [deg]: 0.45
Rudder [deg]: 0.00

Thrust [kN]: 0.00

Flaps: UP TakeOff Landing
50.0 %

LQR FCS
SAS

AirBrake Off/On 0 %

Landing Gear

nose left 0.000 right 0.000
Wheel brake (stick) [%]: 0.0
Wheel brake: L 0.0 R 0.0
Gear Up/Down 0 %
Touchdown

OK Apply Cancel

SimSAC: SDSA - Simulation and Dynamic Stability Analysis

Aircraft Simulation Stability FCS Performance Options Output Help

Real time: 16.93
simul time: 16.75
time step: 0.047
Reset Clock Rat on start

Simulation commands
Command Status
Idle Idle
Start Ready
Run Run
Stop Stop
Pause Pause

Initial conditions
Altitude AGL [m]: 1000
Airspeed [m/s]: 60
More init var. ...

Active Aero data: 1st 2nd

Control
Throttle [%] LQR
Stick pitch Stick roll
Pilot SAS
Pitch Pitch
Roll Roll
Yaw Yaw
Pedals
More control ...

Attitude
Results of simulation
Altitude AGL [m]: 979.18
Ground Speed [km/h]: 230.254
Vertical velocity [m/s]: -1.370
Horizontal velocity [m/s]: 63.945
Airspeed [m/s]: 63.959
IAS [m/s]: 61.017
Mach number: 0.190
Angle of attack [deg]: 10.721
Sideslip angle [deg]: -5.614
Heading [deg]: 0.816
Velocity course deg: 358.334
Path angle [deg]: -0.117
Max. performed Oz: 1.03
More results ...

Data from: C:/Users/Lucas/SDSA/data/Ranger/ | Simulation status: Flight OK !

The direct access to the most common features during simulation process makes SDSA more operational and easy.

SIMULATION submenu Run simulation... internal simulation window

Linear Quadratic Regulator

Click ON to enable Linear Quadratic Regulator (when running in flight simulation mode)



NEW FEATURE!

LQR

ON

State

PilotSAS

PitchPitch

RollRoll

YawYaw

SimSAC: SDSA - Simulation and Dynamic Stability Analysis

AircraftSimulationStabilityFCSPerformanceOptionsOutputHelp

Real time: 9.84
simul time: 9.81
time step: 0.031
Reset ClockRst on start

Simulation commands
CommandStatus
IdleIdle
StartReady
RunRun
StopStop
PausePause

Initial conditions
Altitude AGL [m]: 1000
Airspeed [m/s]: 60
More init var. ...

Active Aero data: 1st2nd

Control
0.00
Stick pitch0.43
Stick roll68.2
Pedals
More control ...

Throttle [%]
68.2
LQR
ONState
PilotSAS
PitchPitch
RollRoll
YawYaw
More control ...

Attitude
Attitude gauge

Results of simulation
Altitude AGL [m]: 1000.02
Ground Speed [km/h]: 215.986
Vertical velocity [m/s]: 0.004
Horizontal velocity [m/s]: 59.996
Airspeed [m/s]: 59.996
IAS [m/s]: 57.175
Mach number: 0.178
Angle of attack [deg]: 12.401
Sideslip angle [deg]: 0.000
Heading [deg]: 359.999
Velocity course [deg]: 359.999
Path angle [deg]: 0.004
Max. performed Gz: 1.00
More results ...

Data from: C:/Users/Lucas/SDSA/data/Ranger/ | Simulation status: Flight OK.!

The Pilot & SAS feature is disabled when in LQR mode. State button turns yellow when LQR meets the FCS envelope requirements. Pilot & SAS feature will be discussed in detail in separate presentation.

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SIMULATION submenu Run simulation... internal simulation window

Pilot

Click one of Pilot or SAS buttons ON to enable pilot in the closed loop and stability augmentation system (when running in flight simulation mode)



NEW FEATURE!

LQR

ON State

Pilot SAS

Pitch Pitch

Roll Roll

Yaw Yaw

One button for: Pitch, Roll, Yaw channel

SimSAC: SDSA - Simulation and Dynamic Stability Analysis

Aircraft Simulation Stability FCS Performance Options Output Help

Real time: 372.02
simul time: 39.53
time step: 0.031
Reset Clock Rst on start

Simulation commands

Command Status

Idle Idle

Start Ready

Run Run

Stop Stop

Pause Pause

Initial conditions

Altitude AGL [m]: 1000

Airspeed [m/s]: 60

More init var. ...

Active Aero data: 1st 2nd

Control

0.10 0.29 Stick roll

Stick pitch

Throttle [%]

81.5

LQR

ON State

Pilot SAS

Pitch Pitch

Roll Roll

Yaw Yaw

More control. ...

Pedals

0.00

Attitude

Results of simulation

Altitude AGL [m]: 973.82

Ground Speed [km/h]: 198.504

Vertical velocity [m/s]: -15.605

Horizontal velocity [m/s]: 52.886

Airspeed [m/s]: 55.140

IAS [m/s]: 48.661

Mach number: 0.164

Angle of attack [deg]: 26.736

Sideslip angle [deg]: -4.125

Heading [deg]: 339.734

Velocity course deg: 347.413

Path angle [deg]: -17.236

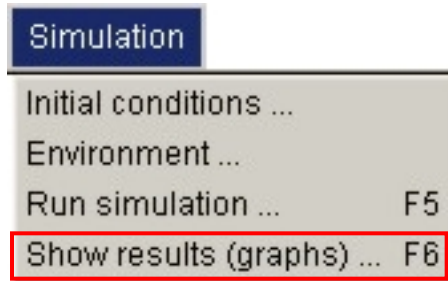
Max. performed Gz: 1.03

More results. ...

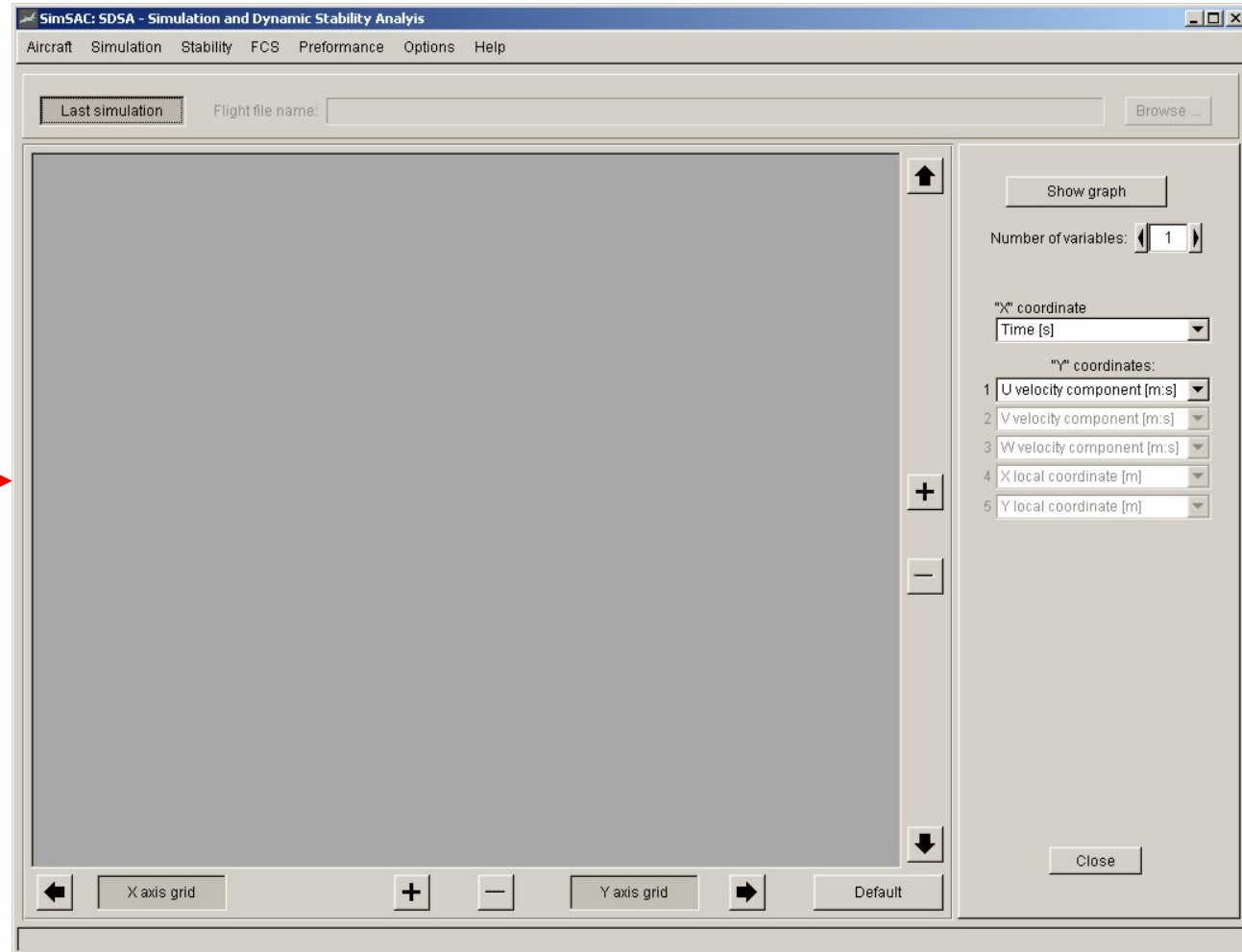
Data from: C:/Users/Lucas/SDSA/data/Ranger/ Simulation status: Flight OK. I

The LQR button (Linear Quadratic Regulator) is disabled when in Pilot and in SAS mode.

SIMULATION submenu Show results (graphs)... (F6) internal window



This option was made to review the simulation results (from current, carried out simulation or stored on disk past simulations).

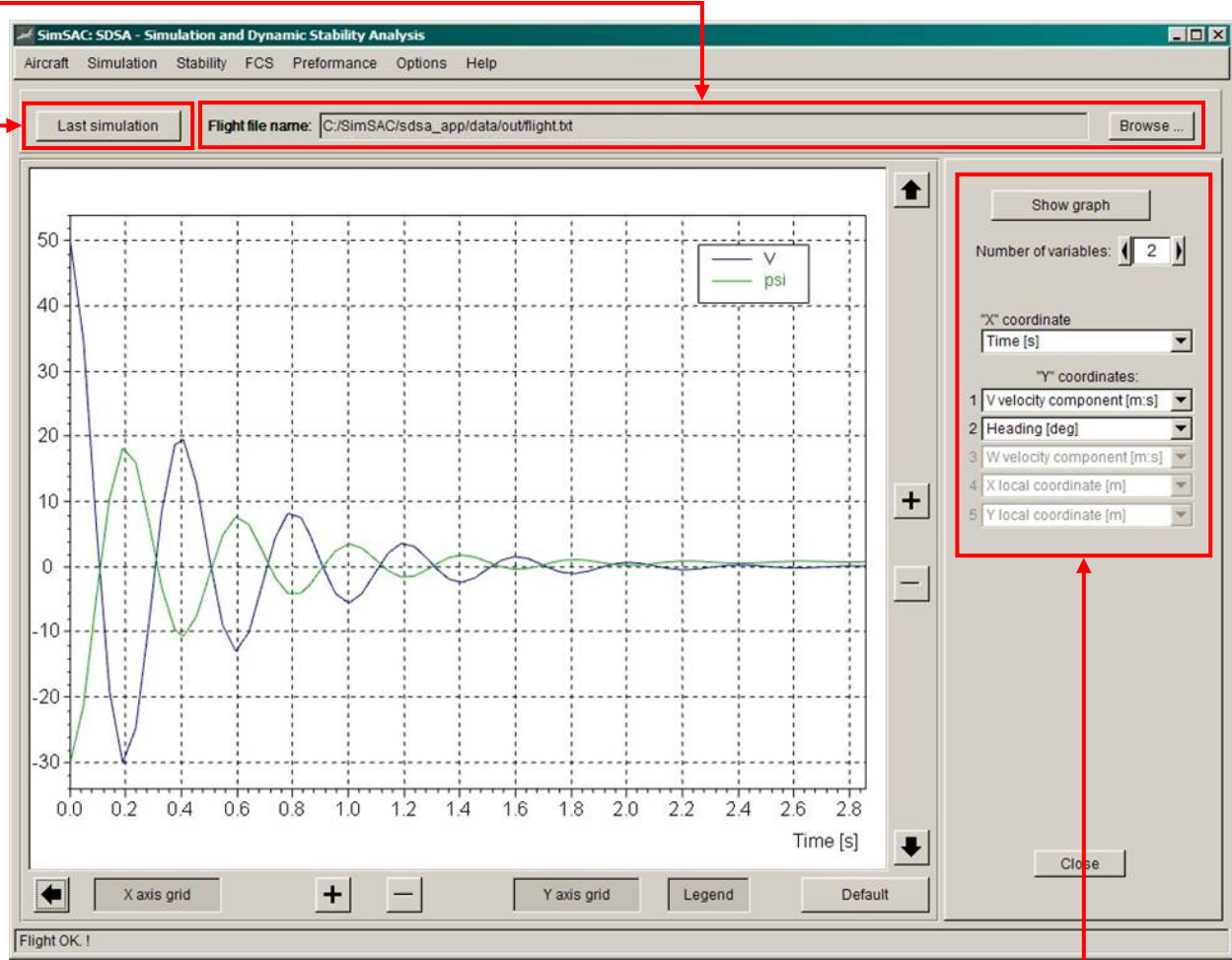


SIMULATION submenu Show results (graphs)... (F6) internal window

Click to point the path to file with recorded flight simulation results

Click to show last simulation results

- Variable type and number selection
- Time [s]
 - U velocity component [m:s]
 - V velocity component [m:s]
 - W velocity component [m:s]
 - X local coordinate [m]
 - Y local coordinate [m]
 - Altitude Above Ground Level [m]
 - Altitude Above Sea Level [m]
 - Roll angle [deg]
 - Pitch angle [deg]
 - Heading [deg]
 - Angle of Attack [deg]
 - Sideslip angle [deg]
 - Path angle [deg]
 - True airspeed [km:h]
 - Indicated airspeed [km:h]
 - Ground speed [km:h]
 - Horizontal speed [km:h]
 - Vertical speed [m:s]
 - Mach number
 - ...



