Interface Control Document

Gas Turbine Propulsion Toolbox

Variable Definitions and Function Input and Output

ICD-GTPT-001

Revision Record		
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1 Scope

1.1 Scope

This Interface Control Document (ICD) defines the variables that are common across the Gas Turbine Propulsion Toolbox and the format of inputs and outputs for functions of the Gas Turbine Propulsion Toolbox.

The Gas Turbine Propulsion Toolbox is a GNU Octave software package that implements the equations necessary to perform Ideal Cycle Analysis, Non-Ideal Cycle Analysis, and Engine Off-Design Performance for gas turbine engines.

1.2 Interface Control Document Changes

The author of this document is responsible for the basic preparation, approval, distribution, and retention of the ICD. Changes to the approved version of this ICD can be initiated by the author. The approved version of this ICD will be kept under version control by committing it to the master branch of the version control system used for the Gas Turbine Propulsion Toolbox.

2 Requirements

2.1 Interface Identification

Figure 1 captures the interfaces defined in this ICD. The point of demarcation separates the workspace and the functions that form the Gas Turbine Propulsion Toolbox. For the purpose of this ICD, function outputs terminate at the line of demarcation, because the program is designed such that data can be directly shared between internal functions or used independently within the external workspace.

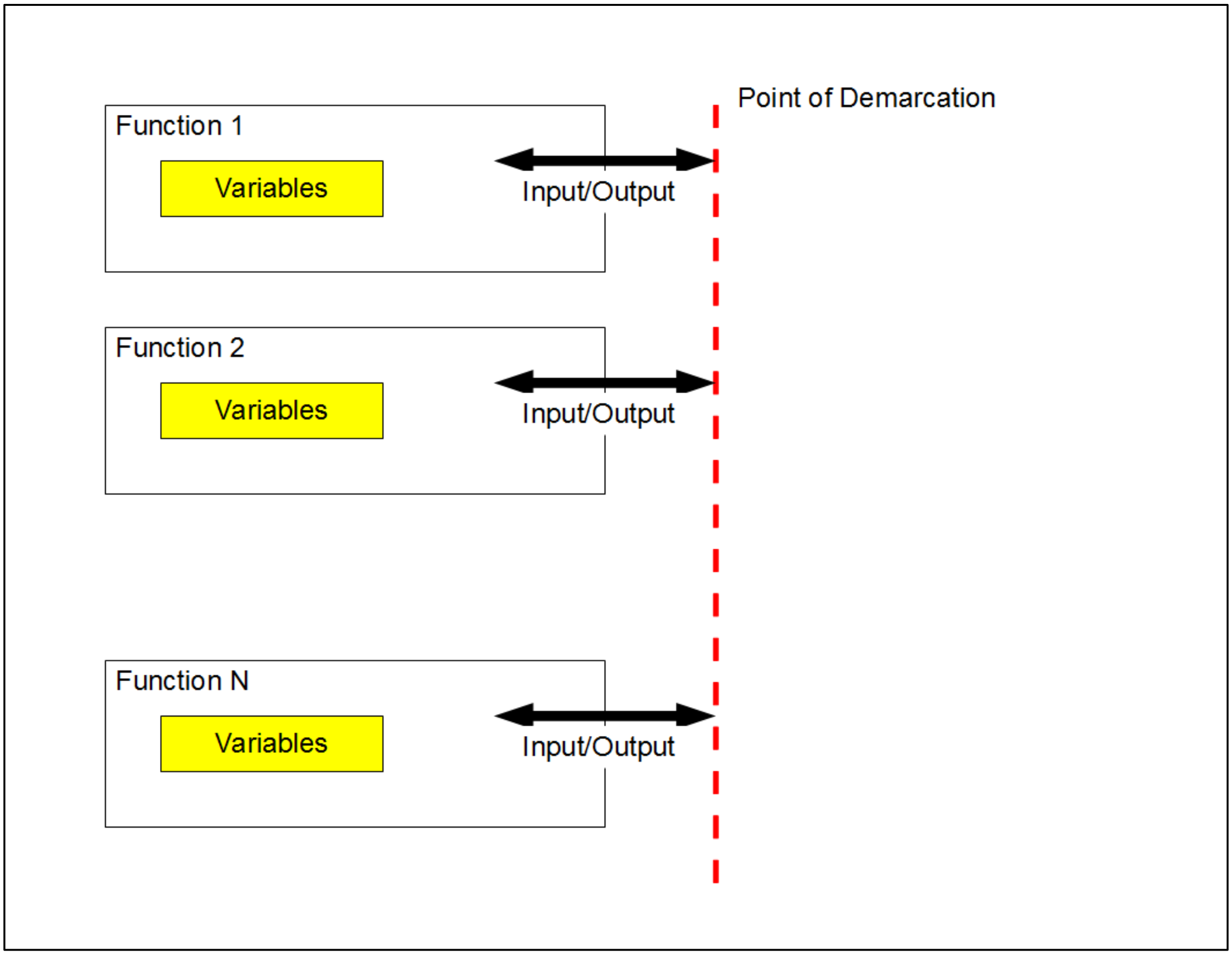

Figure 1 Gas Turbine Propulsion Toolbox Variables and Input and Output

2.2 Variable Definitions

Variable	Description	Units	Type
A0	Speed of sound	m/s	Double
A9_RAT	Ratio $\frac{A_9}{A_{9R}}$	-	Double
AB	Afterburning flag (primary stream)	-	Logical
AB2	Afterburning flag (secondary stream)	-	Logical
ALPHA	Bypass ratio	-	Double
