# **APP Aircraft Performance Program Training Manual**



Using Global Hawk (UAV) as an Example

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# 1. APP Main Graphical User Interface (GUI)

The main graphical user interface of the APP is as follows:



Figure 1. APP Main Graphical User Interface (GUI)

There are a total of 8 modules inside the APP

- Configuration Module
- Aerodynamics Module
- Thrust Module
- Fuel Module
- Store Module
- Performance Module
- Mission Module

The first 5 modules are called the Input modules

The last 2 modules are called the Calculation modules.

# 2. Input Modules

Input modules include:

•	Configuration Module	Filename Extension:	*.apc
•	Aerodynamics Module	Filename Extension:	*.apd
•	Thrust Module	Filename Extension:	*.apt
•	Fuel Module	Filename Extension:	*.apf
•	Store Module	Filename Extension:	*.aps

The first four modules, i.e. Configuration, Aerodynamic, Thrust, and Fuel modules, NEED to be completed before Calculation modules can generate aircraft performance results.

The store module can be left blank, depending on the type of aircraft analyzed. For demonstration purposes, the store module for this Global Hawk example is left blank.

# 2-1. Configuration Module

There are a total of 10 tabs inside the Configuration module

- Mass
- Engine
- Aero
- Gear
- Limit
- Mach Limiter
- AOA-G Limiter
- Description
- <Sheet>
- <Chart>

The first 8 tabs are input tabs, while the last two tabs are output tabs. Once the first 8 tabs are filled up, summary of the inputs are displayed on the last two output tabs.

#### 2-1-1. Mass Tab

ass   Engine   Aero   dea			A-a ciniter   Description	T vaneed T venaid T
Structure	5023.69561	[lbs]		
Propulsion Group	2201.60008	[lbs]		
Equipment	0	[lbs]		
Mass Deviation	0	[lbs]	= Standard Empty	7225.2957 [lbs]
Fixed Op. Equipment	1872.89967	[lbs]	= Empty Mass	9098.19537 [lbs]
Unusable Fuel and Oil	127.999949	[lbs]		
Gun	0	[lbs]		
Removable Op. Equipment	0	[lbs]	= Basic Mass	9226.19532 [lbs]
Usable Oil	0	[lbs]		
Crew	0	[lbs]		
Spec. Mission Equipment	0	[lbs]	= Operating Empty	9226.19532 [lbs]
Ammunition	0	[lbs]		
Payload	1900.0011	[lbs]	= Zero Fuel Mass	11126.1964 [lbs]
Fuel Mass	14481.5928	[lbs]	= Operating Mass	25607.7892 [lbs]

Figure 2-1. Mass Tab of Configuration Module

In this tab, the weight data of the Global Hawk is entered.

The total takeoff weight of the Global Hawk of 25607.7892 lbf, which is an output, is shown in Figure 2-1.

# 2-1-2. Engine Tab

GH-Config.apc		X
Mass Engine Aero G	iear   Limit   Mach Limiter   AoA-G Limiter   Description   <sheet>   <chart>  </chart></sheet>	
Number of Engine	E E	
Thrust Multiplier	1 [·]	
Fuel Flow Multiplier	1 []	
Thrust Line Angle	0 [deg]	

Figure 2-2. Engine Tab of Configuration Module

In this tab, the basic engine information data of the Global Hawk is entered.

Refer to user manual (Page 16) on the thrust Multiplier and the fuel flow multiplier. Normally both of them are zero.

### 2-1-3. Aero Tab

GH-Config.apc
Mass Engine Aero Gear Limit Mach Limiter AoA-G Limiter Description <sheet> <chart>   Delta Drag Area [ft2] Drag Multiplier ] [-]</chart></sheet>

Figure 2-3. Aero Tab of Configuration Module

In this tab, the top level aerodynamic information data of the Global Hawk is entered.

Refer to user manual (Page 17) on the above two parameters.

### 2-1-4. Gear Tab

😭 GH-Config.apc			X
Mass   Engine   Aero	àear   Limit   M	lach Limiter   AoA-G Limiter   Description   <sheet>   <chart>  </chart></sheet>	
Gear Drag Area	D	[ft2]	
AoA on Ground	0	[deg]	
Fixed Gear			

Figure 2-4. Gear Tab of Configuration Module

In this tab, the gear information data of the Global Hawk is entered. If the aircraft has retractable gear system, like the Global Hawk, then inputting zero gear drag area will have negligible impact on the accuracy of the solution. With an input of zero, only in ground operation and takeoff stages when landing gears are down that the drag of the airplane will be underestimated, but by just a short portion of the overall flight segments.