STABILITY submenu Eigenvalues... (F7) internal window

Stability

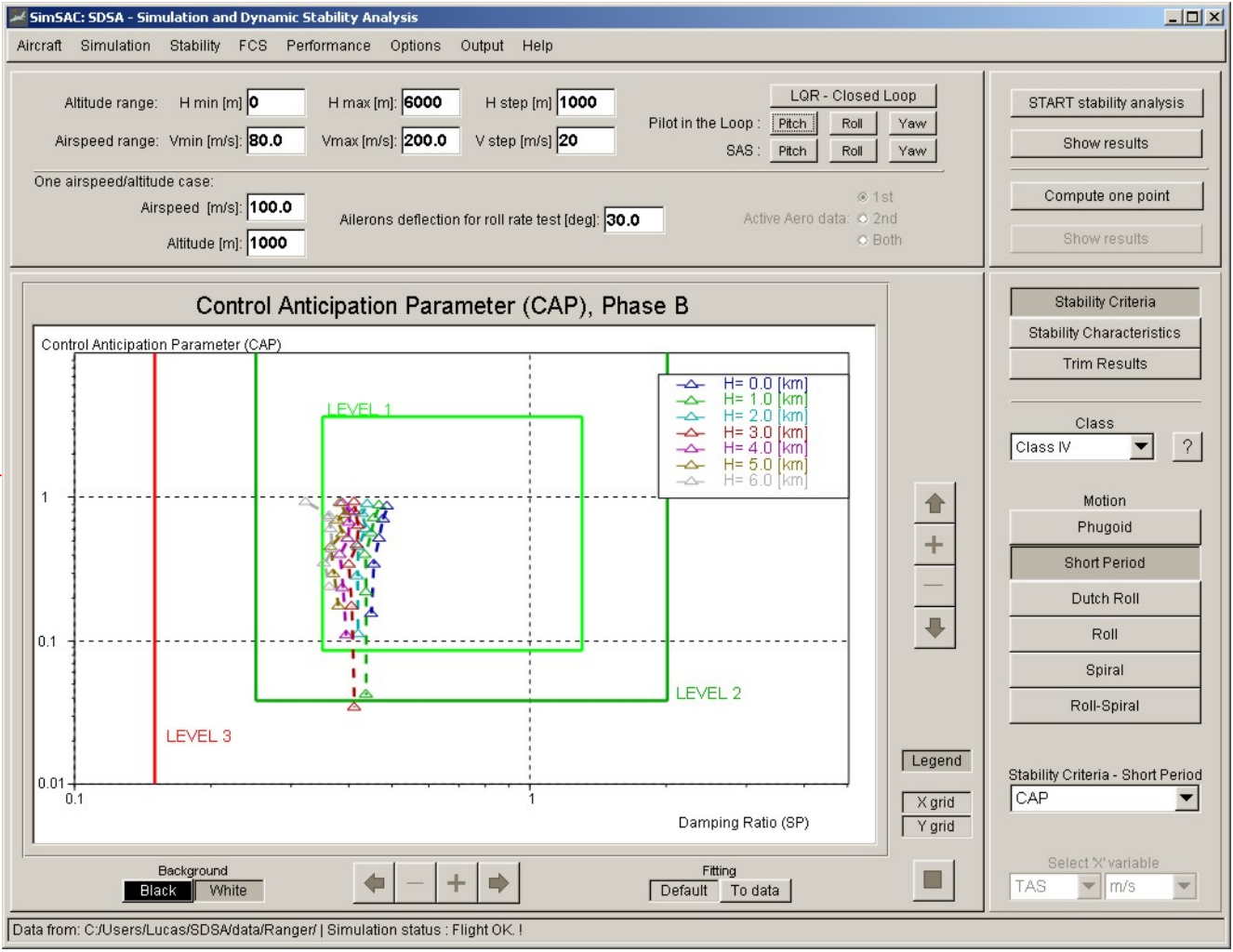
Eigenvalues ... F7

Time history ...

Static margins ... F8

In Eigenvalues... mode user can perform stability analysis computations, versus the stability or trim and stability criteria for specified aircraft class and motion.

(as well with the LQR Pilot, SAS mode on/off)



IMPROVED WINDOW navigation and features!

STABILITY submenu Eigenvalues... (F7) internal window

Compute control panel

Input variables control panel

New - Active Aero Data...
selection panel

Results visualization and stability criteria selection panel

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STABILITY submenu Eigenvalues... (F7) internal window

Show results button
(for airspeed/altitude
range calculations)

Show results button (for
only one airspeed/altitude
case)



Output

Stability analysis - Results
Number of computing points : 20

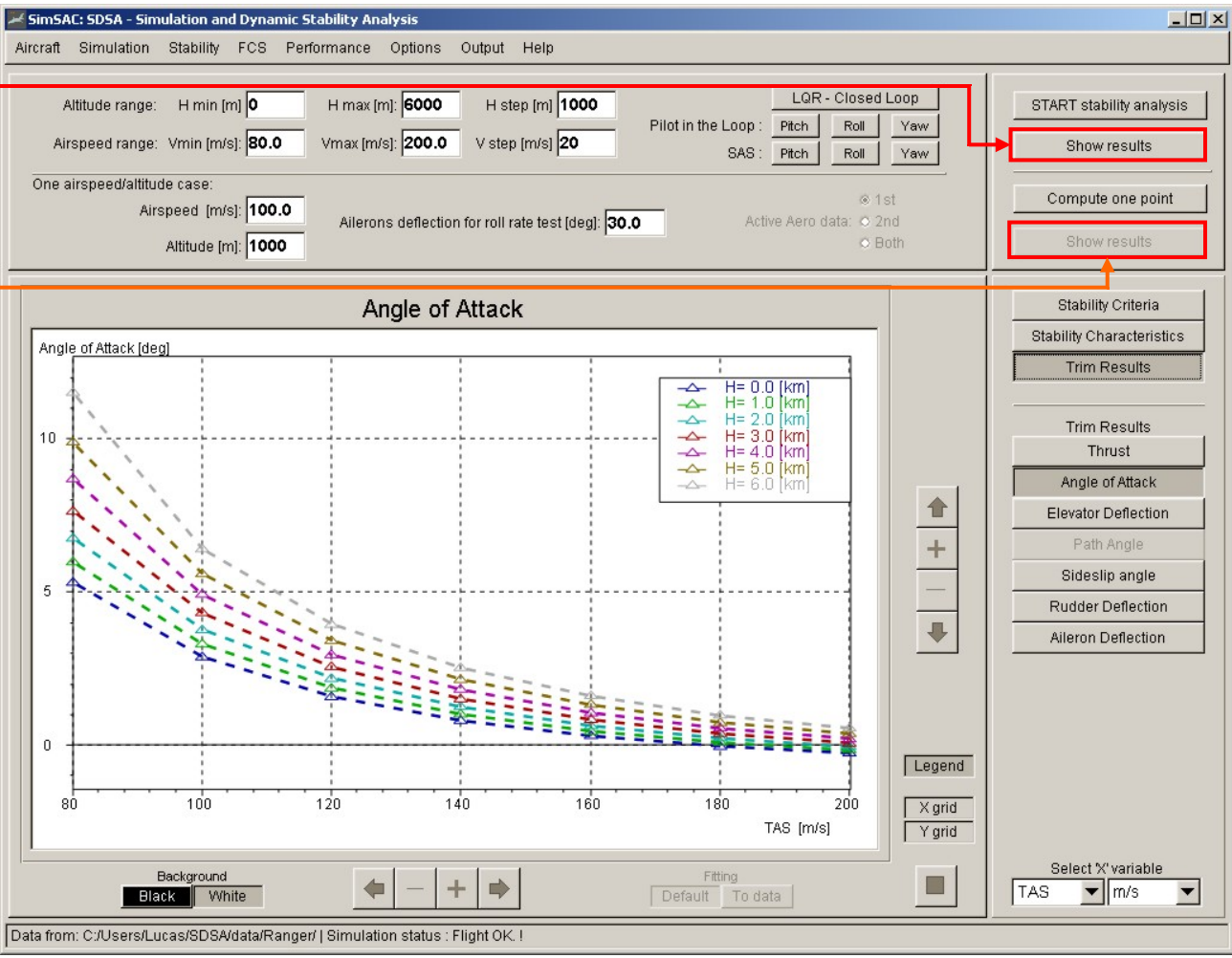
Point 1
H= 1000 [m] V= 100.0 [m/s]

No.	Re	Im	Mode	Period	T1/2	UFreq	DampR
1	-0.52636	1.28431	(2)short period	4.892	1.317	1.3880	0.3792
2	-0.52636	-1.28431	(2)short period	4.892	1.317	1.3880	0.3792
3	-0.00920	0.12599	(1) phugoid	49.872	75.350	0.1263	0.0728
4	-0.00920	-0.12599	(1) phugoid	49.872	75.350	0.1263	0.0728
5	-2.79709	0.00000	(4) roll	0.000	0.248	2.7971	1.0000
6	-0.57861	1.65514	(3) Dutch roll	3.773	1.198	1.7628	0.3282
7	-0.57861	-1.65514	(3) Dutch roll	3.773	1.198	1.7628	0.3282
8	-0.01658	0.00000	(5) spiral	0.000	41.797	0.0166	1.0000

Point 2
H= 1000 [m] V= 150.0 [m/s]

No.	Re	Im	Mode	Period	T1/2	UFreq	DampR
1	-0.78987	1.94899	(2)short period	3.224	0.878	2.1030	0.3756
2	-0.78987	-1.94899	(2)short period	3.224	0.878	2.1030	0.3756
3	-0.00599	0.08559	(1) phugoid	73.413	115.631	0.0858	0.0699
4	-0.00599	-0.08559	(1) phugoid	73.413	115.631	0.0858	0.0699
5	-4.85724	0.00000	(4) roll	0.000	0.143	4.8572	1.0000
6	-0.49334	2.20701	(3) Dutch roll	2.847	1.405	2.2615	0.2181
7	-0.49334	-2.20701	(3) Dutch roll	2.847	1.405	2.2615	0.2181
8	0.00255	0.00000	(5) spiral	0.000	-272.000	0.0025	-1.0000

External text window
(easy to export data)



STABILITY submenu Eigenvalues... (F7) internal window

NEW FEATURE!

LQR Linear Quadratic
Regulator Closed Loop
&
Pilot in the Loop
on/off button
&
SAS stability
augmentation system



LQR - Closed Loop

Pilot in the Loop :

Pitch

Roll

Yaw

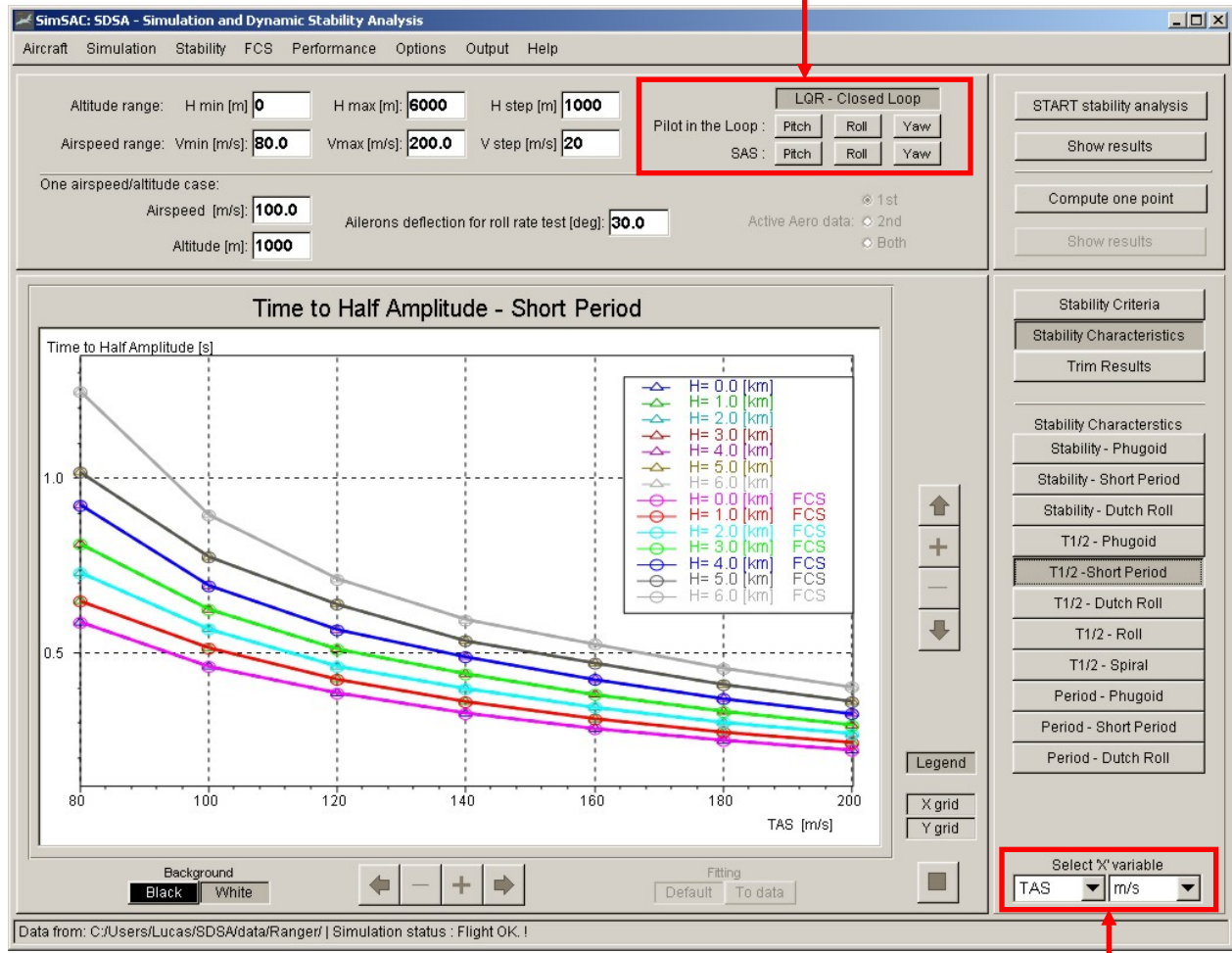
SAS :

Pitch

Roll

Yaw

User can choose
between the LQR Pilot
and SAS stability
computations.



NEW - Select X variable (TAS, EAS, CAS or MACH)

STABILITY submenu Eigenvalues... (F7) internal window

NEW FEATURE!

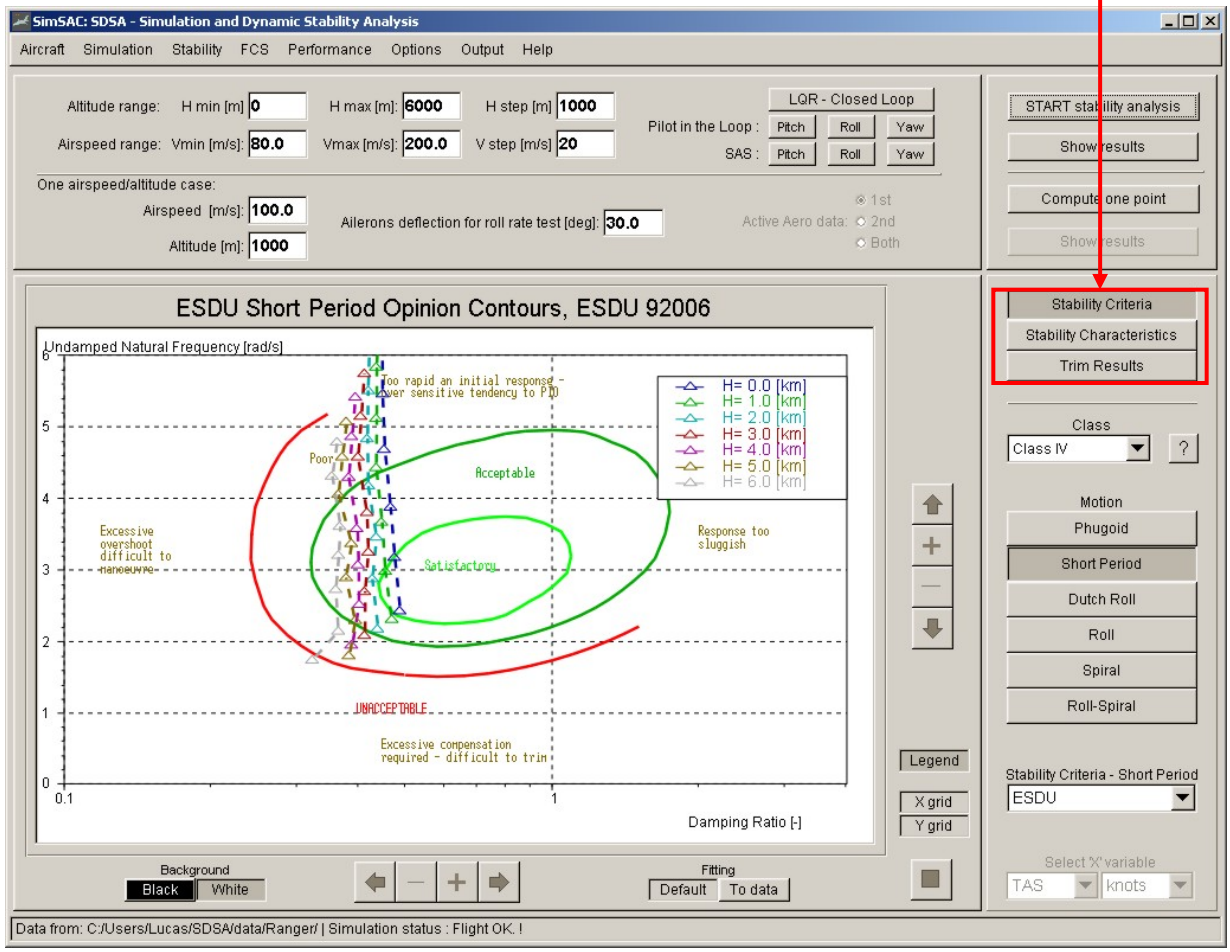
Stability Criteria
button panel

Stability Criteria button ON

Class
Class III ?