ALPHA_OPT	Optimal bypass ratio	-	Double
CP	Specific heat of air 1004.9 J/(kg*K)	J/(kg*K)	Double
CP_AB	Specific heat of air, afterburner (primary stream)	J/(kg*K)	Double
CP_AB2	Specific heat of air, afterburner (secondary stream)	J/(kg*K)	Double
CP_C	Specific heat of air, compressor	J/(kg*K)	Double
CP_T	Specific heat of air, turbine	J/(kg*K)	Double

E_C	Polytropic efficiency, compressor (primary stream)	-	Double
E_C2	Polytropic efficiency, compressor (secondary stream)	-	Double
E_T	Polytropic efficiency, turbine	-	Double
ETA_AB	Afterburner efficiency (primary stream)	-	Double
ETA_AB2	Afterburner efficiency (secondary stream)	-	Double
ETA_B	Burner efficiency	-	Double
ETA_C	Compressor efficiency	-	Double
ETA_C2	Efficiency, fan, $\eta_{c'}$	-	Double
ETA_CH	Efficiency, high-pressure compressor, η_{ch}	-	Double
ETA_M	Mechanical efficiency 0.9 implies the use of drawn-off air for auxiliary power	-	Double
ETA_T	Efficiency, turbine	-	Double
F	$f = \frac{\dot{m}_f}{\dot{m}}$	-	Double
F	Fuel-to-air ratio $\frac{\text{kg fuel / s}}{\text{kg air / s}}$	-	Double
F_MDOT	Specific thrust $\frac{F}{\dot{m}}$	m/s	Double
F_MDOT_OPT	Optimal specific thrust	m/s	Double
F_RAT	Ratio $\frac{F}{F_R}$	-	Double
GAM	Ratio of specific heats	-	Double
GAM_AB	Ratio of specific heats, afterburner (primary stream)	-	Double
GAM_AB2	Ratio of specific heats, afterburner (secondary stream)	-	Double
GAM_C	Ratio of specific heats, compressor	-	Double
GAM_T	Ratio of specific heats, turbine	-	Double
H	Fuel heating value 4.4194E7 J/kg = 19,000 Btu/lbm	J/kg	Double
INPUTS	Structure Fields are the input variables Field names correspond to the variables defined in this ICD	-	Structure
M0	Flight Mach number	-	Double
M0U92U0R	Reference Mach number at secondary nozzle exit $\left(M_0 \frac{u_{9'}}{u_0}\right)_R$	-	Double
M0U9U0R	Reference Mach number at primary nozzle exit $\left(M_0 \frac{u_9}{u_0}\right)_R$	-	Double