Refer to user manual (Page 18) on the above two parameters.

#### 2-1-5. Limit Tab

GH-Config.apc			X
Mass   Engine   Aero   G	ear Limit N	Mach Limiter   AoA-G Limiter   Description   <sheet>   <chart>  </chart></sheet>	
Pos. Limit Load Factor	9	[·]	
Neg. Limit Load Factor	-6	F1	
Maximum AoA	45	[deg]	
Minimum AoA	-30	[deg]	
Fixed Op. Equipment	0	[lbs]	

Figure 2-5. Limit Tab of Configuration Module

Refer to user manual (Page 19) on the description of the first four parameters.

Back in the Mass Tab, if a non-zero Fixed Op. Equipment weight has been entered, then here in Figure 2-5, make the last input zero.

#### 2-1-6. Mach Limiter Tab

s   Eng	gine Aero Gear Limit	Mach Limiter	.oA-G Limiter   Description   <sheet>   <chart>  </chart></sheet>
Ins Line	D <u>e</u> l Line		
	Altitude [ft]	Placard Mac	
1	0	0.9	
2	65000	0.9	
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			

Figure 2-6. Mach Limiter Tab of Configuration Module

A maximum diving Mach number of 0.9 is assumed. The aircraft ceiling altitude (max. altitude attainable) is assumed to be 65,000 ft

## 2-1-7. AOA-G Limiter Tab

s   Engi	ine   Aero   Gear   Limit	Aach Limiter A	koA-G Limiter Description <sheet> <chart></chart></sheet>
Ins Line	D <u>e</u> l Line		
	AoA [deg]	G(AoA) Limite	
1	0	-1	
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			

Figure 2-7. AOA-G Limiter Tab of Configuration Module

Refer to user manual (Page 20) on the input values.

#### 2-1-8. Description Tab

GH-	Config.a	арс								X
Mass	Engine	Aero	Gear	Limit	Mach Limite	r   AoA-G Limiter	Description	<sheet></sheet>	<chart></chart>	

Figure 2.9. AOA-G Limiter Tab of Configuration Module

This is where user writes down his notes. The entry in the Description tab has no effect on the accuracy of the solution. It can be left blank by the user.

# 2-2. Aerodynamics Module

There are a total of 9 tabs inside the Aerodynamics module

- Data
- C<sub>Do</sub>
- C<sub>Lo</sub>
- C<sub>Di</sub>
- C<sub>L</sub>
- C<sub>Lmax</sub>
- Description
- <Sheet>
- <Chart>

The first 7 tabs are input tabs, while the last two tabs are output tabs.

Once the first 7 tabs are filled up, summary of the inputs are displayed on the last two output tabs.

# 2-2-1. Data Tab

GH-Aero.apd	
Data CDo CLo CDI	CL CLmax Description <sheet> <chart></chart></sheet>
Aspect Ratio	25 [·]
Reference Area	[539.999552 [ft2]
<i>0</i>	

Figure 2-10. Data Tab of Aerodynamics Module

In this tab, the wing aspect ratio and the wing reference area of the Global Hawk is entered.

## 2-2-2. C<sub>Do</sub> Tab

🙀 GH-Aero.apd			×
Data CDo CLo CDI CL CLmax Descripti	on   <sheet></sheet>	<chart>  </chart>	
Add Table Del Table	Ins Line	D <u>e</u> l Line	
Altitude 0 [ft]		Mach [-]	CDo [-]
Altitude 30000 [ft]	1	0.1	0.0241
Altitude 60000 [ft]	2	0.2	0.0158
	3	0.3	0.0145
	4	0.4	0.0147
	5	0.5	0.0146
	6	0.598	0.0142
	7		
	8		
	9		]
	10		
	11		
	12		
	13		
	14		
	15		
	16		
	17		
Table Setting	18		
	L		

Figure 2-11.  $C_{Do}$  Tab of Aerodynamics Module (@ Alt = 0)

In this tab, the Global Hawk zero lift drag coefficient at three different altitudes, as a function of Mach number, is entered into the program. The remaining input data is summarized in the following table.