Motion
Phugoid
Short Period
Dutch Roll
Roll
Spiral
Roll-Spiral

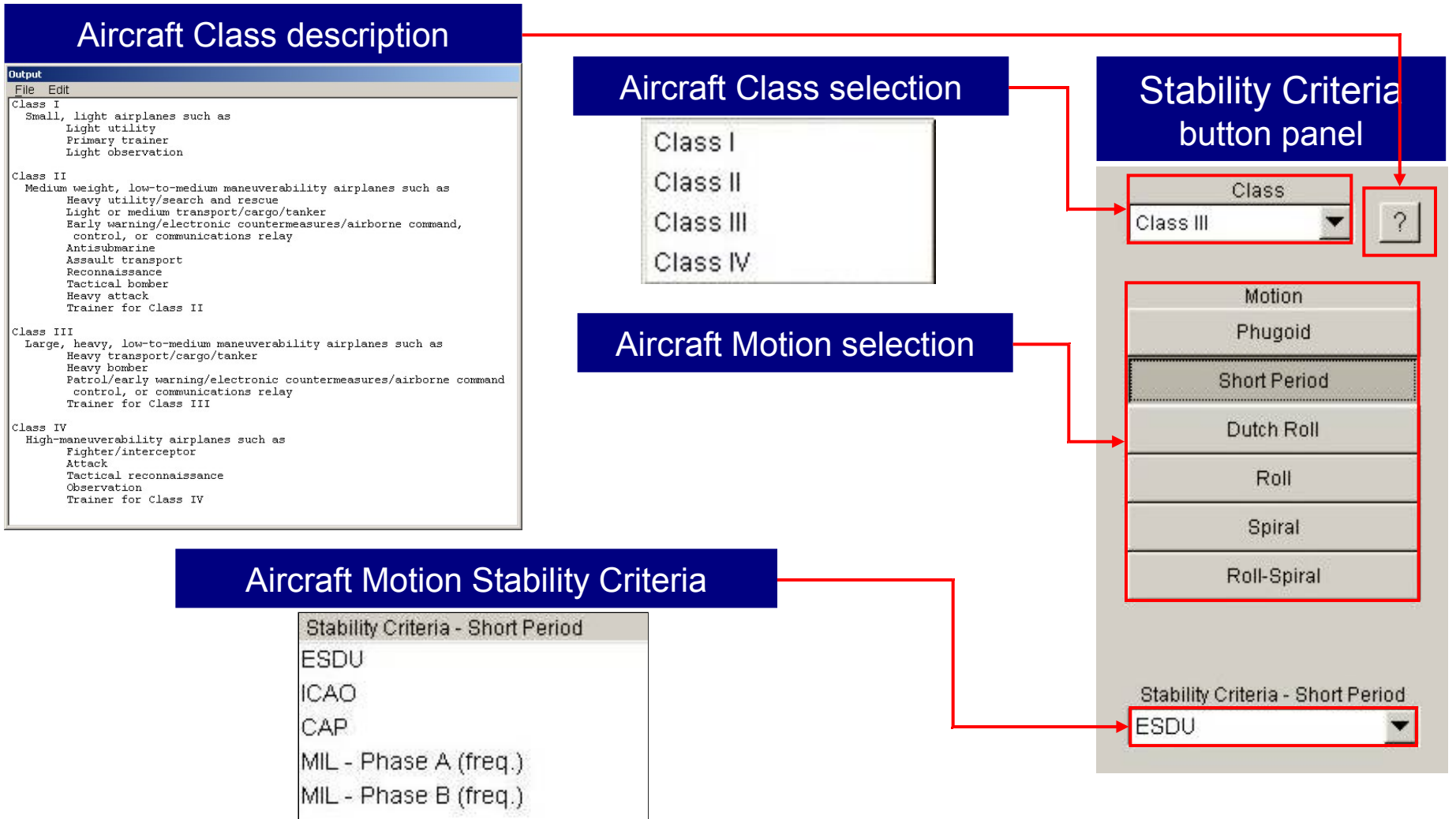
Stability Criteria - Short Period
ESDU



Example Stability Criteria Short Period motion results for Class III by ESDU!

STABILITY submenu Eigenvalues... (F7) internal window

NEW FEATURE!



Stability criteria types for Short Period motion (example).

STABILITY submenu Eigenvalues... (F7) internal window

Stability Characteristics button panel

Stability Criteria

Stability Characteristics

Trim Results

Stability Characteristics

Stability - Phugoid

Stability - Short Period

Stability - Dutch Roll

T1/2 - Phugoid

T1/2 -Short Period

T1/2 - Dutch Roll

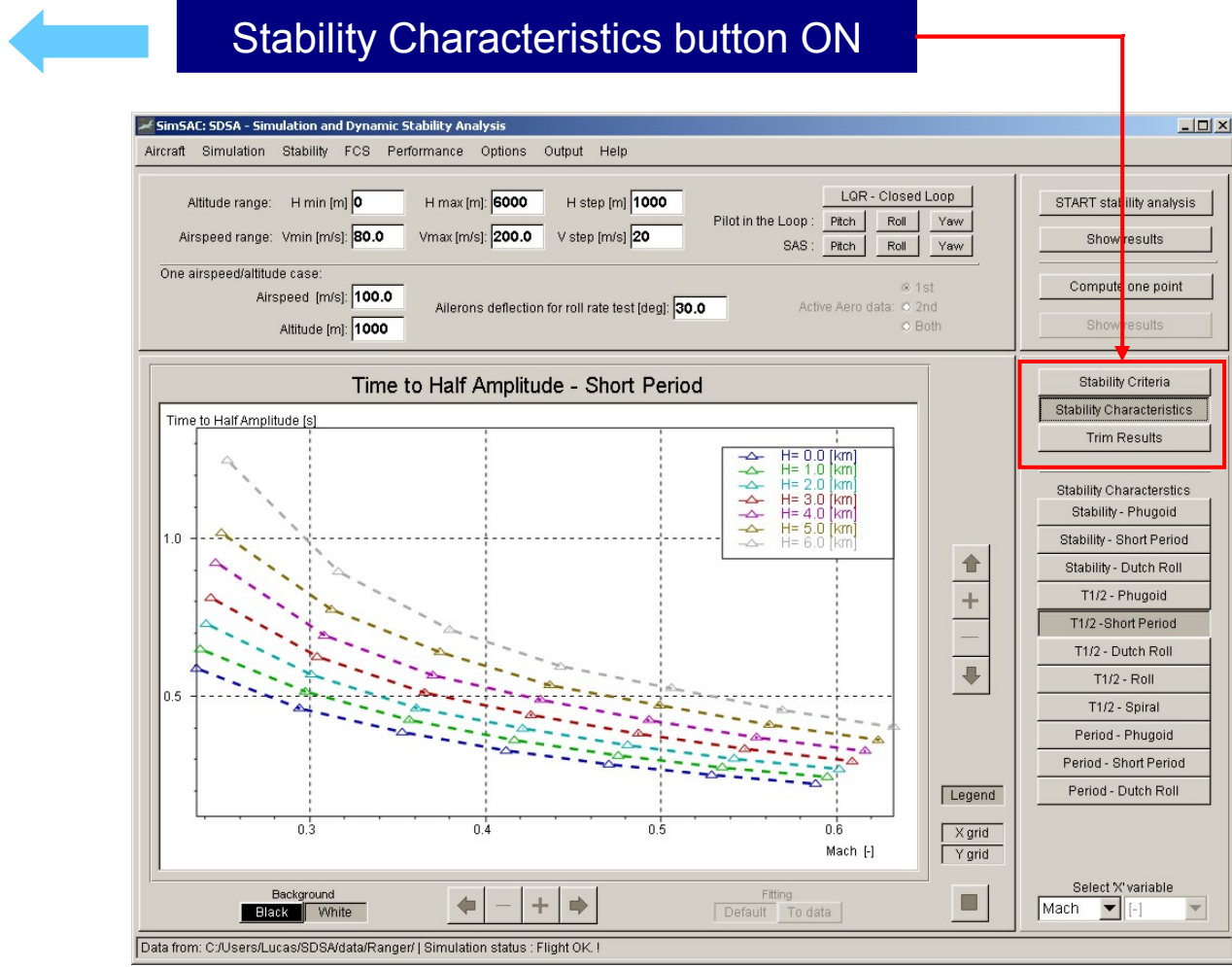
T1/2 - Roll

T1/2 - Spiral

Period - Phugoid

Period - Short Period

Period - Dutch Roll



Example T1/2 – Short Period results!

STABILITY submenu Eigenvalues... (F7) internal window

Trim results
button panel

Trim results button ON

Stability Criteria

Stability Characteristics

Trim Results

Trim Results

Thrust

Angle of Attack

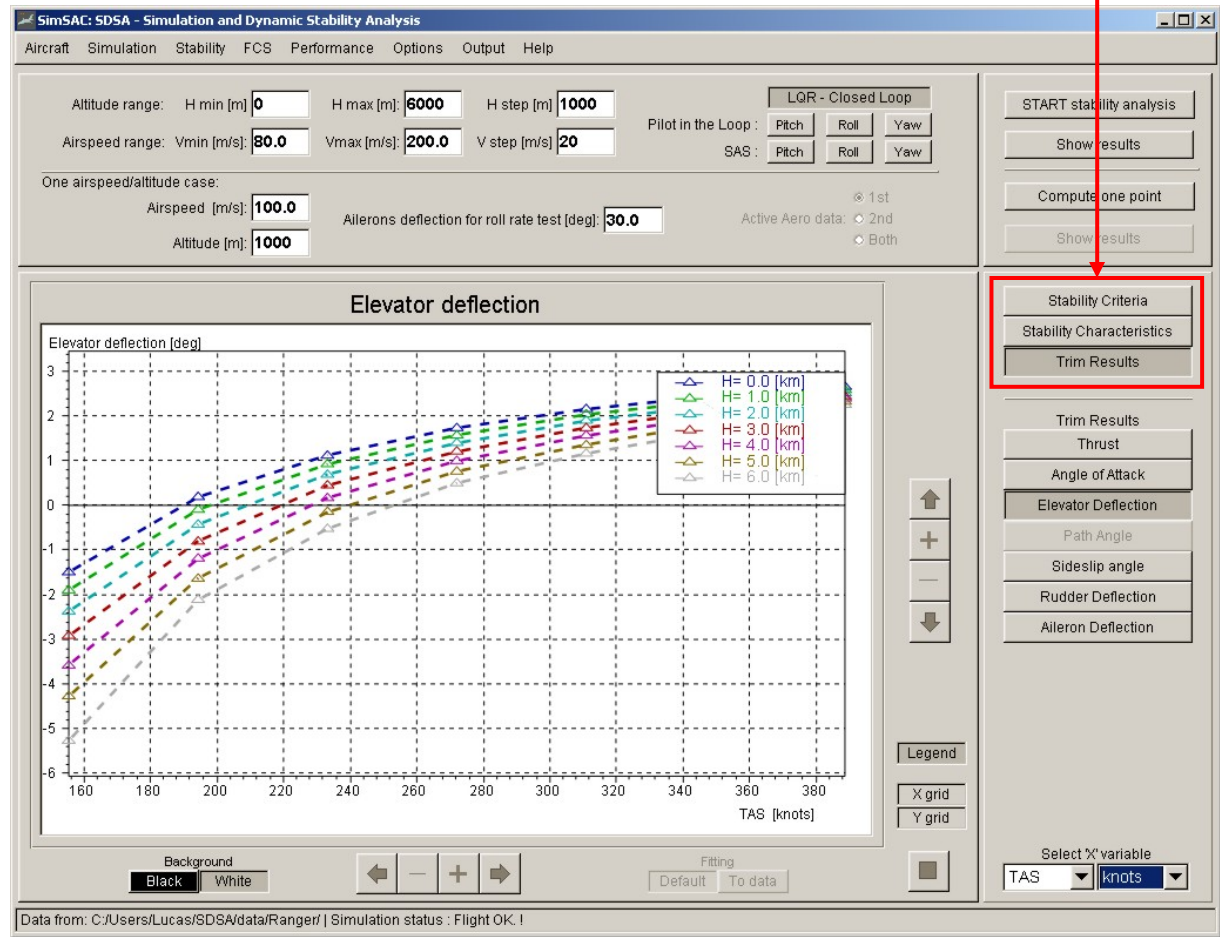
Elevator Deflection

Path Angle

Sideslip angle

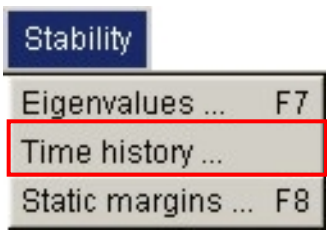
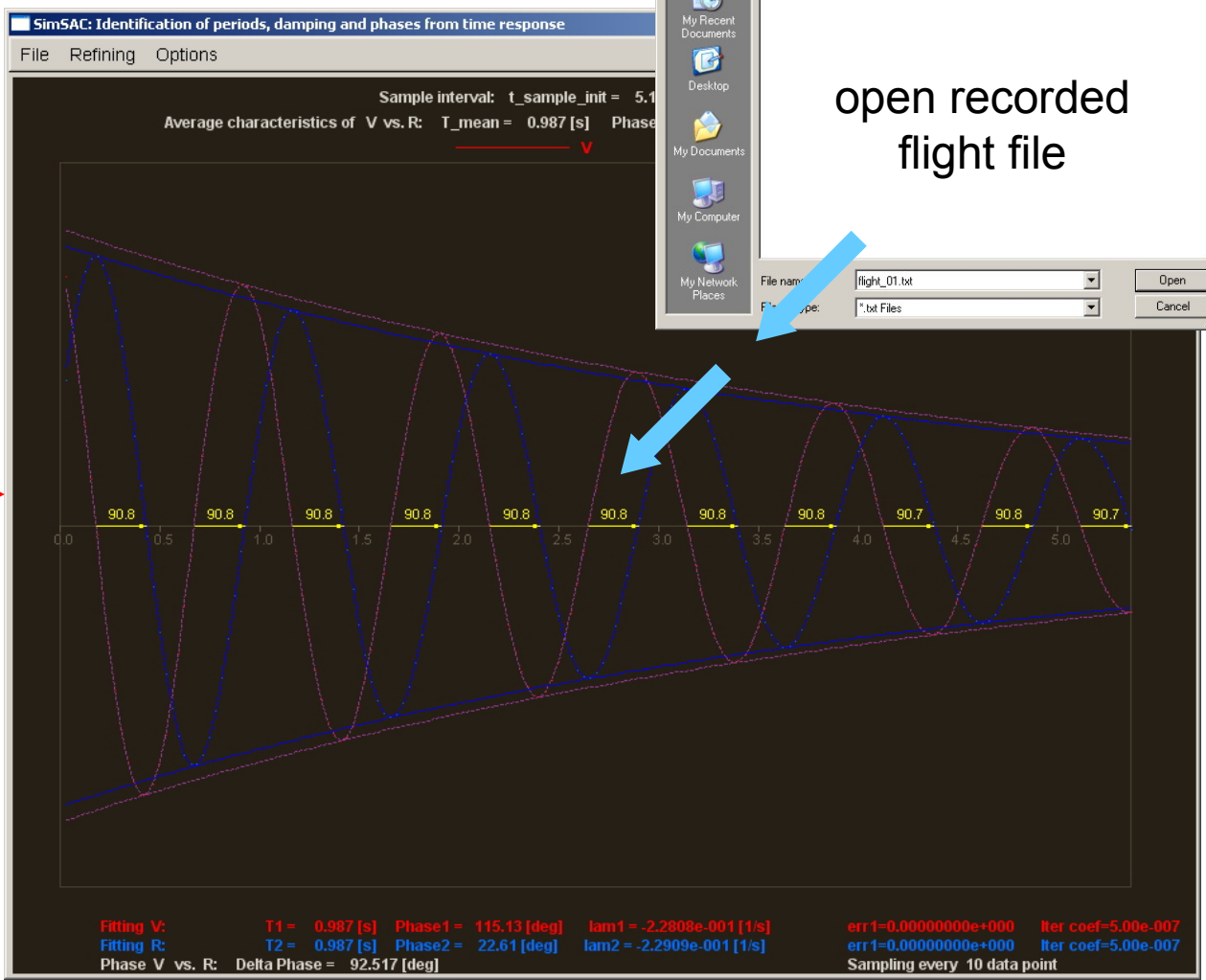
Rudder Deflection

Aileron Deflection



Example Trim elevator deflection results!