M5	Mach number at turbine exit	-	Double
MDOT_C_RAT	Ratio $\frac{\dot{m}_c}{\dot{m}_{cR}}$	-	Double
P0P0R	Ratio p_0/p_{0R}	-	Double
P92P0	Nozzle exit pressure ratio (secondary stream) $$\frac{p_{9\prime}}{p_0}$$	-	Double
P9P0	Nozzle exit pressure ratio (primary stream) $$\frac{p_9}{p_0}$$	-	Double
PI_B	Burner pressure ratio	-	Double
PI_C	Compressor pressure ratio (primary stream)	-	Double
PI_C_RAT	Ratio $\frac{\pi_c}{\pi_{cR}}$	-	Double
PI_C2	Compressor pressure ratio (secondary stream)	-	Double
PI_D	Inlet pressure ratio	-	Double
PI_N	Nozzle pressure ratio (primary stream)	-	Double
PI_N2	Nozzle pressure ratio (secondary stream)	-	Double
R	Gas constant	m^2/(s^2*K)	Double
S	Thrust specific fuel consumption (TSFC) $$S = \frac{\frac{mg\ fuel}{s}}{(N\ thrust)}$$	mg/(N*s)	Double
S_OPT	Optimal TSFC	mg/(N*s)	Double
S_RAT	Ratio $\frac{S}{S_R}$	-	Double
T0	Free-stream temperature	K	Double
T0T0R	Ratio T_0/T_{0R}	-	Double
TAU_C	Compressor stagnation temperature ratio	-	Double
TAU_C2	Compressor stagnation temperature ratio (secondary stream)	-	Double
TAU_LAM	Maximum allowable turbine inlet stagnation enthalpy, $C_{p_t}T_{t_4}$ $$\tau_\lambda \equiv \frac{C_{p_t}T_{t_4}}{C_{p_c}T_0}$$	-	Double
TAU_LAM_AB	Similar to TAU_LAM, where the maximum stagnation enthalpy referred to is the stagnation enthalpy following the primary stream afterburner. $$\tau_{\lambda AB} = \frac{C_{p_{AB}}}{C_{p_c}}\frac{T_{t_8}}{T_0}$$ For no afterburning, $(\tau_{\lambda AB})_{min} = \tau_\lambda \tau_t$	-	Double
TAU_LAM_AB2	Similar to TAU_LAM, where the maximum stagnation enthalpy referred to is the	-	Double

	stagnation enthalpy following the duct afterburner. $$\tau_{\lambda AB'} = \frac{C_{p_{AB'}}}{C_{p_c}} \frac{T_{t_8'}}{T_0}$$ For no afterburning, $(\tau_{\lambda AB})_{min} = \tau_r \tau_{c'}$		
TAU_R	Recovery stagnation temperature ratio	-	Double
TAU_T	Turbine stagnation temperature ratio	-	Double
TAU_T_OPT	Optimal turbine stagnation temperature ratio	-	Double
VERBOSE	Flag for verbose display	-	Integer

2.2.1 Reference Values

Oates states, “It is usually most convenient to obtain the off-design behaviors in terms of the ratio of the desired parameter to the value of the parameter at on-design.” Reference, or on-design, quantities are denoted by a suffix R. For example, M0 is the flight Mach number, and M0R is the reference flight Mach number. Similarly, TAU_R is the recovery stagnation temperature ratio, and TAU_RR is the reference recovery stagnation temperature ratio.