Table 2-1.	Global Hawk Zer	Dift Drag	Coefficient as	functions o	f Altitude	& Mach #
10010 2 1.	Olobul Hum Len	Diji Drug		junciions o	jiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiii	a mach n

Alt [kft]	Mach	$C_{Do}$
30	0.200	0.0226
30	0.300	0.0182
30	0.400	0.0168
30	0.500	0.0165
30	0.598	0.0164
60	0.400	0.0249
60	0.450	0.0231
60	0.500	0.0220
60	0.550	0.0214
60	0.598	0.0211

# 2-2-3. C<sub>Lo</sub> Tab

GH-Aero	.apd				X
Data   CDo	, CLo   CDI   CL	CLmax Description	<sheet>   <cha< th=""><th>rt&gt; ]</th><th></th></cha<></sheet>	rt> ]	
Ins Line	D <u>e</u> l Line				
	Mach [-]	CLo [-]			
1	0	0			
2		Ű			
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
Iable	Setting				

Figure 2-12. C<sub>Lo</sub> Tab of Aerodynamics Module

This set of data entry can be filled with zeros. Refer to user manual (Page 22) on the input values.

#### 2-2-4. C<sub>Di</sub> Tab

🙀 GH-Aero.apd			X
Data CDo CLo CDI CL CLmax Descrip	ion   <sheet></sheet>	<chart>  </chart>	
Add Table Del Table	Ins Line	D <u>e</u> l Line	
		CL [-]	CDI [-]
Mach 0.598 [-]	1	0	
0	2	0.02247191	-8.04231
	3	0.04494382	1.44474
	4	0.06741573	4.56774
	5	0.08988764	9.28078
	6	0.112359551	0.00015
	7	0.134831461	0.00023
	8	0.157303371	0.00032
	9	0.179775281	0.00043
	10	0.202247191	0.00050
	11	0.224719101	0.0001
	12	0.247191011	0.0008
	13	0.269662921	0.00103
	14	0.292134831	0.00121
	15	0.314606742	0.00142
	16	0.337078652	0.001
	17	0.359550562	0.0018
	18	0.382022472	0.00211
Table Setting	19	0.404494382	0.0023

Figure 2-13.  $C_{Di}$  Tab of Aerodynamics Module (@ Alt = 60 kft)

In this tab, the Global Hawk induced drag coefficient, as functions of lift coefficient and Mach number, at a cruising altitude of 60 kft, is entered into the program. The user is reminded to enter the induced drag coefficient at the DESIGN CRUISING ALTITUDE of the aircraft into the program.

If the design cruising altitude of the Global Hawk is at 30 kft, then in the above tab, based on Table 2-1, the Mach number range in the left window should include be (AT LEAST) from Mach 0.200 to Mach 0.598. The user should at least enter the induced drag coefficient of the aircraft at both ends of the Mach number, i.e. at Mach 0.200 and Mach 0.598 (at Alt of 30 kft). On the other hand, to improve the accuracy of the solution, the user can choose to input more induced drag coefficient data at other Mach numbers in within Mach 0.200 & Mach 0.598. For example, the user can have one additional data input at Mach 0.400.

The complete input data for the  $C_{Di}$  tab is summarized in the following table.