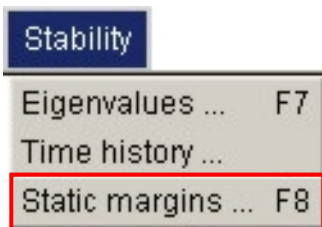
STABILITY submenu Time history... external window



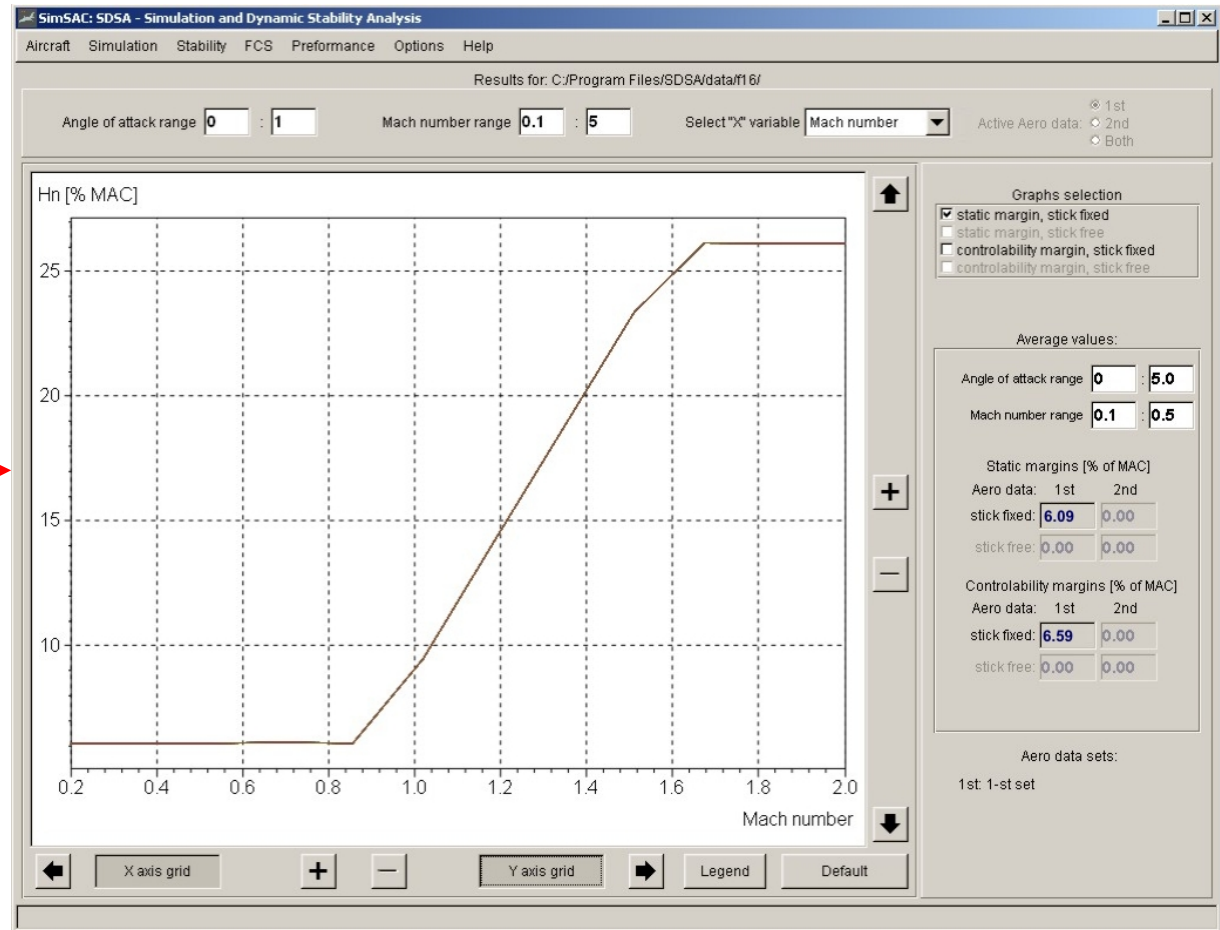
Click Time history ... button in Stability submenu to open recorded flight file and activate external SDSA Time history application window, where user can perform the time domain stability computations!

STABILITY submenu Static margins... (F8) internal window

IMPROVED FEATURE!



This option enables user to compute static margins and controllability margins with stick fixed or free for **active aero data** (stick free option in currently in progress) and display them versus Mach number or angle or attack on graphs.



FCS Flight Control System submenu

- FCS
- Basic FCS parameters ...
- Pilot model ...
- Stability Augmentation System ...
- Linear Quadratic Regulator ...
- Read LQR matrix ...
- Save LQR matrix ...

Click Basic FCS parameters... button in FCS submenu to activate internal SDSA Basic FCS parameters window!

Feature will be discussed in detail in separate presentation.

NEW FEATURE!

SimSAC: SDSA - Simulation and Dynamic Stability Analysis

Aircraft Simulation Stability FCS Performance Options Output Help

Basic FCS parameters

stick/ pedals shift [-1;1] (normalized)

sin correction

$u = A \cdot x + B$

u_{com} (no lag)

$\frac{1}{\tau s + 1}$

$u_{com}(t)$

x_s

$x_{s,cor}$

x_s

$x_{s,cor}$

S - sin correction

x

y

z

In symmetrical case:
 $B = 0$
 $A = \text{max control surface deflection}$

Elevator parameters

A: -25.0 - [deg]
B: 0 - [deg]
 τ : 0.05 - lag time [s]
S: 0.20 - sin correction [-]

Ailerons parameters

A: -21.5 - [deg]
B: 0 - [deg]
 τ : 0.05 - lag time [s]
S: 0.20 - sin correction [-]

Rudder parameters

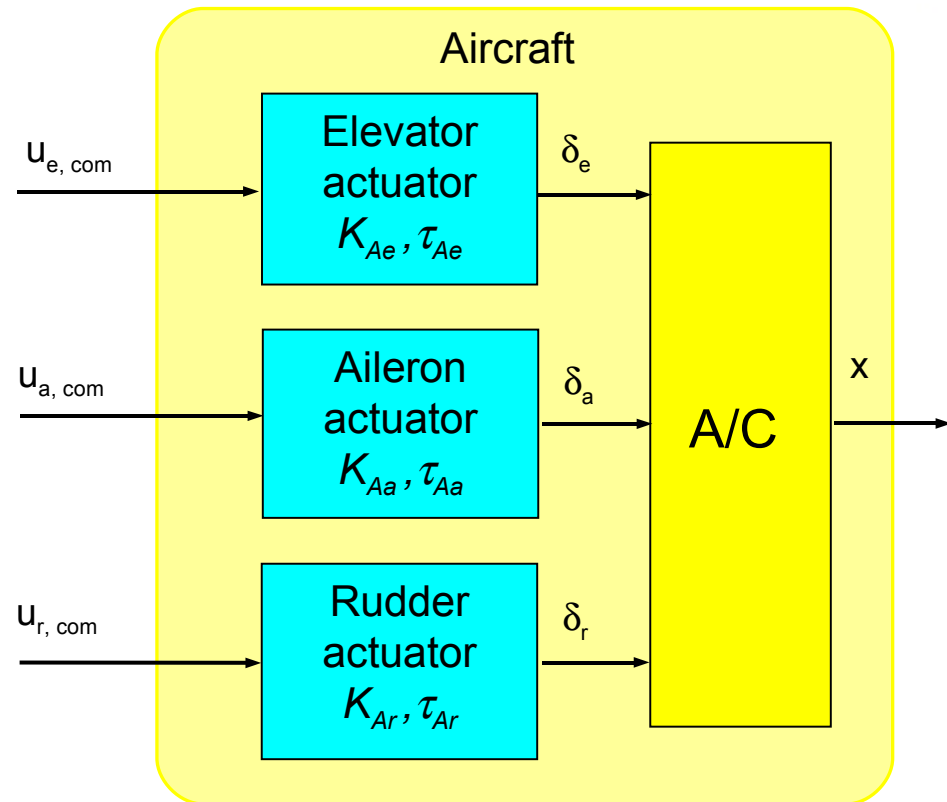
A: -30.0 - [deg]
B: 0 - [deg]
 τ : 0.05 - lag time [s]
S: 0 - sin correction [-]

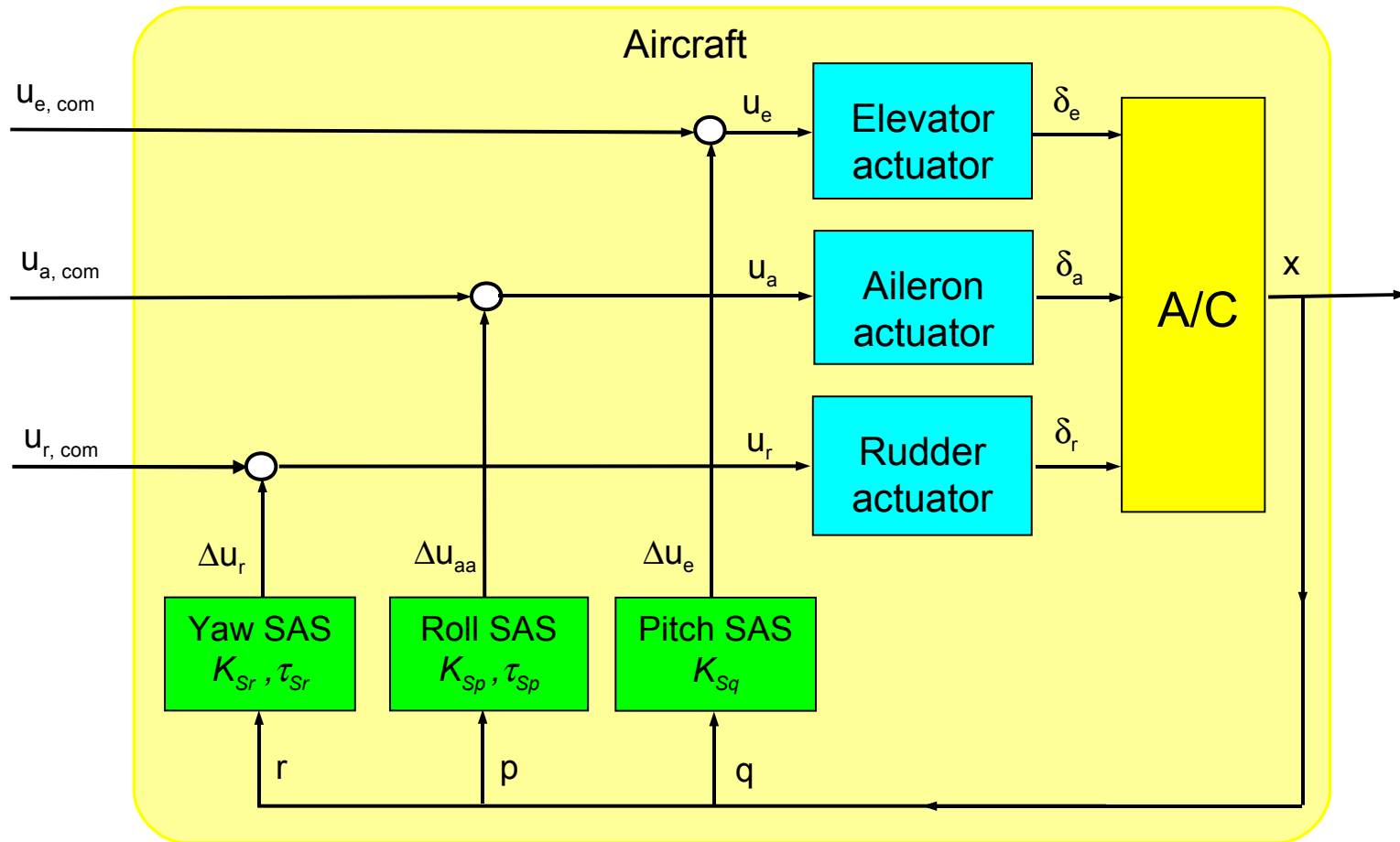
Cancel Save options

Data from: C:\Users\Lucas\SDSA\data\fl16\

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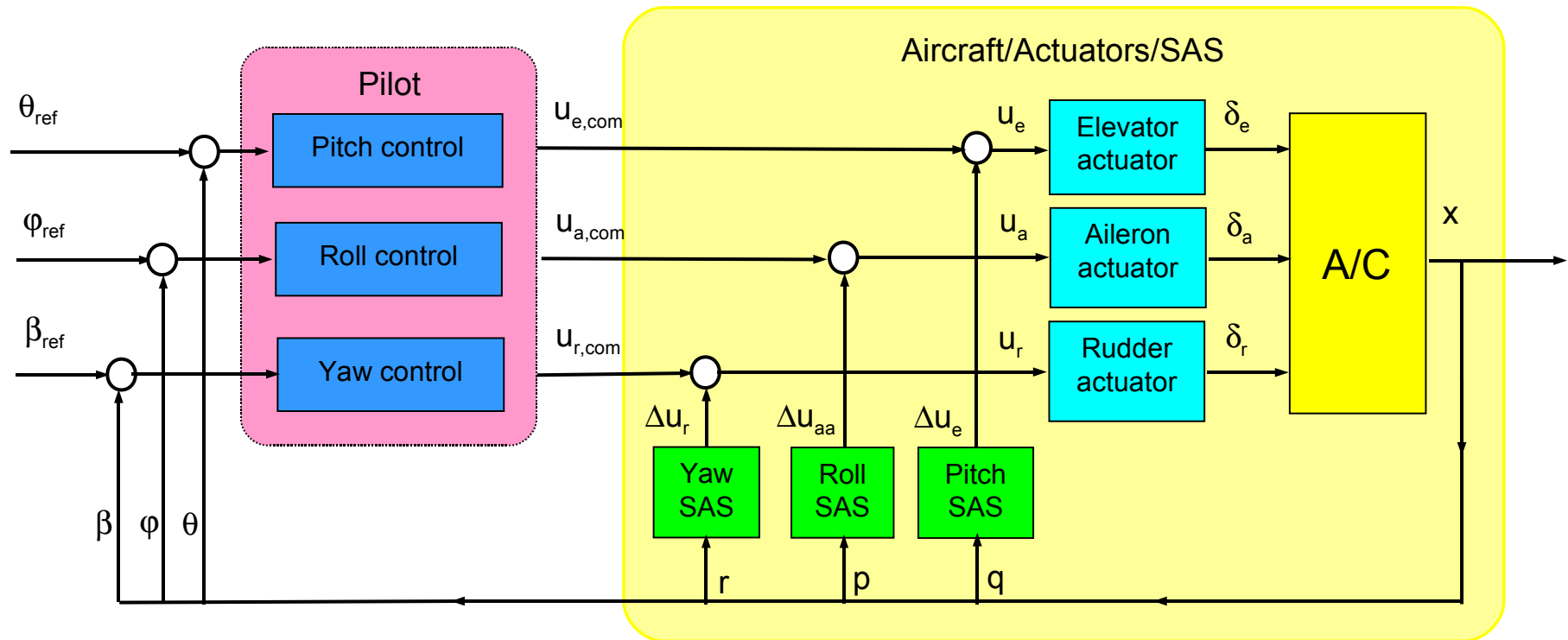
Pilot commands: $u_{e,com}$ – pitch stick, $u_{a,com}$ – roll stick, $u_{r,com}$ – pedals*Deflections:* δ_e – elevator [rad] δ_a – aileron [rad] δ_r – rudder [rad]*Actuator parameters:* K_{Ae}, K_{Aa}, K_{Ar} – elevator, aileron and rudder actuator gains [1] $\tau_{Ae}, \tau_{Aa}, \tau_{Ar}$ – elevator, aileron and rudder actuator lag times [s]