2.3 Function Inputs and Outputs

2.3.1 IDEAL_TURBOJET

INPUTS Structure Fields
T0
GAM
H
CP
TAU_LAM
PI_C
M0

Outputs
F_MDOT
S
INPUTS

2.3.2 IDEAL_TURBOJET_AB

INPUTS Structure Fields
T0
GAM
H
CP
TAU_LAM
TAU_LAM_AB

PI_C
M0

Outputs
F_MDOT
S
INPUTS

2.3.3 IDEAL_TURBOFAN

INPUTS Structure Fields
T0
GAM
H
CP
TAU_LAM
PI_C
PI_C2
M0
ALPHA

Outputs
F_MDOT
S
INPUTS

2.3.4 IDEAL_TURBOFAN_OPT

INPUTS Structure Fields
T0
GAM
H
CP
TAU_LAM
PI_C
PI_C2
M0

Outputs
TAU_T_OPT
ALPHA_OPT
F_MDOT_OPT
S_OPT
INPUTS

2.3.5 IDEAL_TURBOFAN_MIXED

INPUTS Structure Fields
T0
GAM
H
CP
TAU_LAM
PI_C
PI_C2
M0
ALPHA
M5

Outputs
F_MDOT
S
INPUTS

2.3.6 IDEAL_TURBOFAN_AB

INPUTS Structure Fields
T0
GAM
H
CP
TAU_LAM
TAU_LAM_AB
TAU_LAM_AB2
PI_C
PI_C2
M0
ALPHA

Outputs
F_MDOT
S
INPUTS

TAU_LAM_AB = 0 implies no primary stream burning; $\left(\tau_{\lambda_{AB}}\right)_{\min}$ will be assumed.

TAU_LAM_AB2 = 0 implies no secondary stream burning; $\left(\tau_{\lambda_{AB}}\right)_{\min}$ will be assumed.

2.3.7 NONIDEAL_TURBOJET

INPUTS Structure Fields
AB
T0
GAM_C
GAM_T
CP_C
CP_T
H
PI_D
PI_B
PI_N
ETA_B
ETA_M
E_C
E_T
P9P0
TAU_LAM
PI_C
M0
GAM_AB
CP_AB
ETA_AB
TAU_LAM_AB

Outputs
F_MDOT
S
INPUTS

2.3.8 NONIDEAL_TURBOFAN

INPUTS Structure Fields
AB
AB2
T0
GAM_C
GAM_T
CP_C
CP_T
H
PI_D
PI_B
PI_N
PI_N2

ETA_B
ETA_M
E_C
E_C2
E_T
P9P0
P92P0
TAU_LAM
PI_C
PI_C2
M0
ALPHA
GAM_AB
CP_AB
ETA_AB
TAU_LAM_AB
GAM_AB2
CP_AB2
ETA_AB2
TAU_LAM_AB2

Outputs
F_MDOT
S
INPUTS

2.3.9 NONIDEAL_TURBOFAN2

INPUTS Structure Fields
T0
GAM_C
GAM_T
CP_C
CP_T
H
PI_D
PI_B
PI_N
PI_N2
ETA_B
ETA_M
E_C
E_C2
E_T
TAU_LAM
PI_C
PI_C2

M0
ALPHA

Outputs
F_MDOT
S
INPUTS

2.3.10 OD_TURBOJET

INPUTS Structure Fields
GAM_C
GAM_T
P0P0R
T0T0R
ETA_M
ETA_C
ETA_T
PI_CR
PI_DR
PI_BR
PI_NR
TAU_LAMR
M0R
PI_D
TAU_LAM
M0

Outputs
F_RAT
S_RAT
A9_RAT
MDOT_C_RAT
PI_C_RAT

2.3.11 OD_TURBOFAN

INPUTS Structure Fields
GAM_T
CP_C
CP_T
ETA_CH
ETA_C2
ETA_B

PI_D
PI_B
PI_N
PI_N2
T0
P0P0R
H
TAU_LAM
M0
M0R
TAU_LAMR
PI_C2R
PI_CR
ALPHAR
ETA_CHR
ETA_C2R
ETA_BR
PI_DR
PI_BR
PI_NR
PI_N2R
T0R
M0U9U0R
M0U92U0R
TAU_TR
ETA_TR
TAU_C2R
FR

Outputs
S
F_RAT