Mach	0.400	Mach	0.598	Mach	0.400	Mach	0.598
Cı	C <sub>Di</sub>	C,	CDi	C	C <sub>Di</sub>	C	C <sub>Di</sub>
0.0000	0.0000	0.0000	0.0000	0.7191	0.0078	0.7191	0.0077
0.0225	0.0000	0.0225	0.0000	0.7416	0.0084	0.7416	0.0083
0.0449	0.0000	0.0449	0.0000	0.7640	0.0089	0.7640	0.0088
0.0674	0.0000	0.0674	0.0000	0.7865	0.0094	0.7865	0.0093
0.0899	0.0000	0.0899	0.0001	0.8090	0.0100	0.8090	0.0099
0.1124	0.0001	0.1124	0.0002	0.8315	0.0106	0.8315	0.0104
0.1348	0.0002	0.1348	0.0002	0.8539	0.0112	0.8539	0.0110
0.1573	0.0003	0.1573	0.0003	0.8764	0.0118	0.8764	0.0116
0.1798	0.0004	0.1798	0.0004	0.8989	0.0125	0.8989	0.0123
0.2022	0.0005	0.2022	0.0006	0.9213	0.0131	0.9213	0.0129
0.2247	0.0006	0.2247	0.0007	0.9438	0.0138	0.9438	0.0136
0.2472	0.0008	0.2472	0.0009	0.9663	0.0145	0.9663	0.0142
0.2697	0.0010	0.2697	0.0010	0.9888	0.0152	0.9888	0.0149
0.2921	0.0012	0.2921	0.0012	1.0112	0.0160	1.0112	0.0157
0.3146	0.0014	0.3146	0.0014	1.0337	0.0167	1.0337	0.0164
0.3371	0.0016	0.3371	0.0016	1.0562	0.0175	1.0562	0.0171
0.3596	0.0018	0.3596	0.0019	1.0787	0.0183	1.0787	0.0179
0.3820	0.0021	0.3820	0.0021	1.1011	0.0191	1.1011	0.0187
0.4045	0.0023	0.4045	0.0024	1.1236	0.0199	1.1236	0.0195
0.4270	0.0026	0.4270	0.0027	1.1461	0.0208	1.1461	0.0203
0.4494	0.0029	0.4494	0.0030	1.1685	0.0216	1.1685	0.0211
0.4719	0.0033	0.4719	0.0033	1.1910	0.0225	1.1910	0.0220
0.4944	0.0036	0.4944	0.0036	1.2135	0.0234	1.2135	0.0229
0.5169	0.0039	0.5169	0.0039	1.2360	0.0244	1.2360	0.0238
0.5393	0.0043	0.5393	0.0043	1.2584	0.0253	1.2584	0.0247
0.5618	0.0047	0.5618	0.0047	1.2809	0.0263	1.2809	0.0256
0.5843	0.0051	0.5843	0.0051	1.3034	0.0273	1.3034	0.0265
0.6067	0.0055	0.6067	0.0055	1.3258	0.0283	1.3258	0.0275
0.6292	0.0059	0.6292	0.0059	1.3483	0.0293	1.3483	0.0285
0.6517	0.0064	0.6517	0.0063	1.3708	0.0303	1.3708	0.0295
0.6742	0.0069	0.6742	0.0068	1.3933	0.0314	1.3933	0.0305
0.6966	0.0073	0.6966	0.0073	1.4157	0.0325	1.4157	0.0316

*Table 2-2. Induced Drag Coefficient as a function of Mach* # (@ *Alt* = 60 *kft*)

# 2-2-5. C<sub>L</sub> Tab

🙀 GH-Aero.apd			×
Data CDo CLo CDI CL CLmax De	scription   <sheet>  </sheet>	<chart></chart>	
Add Table Del Table	Ins Line	D <u>e</u> l Line	
		AoA [deg]	CL [-]
Mach 0.598 [-]	1	0	0.2880
No serie a concrete fil.	2	10.675	1.4157
	3		
	4		
	5		
	6		
	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15		
	16		
	17		
Table Setting	18		

Figure 2-14.  $C_L$  Tab of Aerodynamics Module (@ Alt = 60 kft)

In this tab, the lift coefficient range, corresponding to its aircraft angle-of-attack range, at the design cruising altitude of the Global Hawk, is entered into the program. Refer to user manual (Page 23) on the several important notes on the description of the input.

The remaining input data for the C<sub>L</sub> tab is summarized in the following table.

*Table 2-3. Global Hawk Lift Coefficient Range as a function of Mach # (@ Alt = 60 kft)* 

Mach	AOA [deg]	CL
0.4	0.000	0.4181
0.4	11.946	1.4157

## 2-2-6. C<sub>Lmax</sub> Tab

GH-Aero	.apd		X
Data CDo	)   CLo   CDI   CL	CLmax Descrip	ion   <sheet>   <chart>  </chart></sheet>
Ins Line	D <u>e</u> l Line		
	Mach [-]	CLmax [-	
1	0.4	1 4157	
2	0.45	1.4157	
3	0.5	1.4157	
4	0.55	1.4157	
5	0.598	1.4157	
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
<u>I</u> able	Setting		

Figure 2-15. C<sub>Lmax</sub> Tab of Aerodynamics Module (@ Alt = 60 kft)

In this tab, the aircraft maximum lift coefficient as a function of Mach number, at the aircraft design cruise altitude, is entered into the program. Refer to user manual (Page 24) on the several important notes on the description of the input.

# 2-3. Thrust Module

There are a total of 6 tabs inside the Thrust module

- Max. Thrust
- Min. Thrust
- Fuel File
- Description
- <Sheet>
- <Chart>

The first 4 tabs are input tabs, while the last two tabs are output tabs.

Once the first 4 tabs are filled up, summary of the inputs are displayed on the last two output tabs.

