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USING ARTIFICIAL INELEGANCE IN BALLISTIC MISSILES DESIGNWITH MULTIWARHEAD

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Abstract
The Design of the space vehicle systems present a wide range of problems to engineers in numerous disciplines which range through propulsion, aerodynamic, structure, guidance, and control. So, finding a method to automatically design a space vehicle with only altitude and Payload as input parameters is little hardly to can get a fully configured space vehicle from overall shape design to fuel type and tank shape. Also, the final design must be optimized to get more accuracy and reliability of the method. All of the above points are approved in this method.

Keywords: Aerospace, Spacecraft, design, launchers, Ballistic, and missiles

Nomenclature

M	Mass
D	Diameter
Isp	Specific Impulse

Subscripts

O	Initial
s	Structural
Pay	Payload
Prop	Propulsion
Cal	Calculated

Introduction

As first start, a statically study done on all space vehicles to get the approximate relations between total weight of the space vehicle and slenderness ratio, Average diameter, Payload weight, and required altitude . The approx. relations give a good results with an error doesn't exceed 25% as a max error and 12.5% average error. This Relations obtained by using Least Square method of power n.

This Statistics is the first step to get the design of the space vehicles which are described in the following section. In addition, for this method, an aerodynamic module, propulsion module, Control Module and a 3D motion module in geocentric equatorial axis with rotational earth effect were be developed to serve this design method From M. Farran. [1].

Fuel database properties needed in this method for liquid and solid propellants, and it was collected as much as the data are available.

Analysis and Design

For overall Design process, it must be prepare somesimulation modules like

1- Genetic Algorithms (GA) Module To Get the Relation between

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weight of the space vehicle and slenderness ratio.

2- Aerodynamics Module: To get the lift and drag from the overall dimensions of the missile in the Sub/Supersonic/Hypersonic Regions with approximation methods

3- Propulsion Module : To simulate the solid and liquid propellant engines with some empirical relations but give a good result with real data

4- Structure Weight Estimator Module : From the Pressure and thrust, we can get the estimation of Structure weight that needed to hold the propellant and the control systems

5- Stage Detection Module: This module present a method to get the number of stages required due to the required Isp

6- Motion Module: This Module is a 3D Simulation Module of a space craft trajectory with rotating earth effect included and passing through different atmospheric levels also is included.

7- Constrains Module: This module is only a detector for failure of the mission due to high drag or non logical maneuvers, …..etc

As shown in Fig 1, from The Statistics, if we get the altitude and payload as input parameters, we can get a diameter and total weight range for this certain input.

By assuming a diameter in the above range, and also from Statistics, the Average slenderness ratio is calculated, so approx. length can be obtained.

Now, Length and diameter are obtained so, aerodynamic characteristics. Like lift, drag and moment can be calculated from aerodynamic Module. To get the max performance, the method checks the current lift-Drag ratio if it is the max or not. If not, the algorithm re-chooses another diameter from the range and calculates another lift-drag ratio and check again until the max ratio reached.

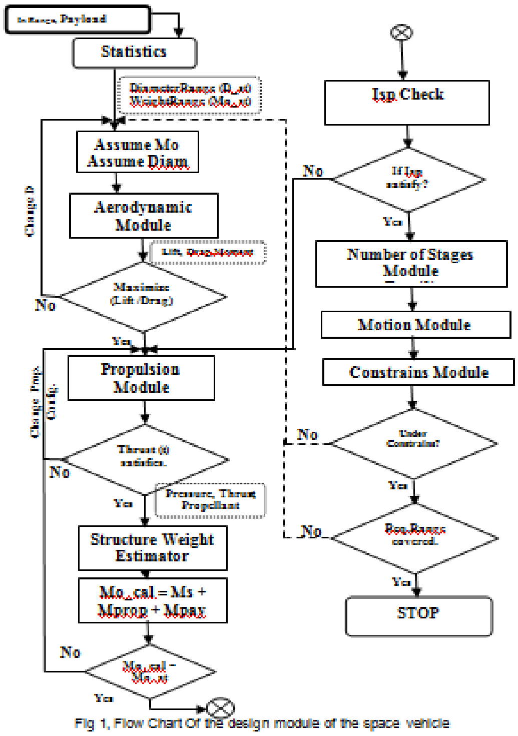

Fig 1, Flow Chart Of the design module of the space vehicle

Now, approx length and diameter are calculated. Database of fuels (solid and liquid) with their properties - like chamber temperature, density, Mol. Weight, Pressure-Burn Rate Relations and ideal Ratio of specific heats – are stored to make the algorithm search within this database with the specified length, diameter , and specified shape of the grain in solid case or tank configuration in liquid prop. Case.