SAS parameters (to be tuned):

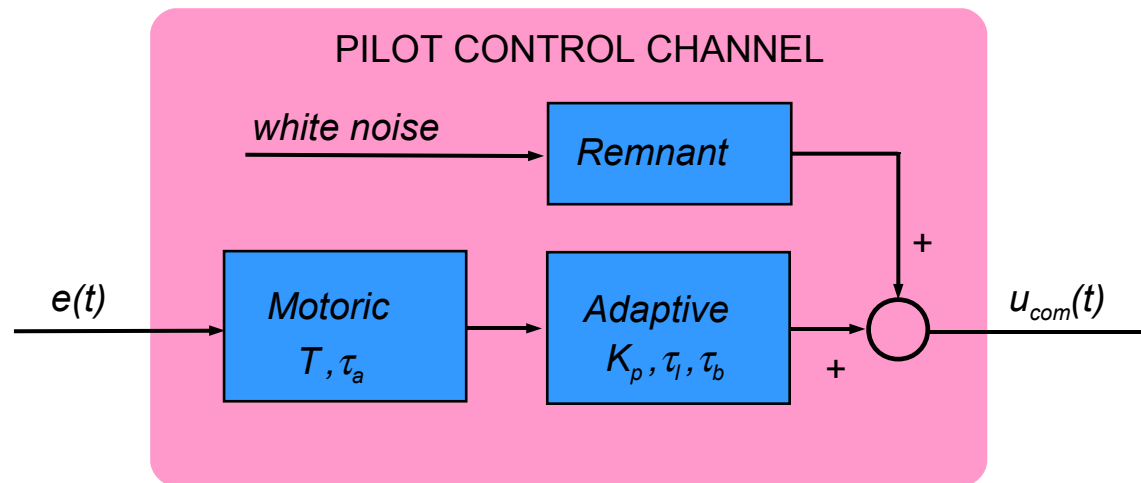
K_{Se} , K_{Sa} , K_{Sr} – elevator, aileron and rudder SAS gains [1]

τ_{Sa} , τ_{Sr} – aileron and rudder SAS lag times [s]



The human-pilot maintains the attitude of an aircraft by tracing some state variables:

- θ_{ref} – pitch angle,
- φ_{ref} – roll angle
- β_{ref} – sideslip angle



$e(t)$ – tracing error input signal,

$u_{com}(t)$ – pilot output control

Pilot model parameters (to be tuned):

T – motoric delay time [s],

τ_a – motoric lag time [s],

K_p – adaptive gain [1],

τ_l – adaptive lead time [s],

τ_b – adaptive lag time [s].

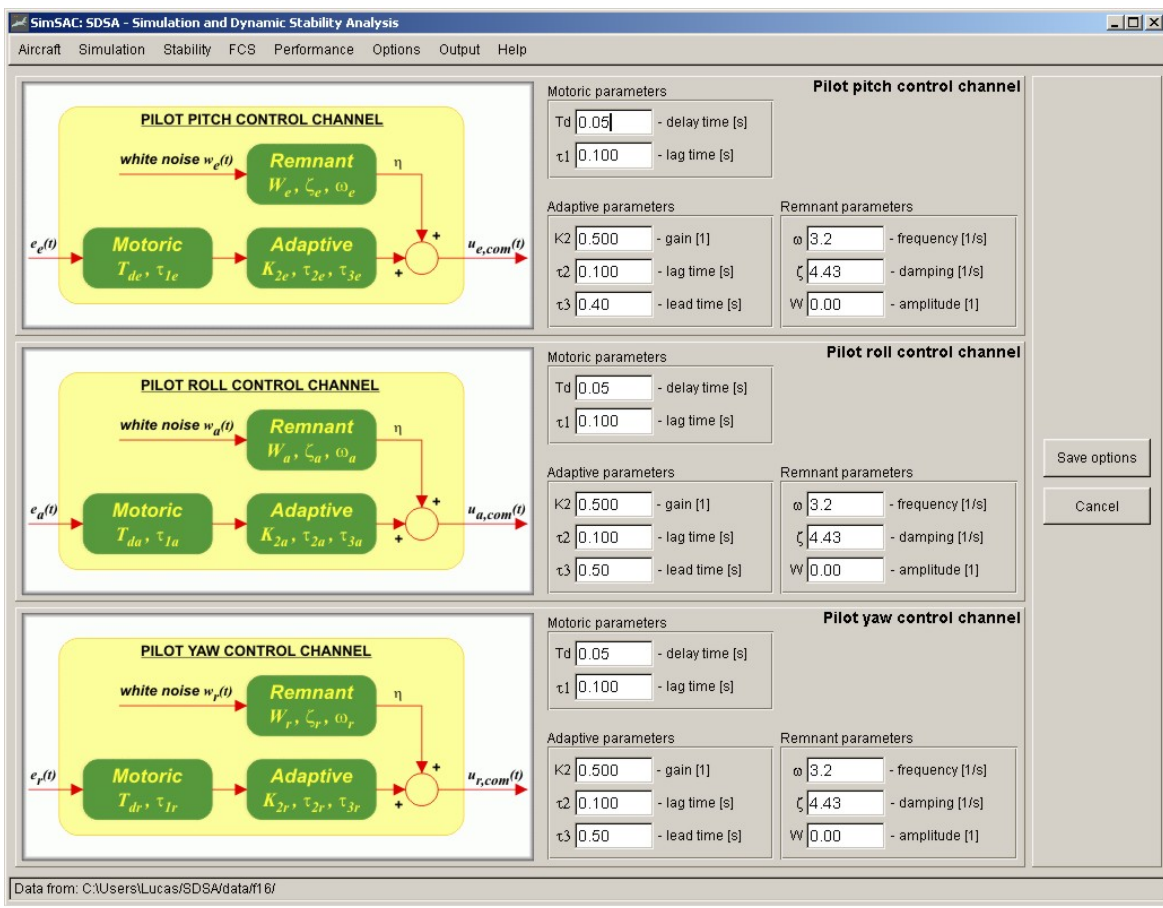
FCS Flight Control System submenu

- FCS
- Basic FCS parameters ...
- Pilot model ...
- Stability Augmentation System ...
- Linear Quadratic Regulator ...
- Read LQR matrix ...
- Save LQR matrix ...

Click Pilot model... button in FCS submenu to activate internal SDSA Pilot model window!

Feature will be discussed in detail in separate presentation.

NEW FEATURE!



FCS Flight Control System submenu

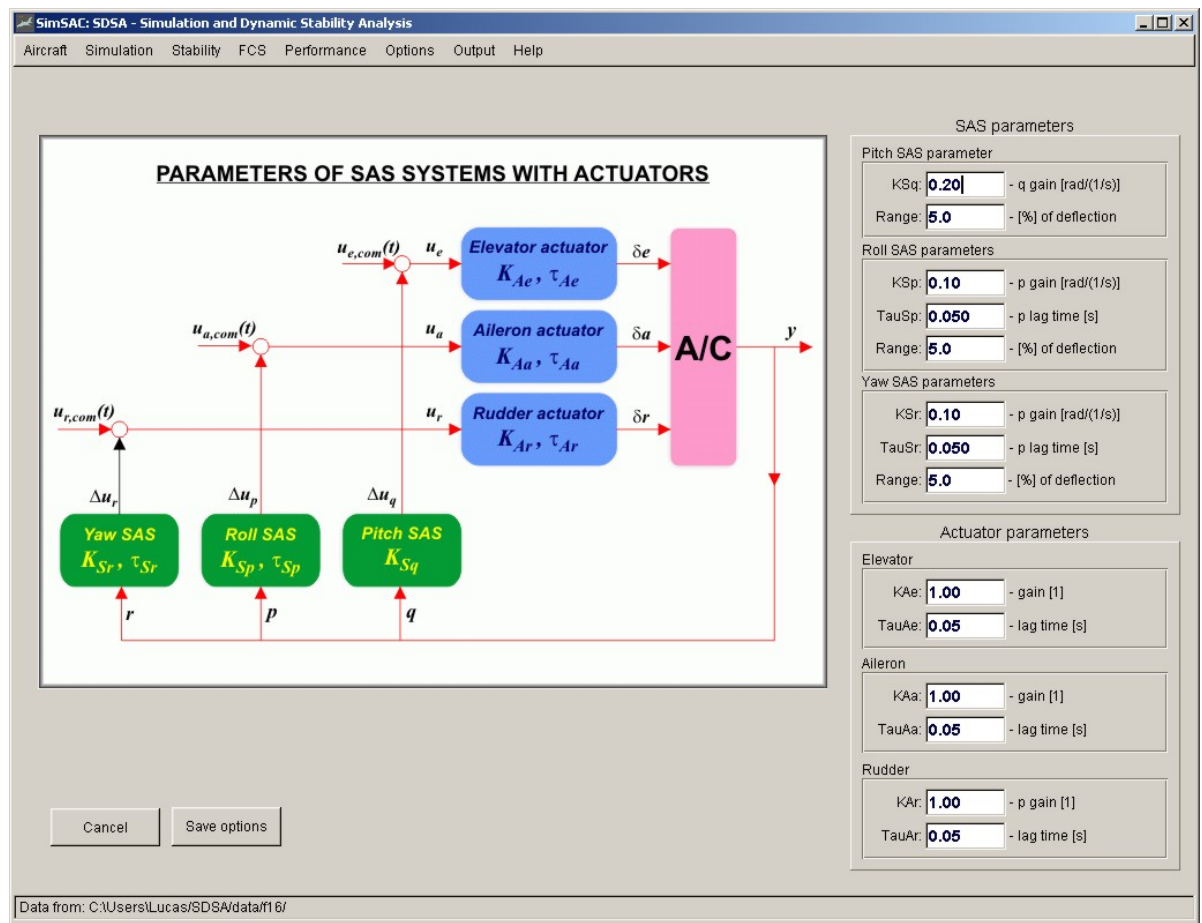
FCS

- Basic FCS parameters ...
- Pilot model ...
- Stability Augmentation System ...
- Linear Quadratic Regulator ...
- Read LQR matrix ...
- Save LQR matrix ...

Click Stability Augmentation System... button in FCS submenu to activate internal SDSA SAS window!

Feature will be discussed in detail in separate presentation.

NEW FEATURE!



FCS Flight Control System submenu

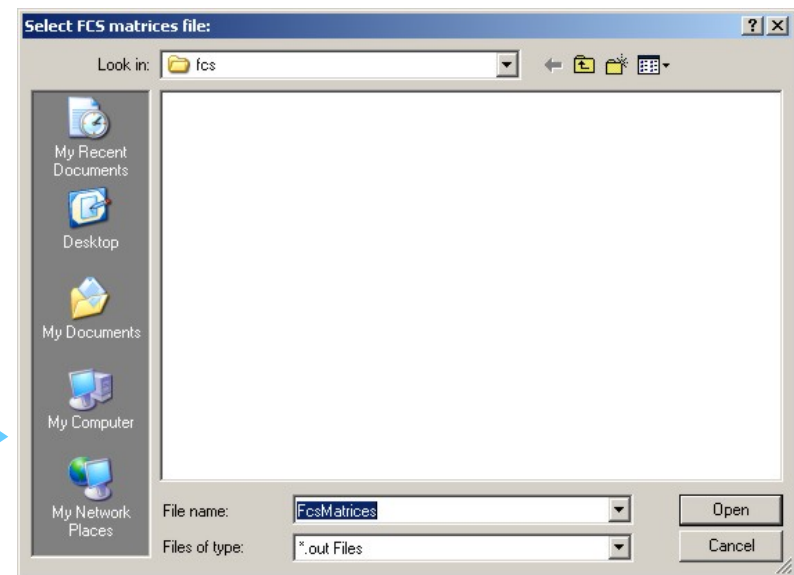
FCS

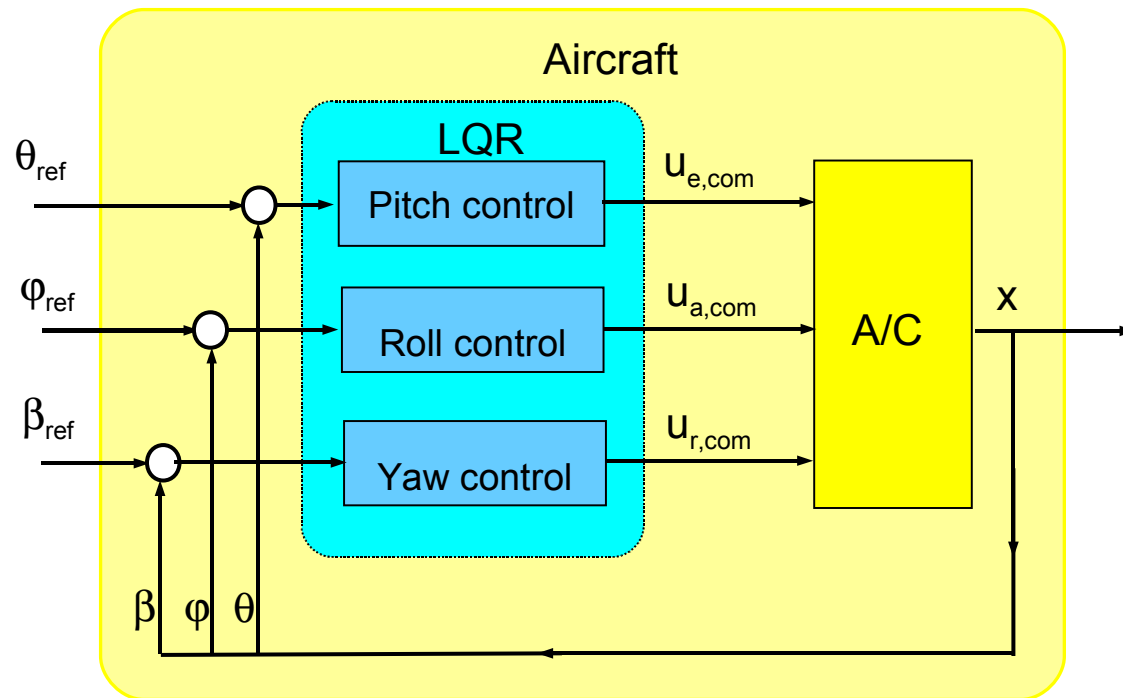
- Basic FCS parameters ...
- Pilot model ...
- Stability Augmentation System ...
- Linear Quadratic Regulator ...
- Read LQR matrix ...
- Save LQR matrix ...

Click Linear Qadratic Regulator... button in FCS submenu to activate internal SDSA LQR window!

Click Read LQR matrix... button in FCS submenu to load saved FCS matrix data!

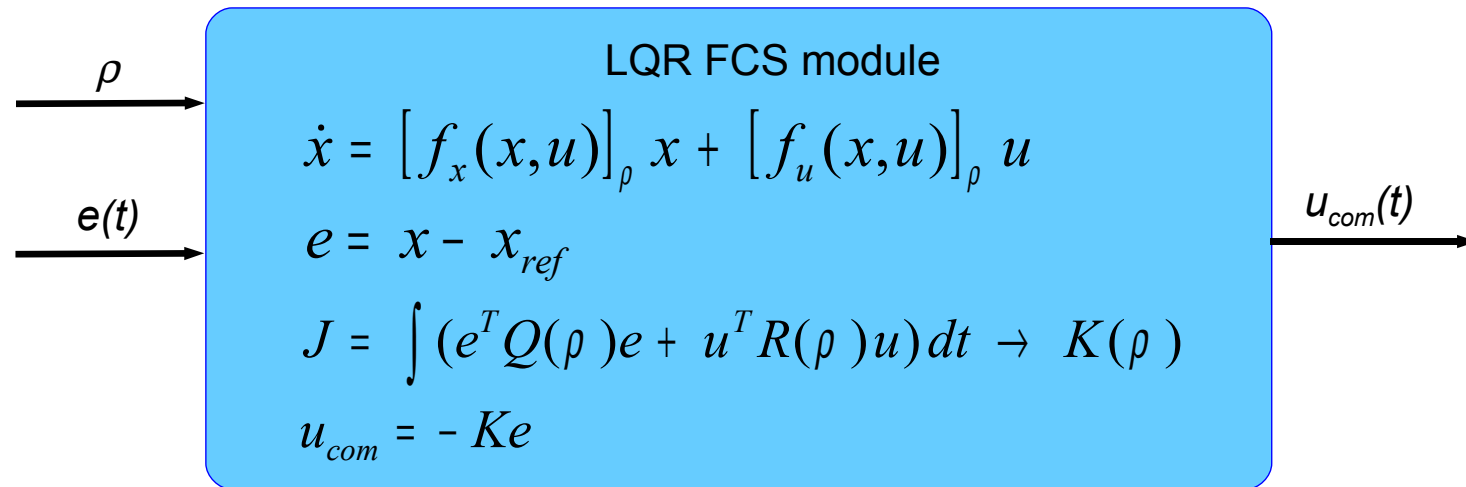
Click Save LQR matrix... button in FCS submenu to save FCS matrix!