Based on published information, the engine on the Global Hawk is the Rolls-Royce North America AE3007H turbofan engine capable of producing a static thrust of 7,150 lbf. Since the detailed engine performance information is not made public, here for demonstration purposes, the publicly available Williams FJ44 engine performance information is scaled up and used instead. The user is reminded that such changes have drastic impact on the results of the performance analysis.

#### 2-3-1. Max Thrust Tab

GH-Thrust.apt			2
Max. Thrust Min. Thrust Fuel File Description	Sheet>   <chart>  </chart>		
Add Table Del Table	Ins Line	D <u>e</u> l Line	
Altitude 0 [ft]		Mach [-]	Max. Thrust
	1	0.4	
Altitude 60000 [ft]	2	0.45	
	3	0.5	
	4	0.55	
	5	0.598	
	6		
	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15		
	16		
	17		
Table Setting	18		

Figure 2-16. Max. Thrust Tab of Thrust Module

In this tab, the aircraft maximum thrust, as functions of Mach number and altitude, is entered into the program. The complete input data is summarized in the following table.

Alt [kft]	Mach	C <sub>Do</sub>
0	0.1	5561
0	0.2	4985
0	0.3	4508
0	0.4	4171
0	0.5	3873
0	0.598	3654
30	0.2	2510
30	0.3	2363
30	0.4	2244
30	0.5	2137
30	0.598	2046
60	0.40	1108
60	0.45	1088
60	0.50	1073
60	0.55	1053
60	0.598	1033

 Table 2-1. Global Hawk Engine Maximum Thrust as functions of Altitude & Mach #

#### 2-3-2. Min Thrust Tab

Max. Thrust Min. Thrust Fuel File Description	<sheet>   <chart>  </chart></sheet>		
Add Table Del Table	Ins Line	D <u>e</u> l Line	
Altitude 0 [ft]		Mach [-]	Min. Thrust
Altitude 30000 [ft]	1	0.4	
📰 Altitude 60000 [ft]	2	0.45	
	3	0.5	
	4	0.55	
	5	0.598	
	6		
	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15		
	16		
J	17		
Table Setting	18		

Figure 2-17. Min. Thrust Tab of Thrust Module

In this tab, the aircraft minimum thrust, as functions of Mach number and altitude, is entered into the program. The complete input data is summarized in the following table.

Alt [kft]	Mach	C <sub>Do</sub>
0	0.1	278
0	0.2	249
0	0.3	225
0	0.4	209
0	0.5	194
0	0.598	183
30	0.2	126
30	0.3	118
30	0.4	112
30	0.5	107
30	0.598	102
60	0.40	55
60	0.45	54
60	0.50	54
60	0.55	53
60	0.598	52

 Table 2-1. Global Hawk Engine Minimum Thrust as functions of Altitude & Mach #

#### 2-3-3. Fuel File Tab



Figure 2-18. Fuel File Tab of Thrust Module

In this tab, the user needs to link the fuel module, which at the present time is yet to be constructed, with the thrust module. This process needs to be done as soon as all the fuel module data entry is completed.

# 2-4. Fuel Module

There are a total of 4 tabs inside the Fuel module

- Fuel Flow
- Description
- <Sheet>
- <Chart>

The first 2 tabs are input tabs, while the last two tabs are output tabs.

Once the first 2 tabs are filled up, summary of the inputs are displayed on the last two output tabs.

#### 2-4-1. Fuel Flow Tab

el Flow   Description   <sheet>   <chart>  </chart></sheet>			
Add Table Add Sub-Table Del Table	Ins Line	D <u>e</u> l Line	
Altitude 0 [ft]		Thrust [lbf]	Fuel Flow
	1	52	45
Mach 0.2 [-]	2	1033	743
Mach 0.3 [-]	3		110
	4		
Mach U.5 [-]	5		
Mach U.038 [-]	6		
Mach 0.2 L1	7		
Mach 0.3 [-]	1		1
	0		1
Mach 0.5 [-]	9		7
Mach 0.598 [-]	10		
Altitude 60000 [ft]	11		
	12		
	13		
Mach 0.5 [-]	14		
Mach 0.55 [-]	15		
Mach U.598 [•]	16		
	10		

Figure 2-19. Fuel Flow Tab of Fuel Module

In this tab, the engine fuel flow [lbm/s] as functions of thrust [lbf], at various altitudes and Mach numbers, is entered into the program. Based on the above figure, at an altitude of 60 kft, at Mach 0.598, it is found that for demonstration purposes, only two entries are present in the right window. This indicates that the engine fuel flow is assumed to vary linearly with engine thrust, which in reality is not true. The user is reminded to enter more data points into the right windows so that the engine fuel consumption, as a function engine thrust, can be more properly represented, thus improving the accuracy of the solution.