If the calculated thrust-pressure curve is satisfy the predefined conditions like safe pressure, thrust-time curve shape, and max prop weight allowable, the current configuration of the propellant is ok. If not, change to another fuel type and repeat the above speed.

At this moment, Thrust, chamber pressure, and propellant properties are obtained. So, from chamber pressure and temperature, the structure weight can be estimated, and then calculating total weight is available. Check if the estimated total weight from the statistics is equals the calculated total weight or not. If not re-choose another propellant configuration and repeat the above steps.

From the propulsion module, Isp "Specific Impulse" is calculated and it's an important parameter to check if this space vehicle can achieve its mission or not. So checking the calculated Isp due to Tsilovisky equation is satisfy the requirements or not.

For calculating the min number of stages to do the specified mission, there is a module developed to calculate this important parameter and it's a good estimator for the number of stages due to the total weight, structure weight, payload weight, and Isp.

As a final check, a 3D motion module - with ellipsoid earth module in geocentric equatorial axis and taking the effect of the earth rotating in the calculation- was developed to check if the designed space vehicle will achieve its mission or not and also will pass the terminal and side constrains or there are something wrong in the design.

If the above checks pass, thereare final configurations of the space vehicle obtained as an output with the following results,,,

- The overall shape design of the missile
- The min number of stages
- The design of each stage from the shape to the internal propellant configuration
- Total weights and estimated performance due to the different stages configuration

Results & Test Cases

This section will start with Launchers test cases..

Test Case 1

The Real Data

This Missile That Hold 160 Kg at Alt = 366 Km is the isrealian Launcher "**SHAVIT**"
With Configuration

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The Output From the program

	Real	Calculated
# of stages	3	3
Propulsion	solid	Liquid
Gross Mass (Ton)	23.63	21.338907
Length	18m	18.2
Body Diameter	1.4m	1.2

The Output From the program

Missile Configuration

Requirements
For Pay Load = 160.000000 Kg
At altitude = 366.000000 Km
Output
Overall
Dimensions
Total Length =18.2 m
Total Dim = 1.2 m

Mass
Total Mass = 21.338907 Ton
Where Propellant Mass = 19.519730 Ton
Structural Mass = 1.659177 Ton

Propellant Information...
Fuel Type is Liquid Propellant Of Type **N2H4F2**
Which has specification.......
Grain density ideal =1.310000
Ratio of specific heats =1.200000
Effective molecular Weight =19.400000
Chamber temperature = 4687.000000
Mix Ratio For Liquid = 2.180000
Isp = 364.000000

Number Of Stages =3.0

Stage 1

Length =9.1 m
Dim = 1.2
Total Mass Of Propellant = 9.759865 Ton
Fuel Tank Length =2.541480 m
Fuel Tank Dim =1.204788 m
Oxidizer Tank Length =3.993755 m
Oxidizer Tank Dim =1.204788 m
Thrust = 336.603027 KN
Thrust Time = 103.431602 Sec
Chamber Length = 0.653524 m
Chamber Dim = 0.518059 m
Throat Dim = 0.129515 m Exit Dim =0.342535 m

Stage 2

Length =6.1 m
Dim = 1.2
Total Mass Of Propellant = 6.506577 Ton
Fuel Tank Length =1.694320 m
Fuel Tank Dim =1.204788 m
Oxidizer Tank Length =2.662503 m
Oxidizer Tank Dim =1.204788 m
Thrust = 336.603027 KN
Thrust Time = 68.954399 Sec
Chamber Length = 0.435682 m
Chamber Dim = 0.518059 m
Throat Dim = 0.129515 m Exit Dim =0.342535 m

Stage 3

Length =3.0 m
Dim = 1.2 Total Mass Of Propellant = 4.066610 Ton
Fuel Tank Length =1.270740 m
Fuel Tank Dim =1.204788 m
Oxidizer Tank Length =1.996877 m
Oxidizer Tank Dim =1.204788 m
Thrust = 336.603027 KN
Thrust Time = 43.096500 Sec
Chamber Length = 0.272301 m
Chamber Dim = 0.518059 m
Throat Dim = 0.129515 m Exit Dim =0.342535 m

Motion Model for SHAVIT

The results of the motion model is presented by **E-POST** (Egyptian Program To optimize and simulate trajectories) M. Farran [1]

Alt	:	366 Km
Payload		160 Kg

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Output from Motion Module Program