LQR FCS maintains the attitude of an aircraft by tracing some state variables:

- θ_{ref} – pitch angle,
- ϕ_{ref} – roll angle
- β_{ref} – sideslip angle



$\dot{x} = f(x,u)$ – nonlinear model of aircraft,

$e(t)$ – tracing error input signal,

$u_{com}(t)$ – LQR output control,

ρ – envelope scheduling parameter (Altitude, Mach),

$K(\rho)$ – LQR gain matrix,

LQR parameters (to be tuned):

$Q(\rho) = \text{diag}[q_1, \dots, q_n]$ – state error weighting matrix,

$R(\rho) = \text{diag}[r_1, \dots, r_m]$ – control weighting matrix

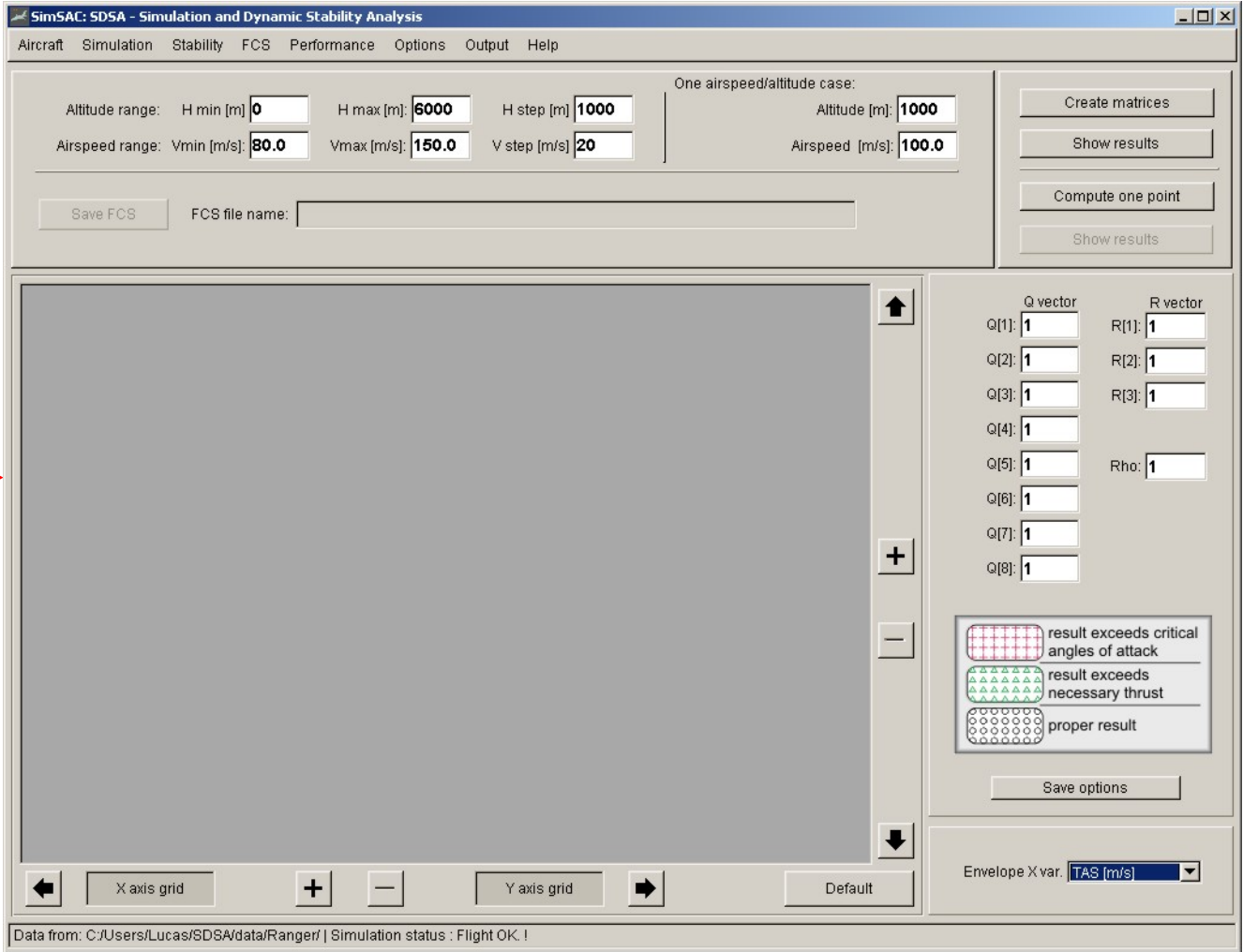
FCS submenu Linear Quadratic Regulator... internal window

FCS

- Basic FCS parameters ...
- Pilot model ...
- Stability Augmentation System ...
- Linear Quadratic Regulator ...**
- Read LQR matrix ...
- Save LQR matrix ...

After LQR... submenu button is activated the internal SDSA FCS „empty” window appears.

Now user can perform FCS flight envelope matrix computations.



SimSAC: SDSA - Simulation and Dynamic Stability Analysis

Aircraft Simulation Stability FCS Performance Options Output Help

Altitude range: H min [m] H max [m] H step [m] One airspeed/altitude case: Altitude [m]

Airspeed range: Vmin [m/s] Vmax [m/s] V step [m/s] Airspeed [m/s]

Save FCS FCS file name:

Q vector R vector

Q[1]: R[1]:

Q[2]: R[2]:

Q[3]: R[3]:

Q[4]: Rho:

Q[5]:

Q[6]:

Q[7]:

Q[8]:

result exceeds critical angles of attack

result exceeds necessary thrust

proper result

Save options

Envelope X var.

Data from: C:/Users/Lucas/SDSA/data/Ranger/ | Simulation status : Flight OK. !

FCS submenu Linear Qadratic Regulator... internal window

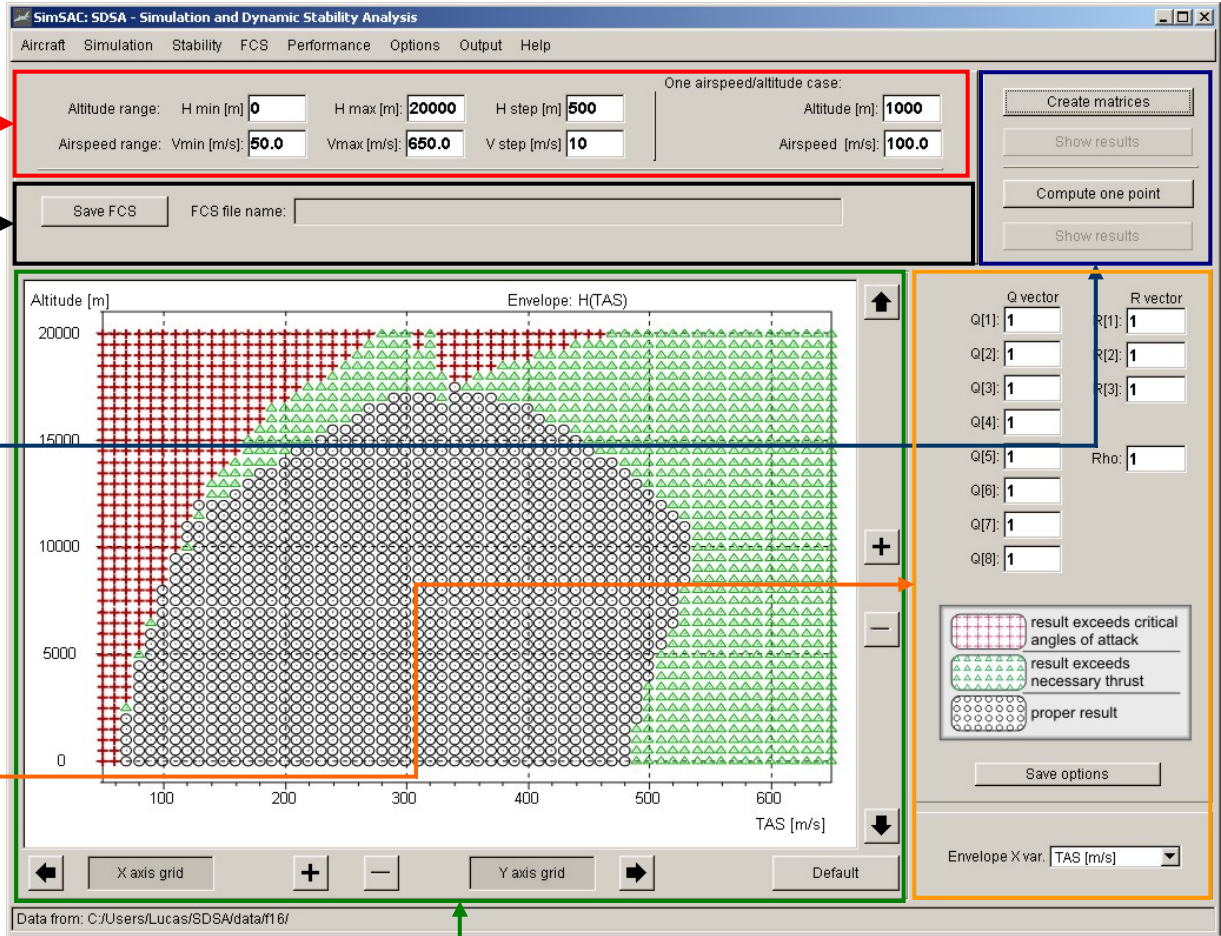
FCS Variable input panel

FCS MATRIX output panel (save computed matrix data)

FCS Control panel

FCS Settings panel

FCS Results graph window

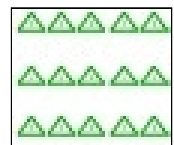


FCS submenu Linear Qadratic Regulator... internal window

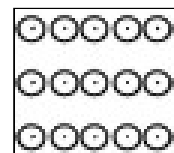
FCS Points on graph – color map description