The data entry information shown in Figure 2-19 can be found in within the attached spreadsheet, titled "Aerodynamics and Engine Info.xls".

Once the Fuel module data entry is completed, the user is reminded to go back to the thrust module, Fuel Flow tab, to establish the thrust-fuel module linkage.

# 3. Calculation Modules

Calculation modules include:

- Performance Module
   Filename Extension: \*.app
- Mission Module

Filename Extension: \*.app Filename Extension: \*.apm

# 3-1. Performance Module

#### 3-1-1. Computation Tab



Figure 3-1. Types of Calculation Available on Performance Module

According to Figure 3-1, there are 7 different types of computations available on Performance module. Refer to user manual (Page 29 – Page 32) on detailed description of the Performance module.

#### 3-1-2. Project Files Tab

Regardless of which type of computation selected by the user, the Project Files tab needs to be filled out completely.



Figure 3-2. Project Files Tab of Performance Module

In this tab, the Configuration, Aerodynamics, Thrust, Fuel, and Store (If necessary) modules are linked before the computation, whichever selected, can proceed. For the present Global Hawk example, it is assumed to operate in standard atmospheric condition, thus the default atmospheric data file that came with the installation of the APP program is used.

#### 3-1-3. Flight Data Tab

Depending on which type of computation selected by the user, the data entry in Flight Data tab might be somewhat different.

🙀 GH-Performanc	e.app				X
<computation>   Proje</computation>	ct Files   Description	Store Dro	p <flight data="">   &lt;</flight>	Range>   <sheet>  </sheet>	<xy-chart></xy-chart>
Altitude		[ft]	Climb Speed	0	[ft/sec]
Mach		[-]	Payload	100	[%]
Velocity		[nm/hr]	AaA		[deg]
Power Setting		[%]	Lift Area		[ft2]
Thrust		[Ibf]	dT	0	[K]
Fuel Percent	100	[%]			
Fuel Mass	14481.5928	[lbs]			
Load Factor		[-]			
Pull-Up Rate		[deg/se			
Turn Rate		[deg/se			
Turn Radius		[ft]			
Acceleration	0	[ft/sec2			
SEP	0	[ft/sec]			
Climb Angle	0	[deg]	Mass	25607.1	7892 [lbs]
-					

Figure 3-3. Flight Data Tab of Performance Module (G-envelope Checked)

In this tab, all the necessary inputs need to be filled up before the computation can proceed.

#### 3-1-4. Range Tab

Regardless of which type of computation selected, in this tab, the user enters the range of the calculation. For the present Global Hawk example with the G-envelope checked, the range refers to the load factor range.

1 Factor			1
1 dottor		Ins Line	<u>D</u> el Line
0	[·]	L	oad Factor [-
( 6	[·]	1	0.0
a 1	[-]	2	1.0
		3	2.0
ige from File	3	4	3.0
	<b>•</b>	5	4.0
		7	5.0
		8	6.0
		9	
		10	
		11	
		12	
		13	
		14	
		15	
		16	
		17	
ve Range		18	

Figure 3-4. Flight Data Tab of Performance Module (G-envelope Checked)

For the present example, the load factor ranges from 0 to 6, with an increment of +1. Once this is completed, the table on the right will show the data entry (instantly).

#### 3-1-4. Calculation

APP 5. 10.0.0 - GH-Performance.app	
GH-Config.apc	
M. 😭 GH-Aero.apd	
C GH-Thrust.apt	
M GH-Fuel.apf	
Fu 🖬 GH-Performance.app	
F Computation> Project Files Description Store Drop <flight data=""> <range> <sheet> <xy-chart></xy-chart></sheet></range></flight>	
Load Factor Ins Line Del Line	
Min 0 [·] Load Factor [·	
Max [6 [·] 1 0.0 Delta 1 [·] 2 1.0	
Range from File 5 4.0	
<b>6</b> 5.0 <b>7</b> 6.0	
8 9	
10	
13	
Save Range 18	
Ready	4

Figure 3-5. Calculation of Performance Module (G-envelope Checked)

To begin the calculation, the user needs to hit the white button, which is to the right of the "green colored 4", shown in Figure 3-5.

#### 3-1-5. X-Y Chart



Figure 3-5. Graphical Solution of the Calculation of Performance Module (G-envelope Checked)

In X-Y Chart tab, the user can select various type of output (on both X and Y axes) to be plotted. The results of the calculation are also stored in the Sheet tab. Refer to user manual (Page 59 – Page 69) for more detailed description.

# 3-2. Mission Module

#### 3-2-1. Optimizer Type Tab



Figure 3-6. Types of Optimization Available on Mission Module

According to Figure 3-6, there are 4 different types of optimizations available on Mission module. Refer to user manual (Page 33 – Page 34) on detailed description of the Mission module.

The reader is reminded that the Project Files Tab in Mission module is identical to that in Performance module.

For the present example, the No Optimization is checked.

#### 3-2-2. Start Tab

GH-Mission	.apm	
Optimizer Type	Project Files Start St	egment List Description <sheet> <xy-chart></xy-chart></sheet>
Altitude	0	[0]
Mach	0	H
Velocity	0	[nm/hr]
Fuel Percent	100	[%]
Fuel Mass	14481.5928	[lbs]
Payload	100	[%]
Mass	25607.78	92 [lbs]

Figure 3-7. Start tab of Mission Module

For the present example, the starting condition refers to the Global Hawk, sitting on the ground, with full fuel and payload, ready to be deployed.

#### 3-2-3. Segment List Tab

In this tab, the mission profile of the Global Hawk is defined.

After defining all the segments, the user can hit the white colored calculation button, shown in Figure 3-5, to begin the actual calculation.

The first segment is ground operation. Details of the first segment are shown in Figure 3-8.

GH-Mission.apm		X
GH-Mission.apm Optimizer Type Project Files Start Add Del Ins Up Dwn Charlen Deration Charlen Content of the set of the s	Segment List       Description <sheet> <xy-chart>         Segment stops at:      </xy-chart></sheet>	[sec]
- Sa /) Descent	GH-Mission     Integrate x-Position       Power Setting     1       Thrust     365.301471	

*Figure 3-8. Segment List tab of Mission Module (1<sup>st</sup> Segment)* 

The second segment is take off. Details of the second segment are shown in Figure 3-9.

optimizer rype   r roleet ries   otdi	Segment List   Descrip	tion   <sheet>   <xy-ch< th=""><th>art&gt;  </th></xy-ch<></sheet>	art>
Add Del Ins Up Dwn 1) Ground Operation 2) Takeoff 3) Climb at Best Rate	Segment stops at: Velocity	<ul><li>▼ 91.9642548</li><li>▼ 0</li></ul>	[nm/hr]
5) Loiter at Best SH 5) Loiter at Best FF 5) Cruise at Best SR 5) Descent	Time Step Project for this segmen GH-Mission	lt: ▼ Integra	[sec] ate <u>x</u> -Position ate <u>z</u> -Position
	Power Setting Thrust	100 6137.01438	[%] [lbf]
	Climb Angle Climb Speed	0	[deg] [ft/sec]

Figure 3-9. Segment List tab of Mission Module (2<sup>nd</sup> Segment)

The third segment is climb at best rate. Details of the third segment are shown in Figure 3-10.

t Description (Sheet) (XY-Chart) ops at:
ng 80 [%]  4971.01177 [lbf] n 0 [ft/sec2]
n

Figure 3-10. Segment List tab of Mission Module (3<sup>rd</sup> Segment)

The fourth segment is cruise at best specific range (SR). Details of the third segment are shown in Figure 3-11.

GH-Mission.apm				X
Optimizer Type Project Files Start	Segment List Descrip	tion   <sheet>   <xy< td=""><td>-Chart&gt;  </td><td></td></xy<></sheet>	-Chart>	
Add Del Ins Up Dwn 3 1) Ground Operation 3 2) Takeoff 3 Climb at Best Rate 3 Climb at Best SR 5 Loiter at Best FF	Segment stops at: Seg. Dist.  > or at: None >	<ul> <li>▼ [1500</li> <li>▼ [0</li> <li>20</li> </ul>	[sec]	[nm] [-]
6) Cruise at Best SR	Project for this segmen	it 🔽 🔽 Inte	egrate <u>x</u> -Position egrate <u>z</u> -Position	
	Load Factor	1	[·]	
	Turn Rate	0	[deg/sec	
	Acceleration	0	[ft/sec2]	
	Climb Angle	0	[deg]	
	Climb Speed	0	[ft/sec]	
	ТЬ	0	[K]	
	L			

*Figure 3-11. Segment List tab of Mission Module (4<sup>th</sup> Segment)* 

The fifth segment is loiter at best fuel flow (FF). Details of the third segment are shown in Figure 3-12.