- Exceeds critical angles of attack

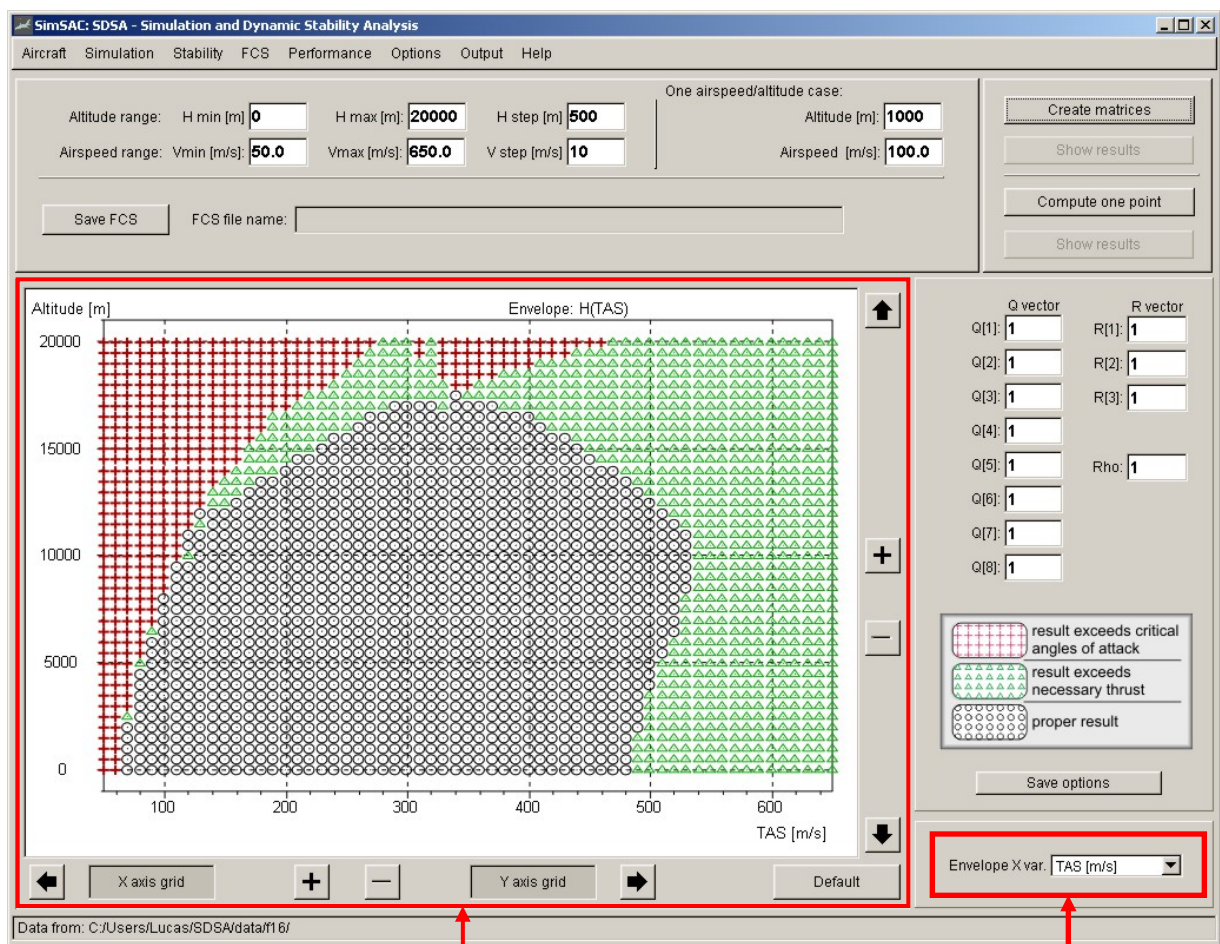


- Exceeds necessary thrust



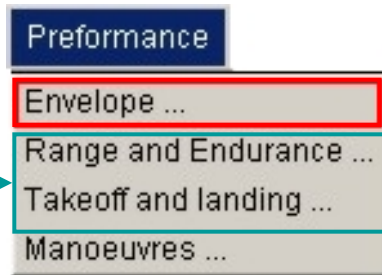
- Proper results

Flight Envelope example results with FCS control points



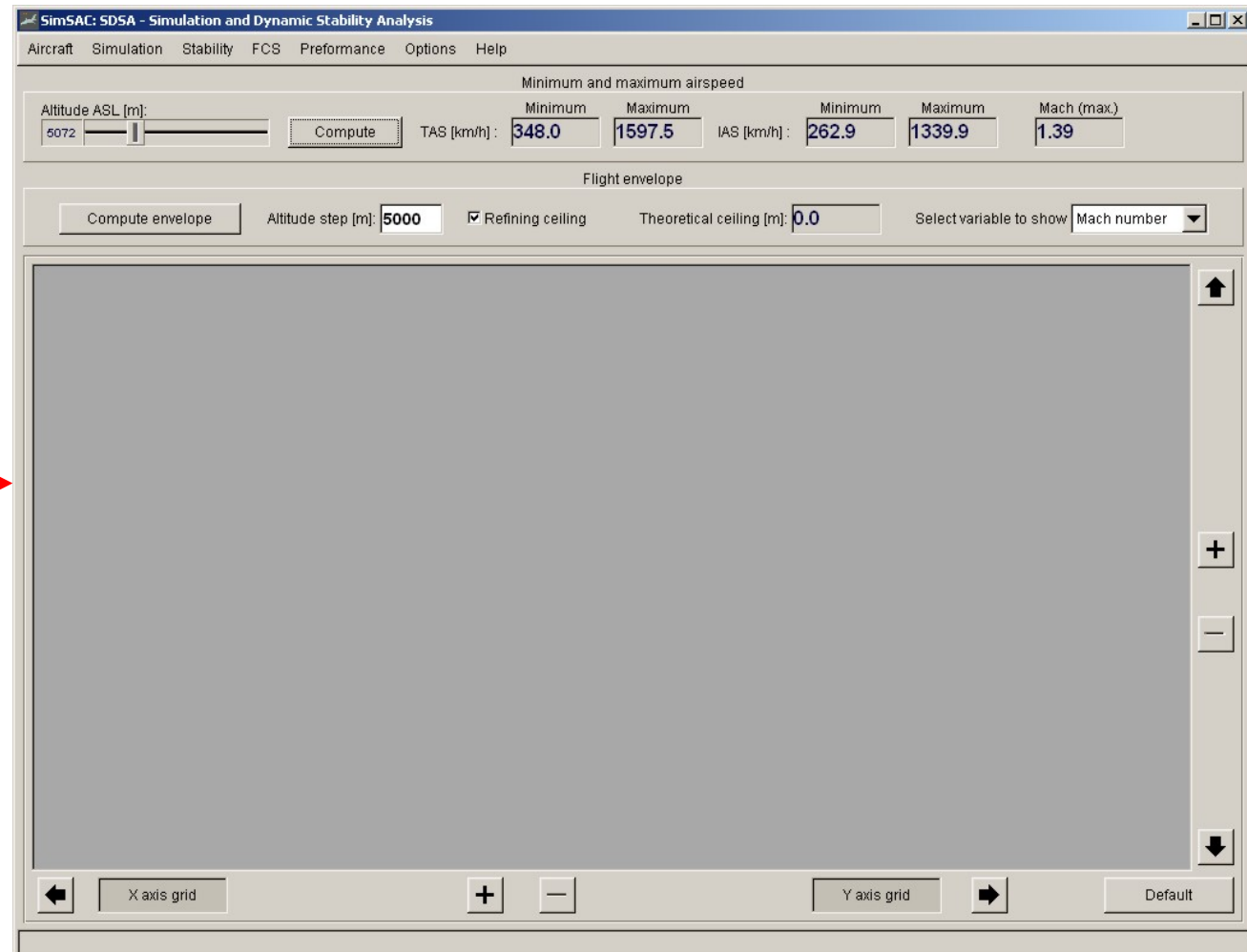
NEW - Select X variable (TAS, EAS, CAS or MACH)

PERFORMANCE submenu Envelope... internal window



In Envelope... mode user can perform flight envelope computations for the required altitude and display the results versus Mach number or angle of attack.

Not ready yet!



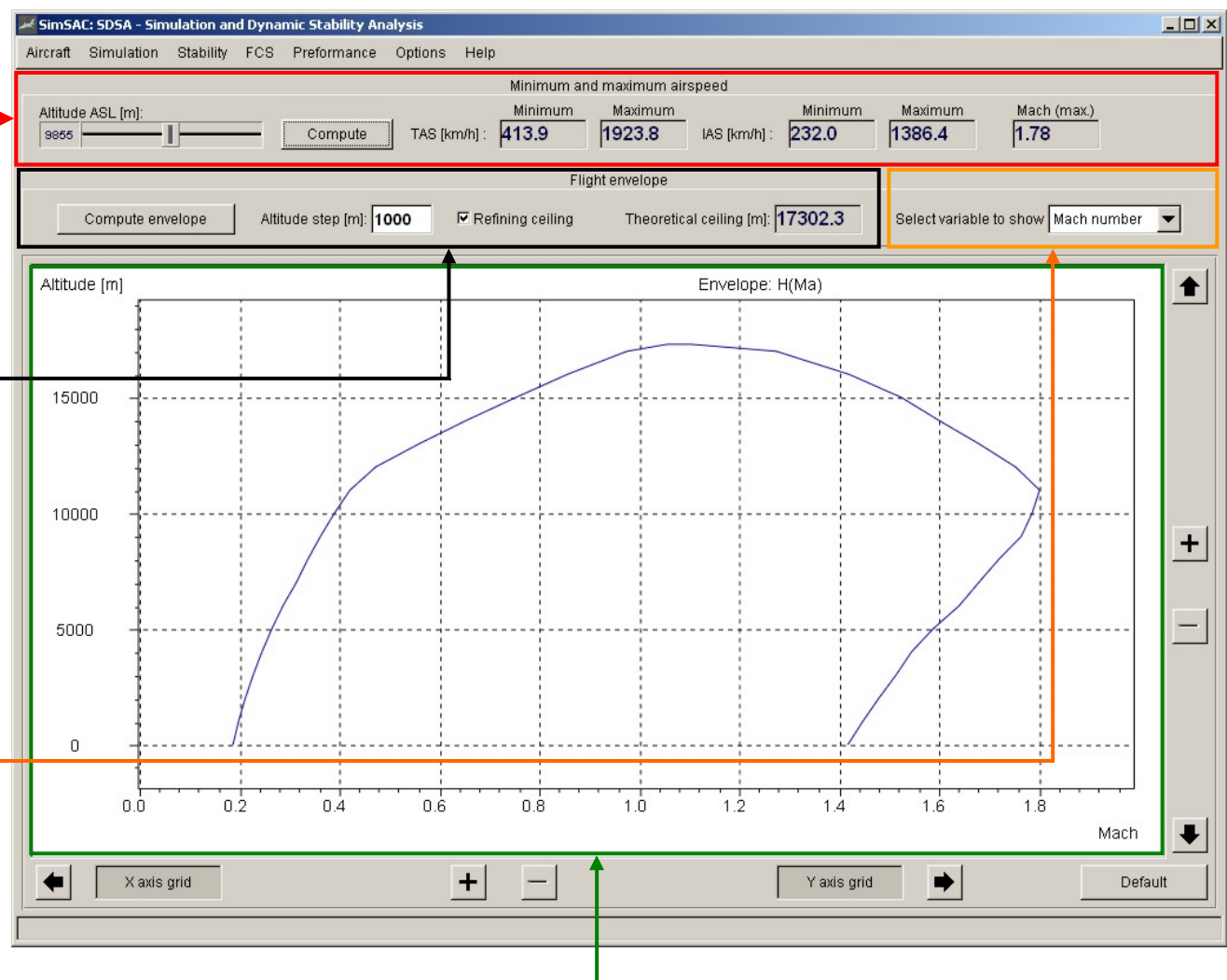
PERFORMANCE submenu Envelope... internal window

Minimum and maximum
airspeed computation
control panel

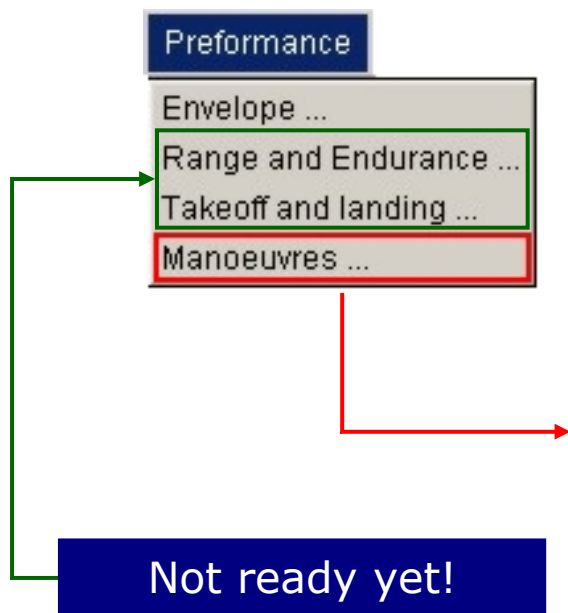
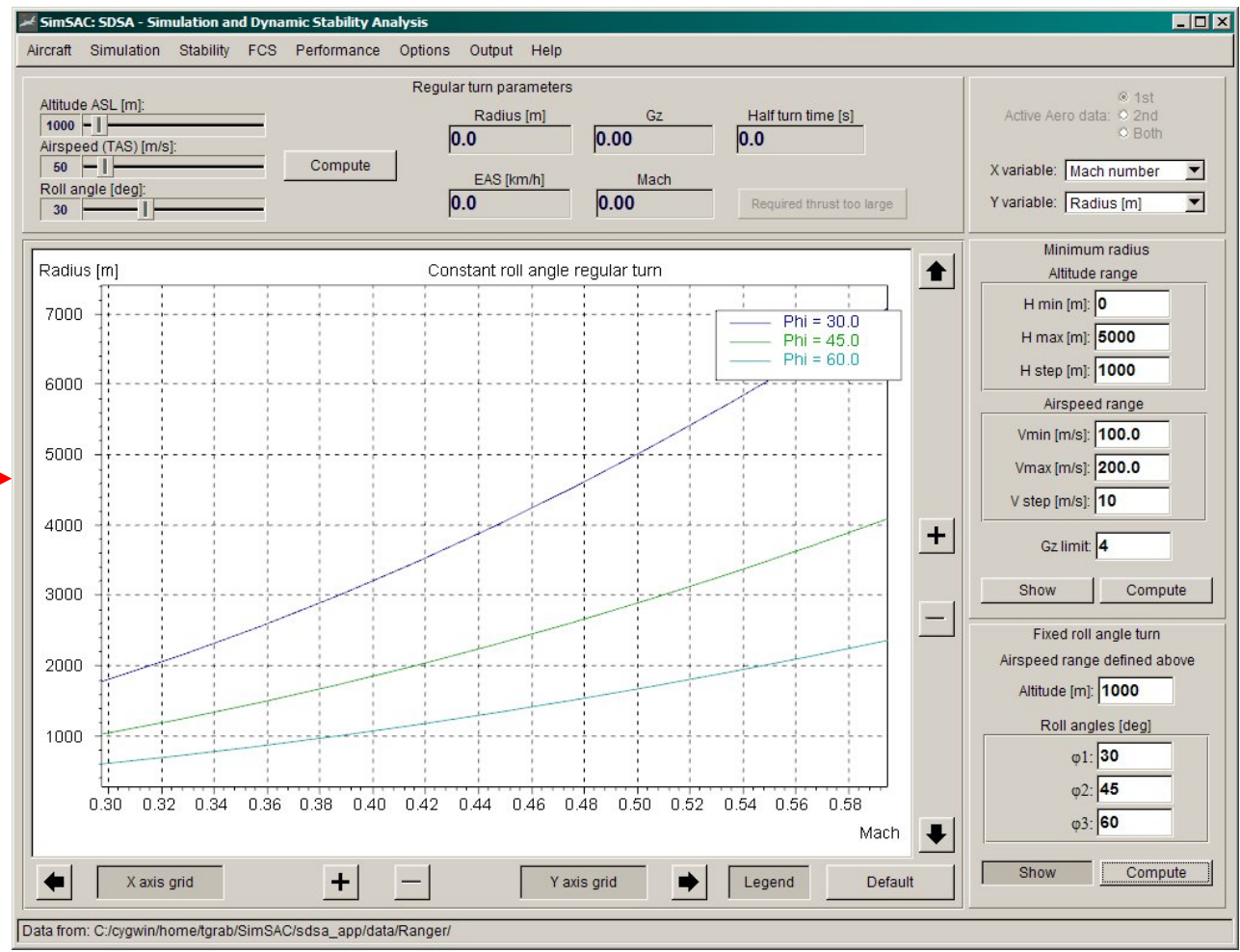
Compute Envelope
panel

Envelope graph X
variable selection

Result Envelope graph
window

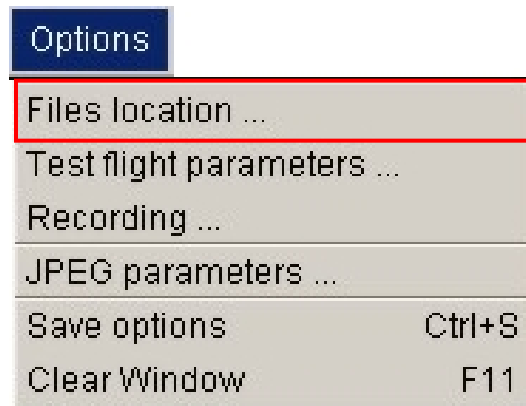


PERFORMANCE submenu Manoeuvres... internal window **NEW FEATURE!**

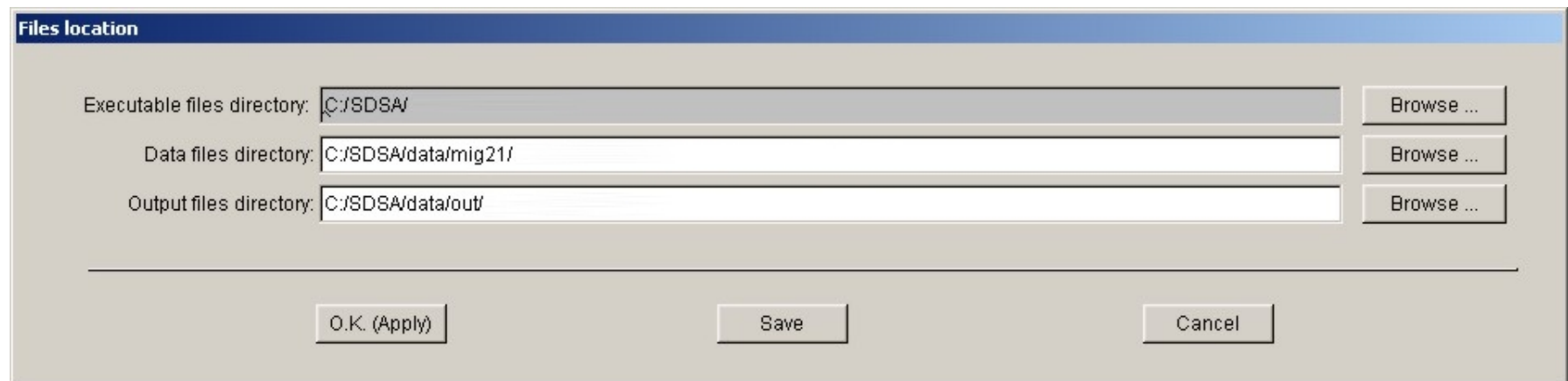


Manoeuvres SDSA performance feature is in progress. At present time user can only Compute regular turn parameters for given altitude, airspeed and roll angle.

OPTIONS submenu Files location... external setup path window

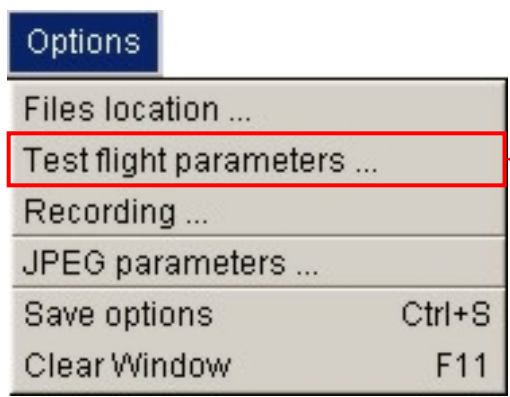


Click Files location ...
button
in Options submenu to
activate external SDSA
File location window!