GH-Mission.apm				X
Optimizer Type   Project Files   Start	Segment List Description	n   <sheet>   <xy-cl< td=""><td>nart&gt;  </td><td></td></xy-cl<></sheet>	nart>	
Add Del Ins Up Dwn 3 1) Ground Operation 3 2) Takeoff 3 Climb at Best Rate 3 Climb at Best SR 3 Loiter at Best FF	Segment stops at: Seg. Time	<ul> <li>↓ 36000</li> <li>↓ 0</li> <li>20</li> </ul>	[sec]	[sec] [-]
5) Cruise at Best SR	Project for this segment: GH-Mission	▼	rate <u>x</u> -Position rate <u>z</u> -Position	
	Load Factor	1	[·]	
	Turn Rate	0	(deg/sec	
	Acceleration	0	[ft/sec2]	
	Climb Angle	0	[deg]	
	Climb Speed	0	[ft/sec]	
	ΤЬ	0	[K]	
1				

*Figure 3-12. Segment List tab of Mission Module (5<sup>th</sup> Segment)* 

The sixth segment is cruise at best specific range (SR). Details of the third segment are shown in Figure 3-13.

Optimizer Type   Project Files   Start	Segment List Descr	iption   <sheet>   &lt;)</sheet>	(Y-Chart>	
Add Del Ins Up Dwn	Segment stops at:			
- 🔧 1) Ground Operation	Seg. Dist. 💌 🔊	<b>•</b> 1500	[nm]	]
Brack 2) Takeoff	or at:		n	
- 🔧 4) Cruise at Best SR	INone (	, <u> </u>	C)	
5) Loiter at Best FF	Time Step	20	[sec]	
- Star Burdise at Best SH Star 7 Descent	Project for this segme	ent: 🔽	ntegrate v-Position	
	GH-Mission		ntegrate <u>z</u> -Position	
	Load Factor	1	[·]	
	Load Factor Turn Rate	0	[·] [deg/sec	
	Load Factor Turn Rate Acceleration	1  0  0	[-] [deg/sec [ft/sec2]	
	Load Factor Turn Rate Acceleration Climb Angle	1  0  0	[+] [deg/sec [ft/sec2] [deg]	
	Load Factor Turn Rate Acceleration Climb Angle Climb Speed	1  0  0  0	[-] [deg/sec [ft/sec2] [deg] [ft/sec]	

*Figure 3-13. Segment List tab of Mission Module (6<sup>th</sup> Segment)* 

The seventh segment is descent. Details of the third segment are shown in Figure 3-14.

Optimizer Type Project Files Start	Segment List Description	<sheet>   <xy-chart>  </xy-chart></sheet>	
Add Del Ins Up Dwn	Segment stops at:	10	[61]
S 1) Ground Operation	or at:		104
3) Climb at Best Rate	None >	• 0	Ð
5) Loiter at Best FF	Time Step	[sec]	
- 🔧 6) Cruise at Best SR - 🔧 7) Descent	Project for this segment:	✓ Integrate x-Po	sition
	GH-Mission	✓ Integrate <u>z</u> -Po	sition
	Power Setting	20 [%]	
	Thrust	1473.00395 [lbf]	
	Acceleration	0 [ft/se	c2]
	dT	0 [K]	

Figure 3-14. Segment List tab of Mission Module (7<sup>th</sup> Segment)

# 3-2-4. X-Y Chart



Figure 3-15. Graphical Solution of the Calculation of Mission Module (No Optimization Checked)

The mission profile of the Global Hawk, in the present example, is summarized as follows:

Take off at full fuel and payload weight. Climb at best rate to an altitude of 60 kft. Cruise at best specific range at 60 kft for 1,500 nm. Loiter over the target area for 5 hours. Cruise at best specific range at 60 kft for 1,500 nm (Return) Descent at 20% power setting

What is illustrated in Figure 3-15 is the fuel percentage aboard the Global Hawk, as a function of the distance traveled.

In X-Y Chart tab, the user can select various type of output (on both X and Y axes) to be plotted. The results of the calculation are also stored in the Sheet tab. Refer to user manual (Page 70 - Page 73) for more detailed description.

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