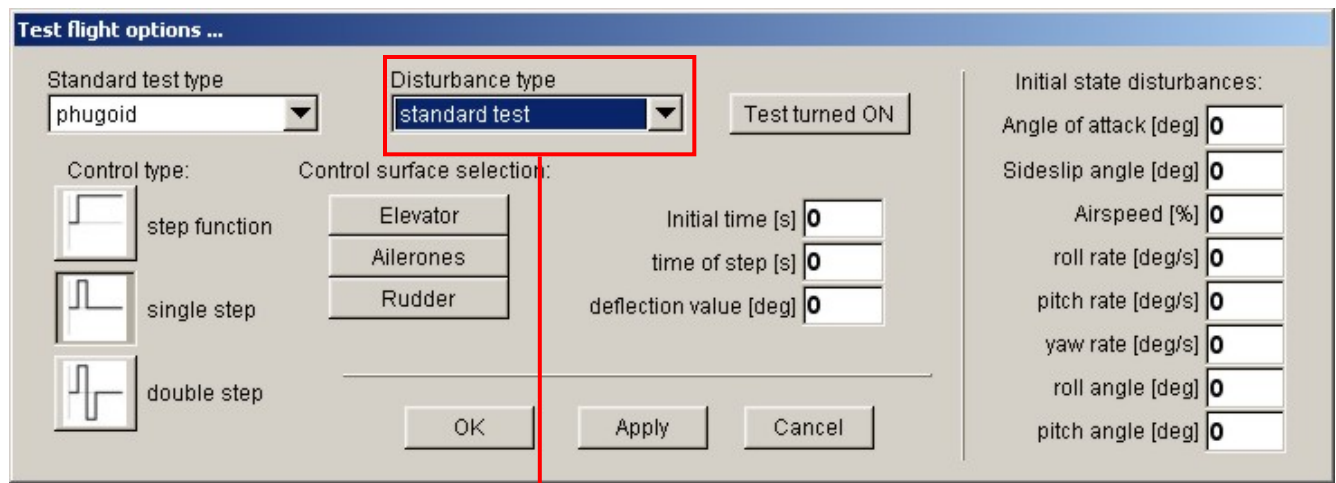
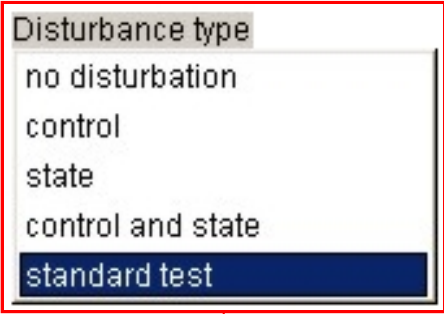


Click Save button to save the paths for selected directories !

OPTIONS submenu Test flight parameters... setup window

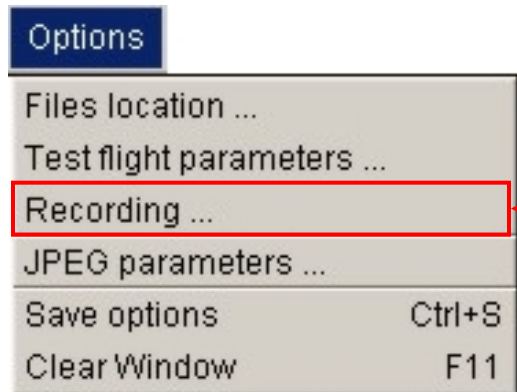


Click Test flight parameters ... button in Options submenu to activate external SDSA Test flight options window!

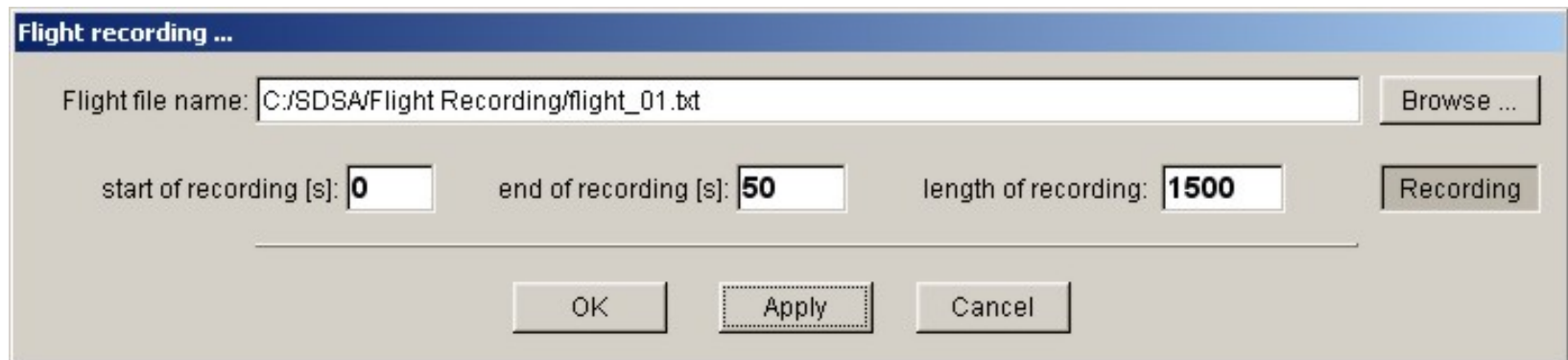


Select the desired disturbance type!

OPTIONS submenu Recording... flight recording window

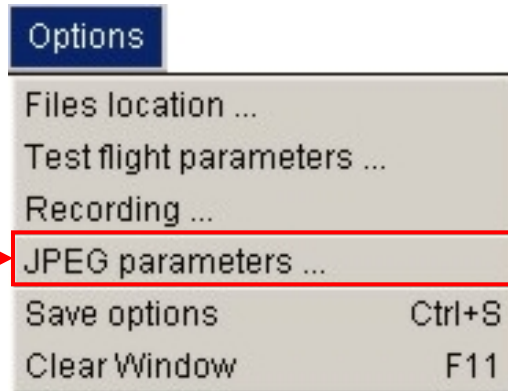


Click Recording ... button
in Options submenu to activate
external SDSA Flight recording
window!



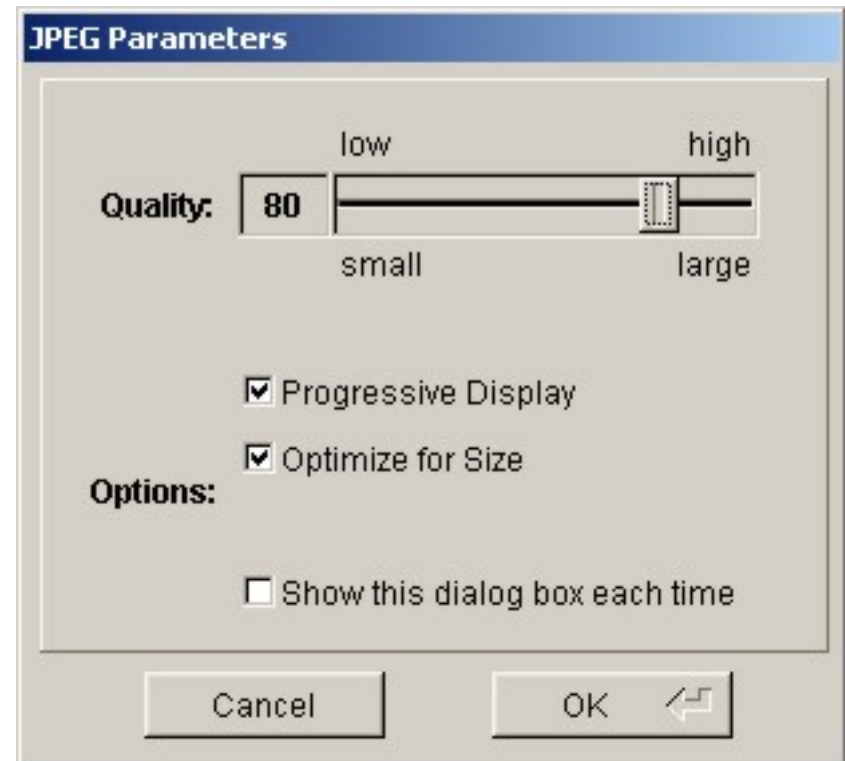
Select path for data recording text file and set up recording input values!

OPTIONS submenu JPEG parameters... JPEG parameters window



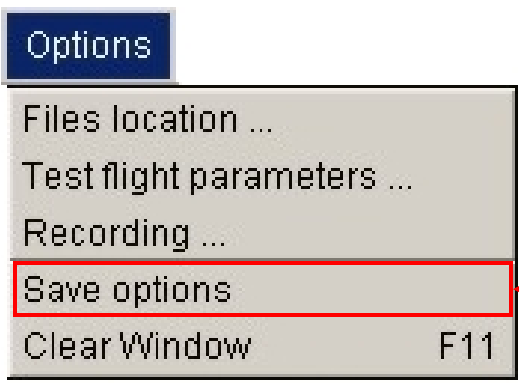
Click JPEG parameters... button in Options submenu to activate external SDSA JPEG parameters window!

NEW FEATURE!



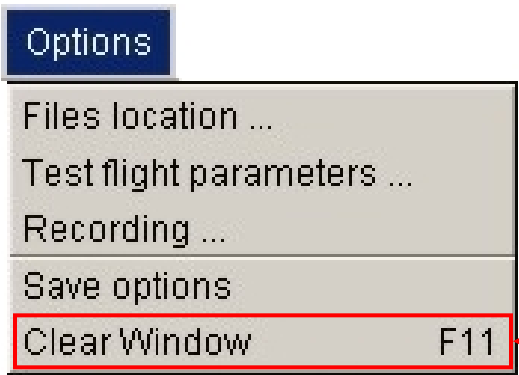
Select and set up JPEG picture capture options!

OPTIONS submenu Save options...



Click here to save SDSA set by user options!

OPTIONS submenu Clear Window (F11)

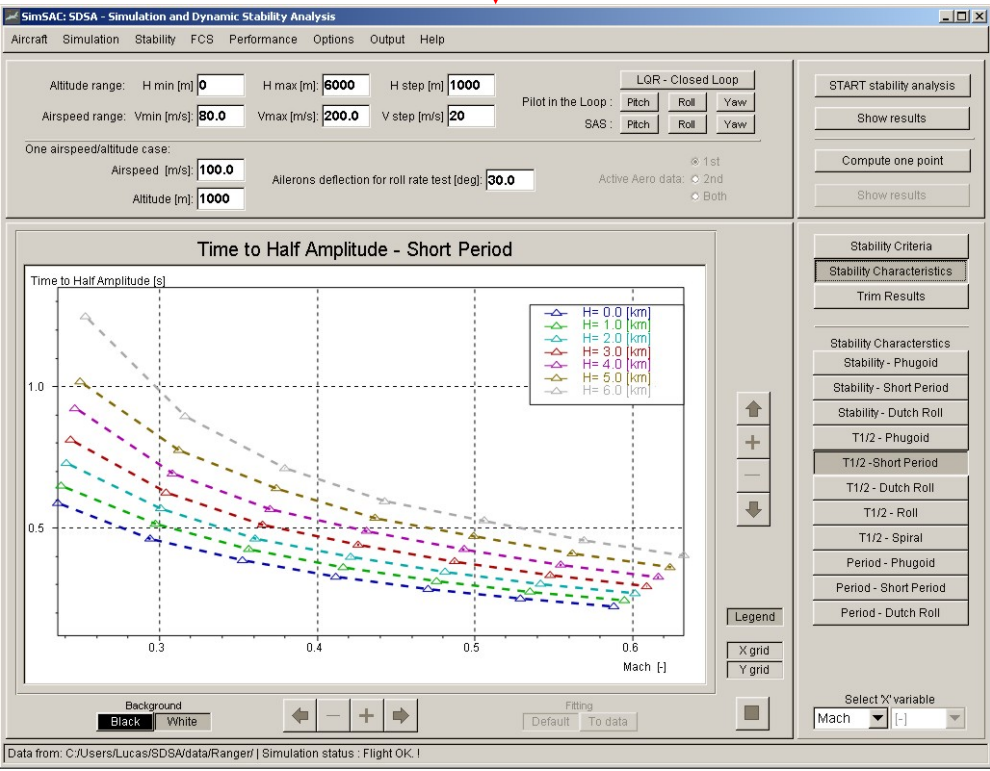


Click here or push F11 button on keyboard to clear the Main SDSA window!

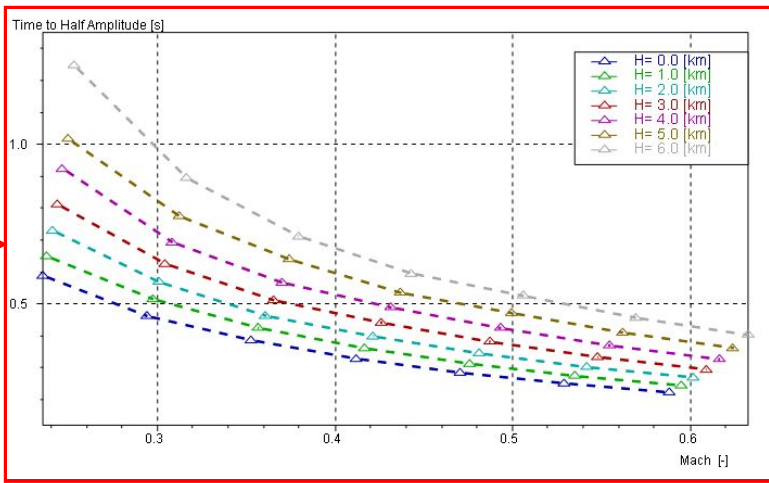
OUTPUT submenu Save current picture as... (Shift+Ctrl+S) **NEW FEATURE!**

Output

Save current picture as ... Shift+Ctrl+S

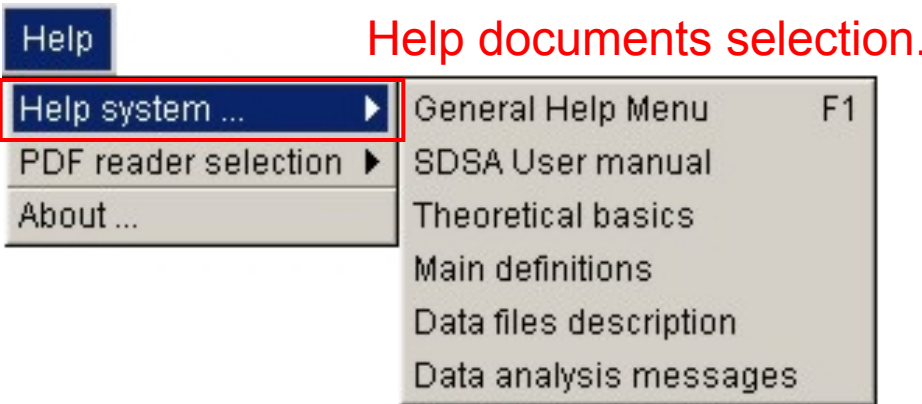
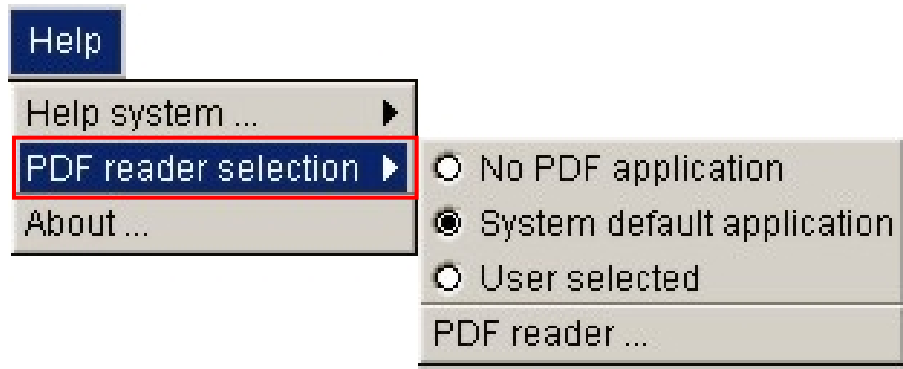


In OUTPUT... user can capture and save to disk the current graph window with results.

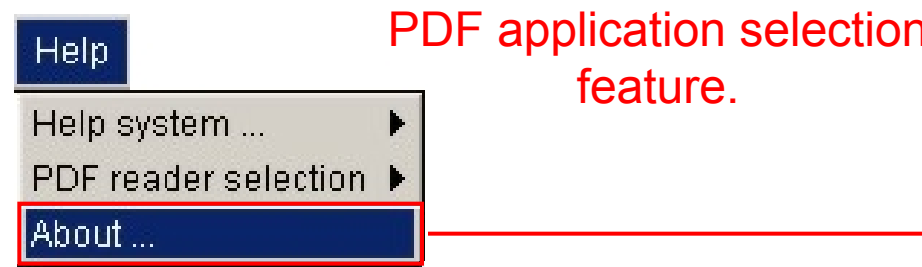


HELP submenu

Help documents selection.



PDF application selection feature.



THE END

Thank You for your patience 😊