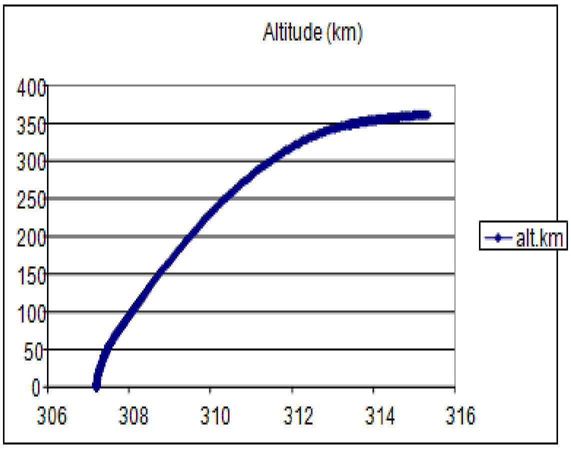

Fig.2: The Altitude Vs Latitude of the mission

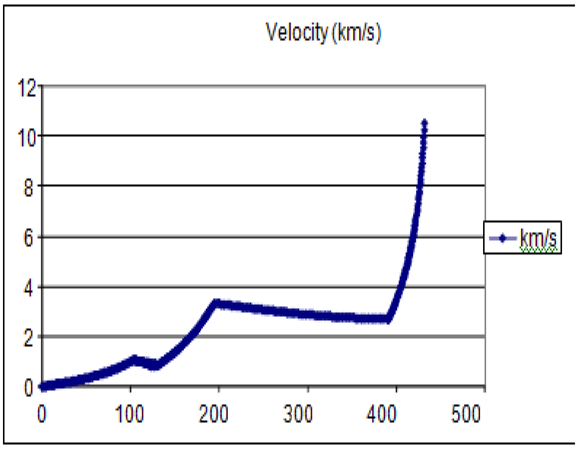

Fig.3: The Velocity Vs Time of the mission

Test Case 2
Real Case:

Launcher : Start -1
Country : Russia

Payload	260 Kg	Calculated
Alt	600 Km	
Dim	1.55 m	1.5 m
Length	22.7	22.3 m
Weight	47 Ton	39.645035 Ton

Calculated
Mass

Total Mass = 39.645035 Ton
Where Propellant Mass = 36.271922 Ton
Structural Mass = 3.083113 Ton

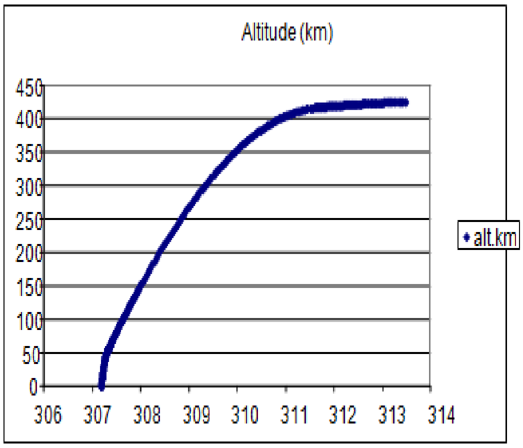

Fig.4: The Altitude Vs Latitude of the mission

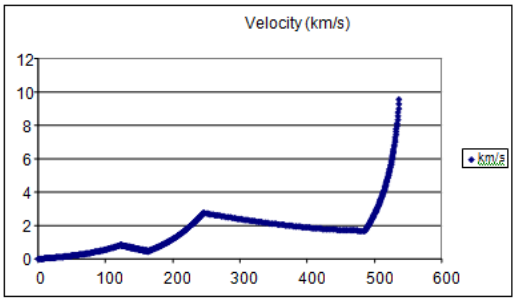

Fig.5: The Velocity Vs Time of the mission

Test CASE (3)
Real Case:

Launcher : Kosmas C-1
Country : Russia

Payload	: 975 Kg	Calculated
Alt	: 1000 Km	
Dim	: 2.4 m	2.2 m
Length	: 32.4 m	33.6 m
Weight	: 109 Ton	134.96 ton

Calculated
Mass
Where Propellant Mass = 123.488563 Ton
Structural Mass = 10.496527 Ton

Test CASE (4)
Real Case:

Launcher : Molynia
Country : Russia

Payload	: 2000 Kg	Calculated
Alt	: 400 Km	
Length	: 43.4 m	41.4 m
Dim	: 2.6 m	2.8 m
Weight	: 101 Ton	80.90 ton

Calculated
Mass
Where Propellant Mass = 72.720523 Ton
Structural Mass = 6.181245 Ton

Test CASE (5)
Real Case:

Launcher : Arian 40
Country : Europe
Payload : 3050 Kg

Alt	: 1000 Km	Calculated
Length	: 58.4 m	48.7 m
Dim	: 4.0 m	3.2 m
Weight	: 240 Ton	352.17 ton

Calculated
Mass
Where Propellant Mass = 321.773250 Ton
Structural Mass = 27.350727 Ton

Conclusion

This method is good as a first estimation of the space vehicle designand the test cases show that the output design is nearly the real data which make a good sense about the reliability of this method in the view of overall design.Some difference between the real data and the calculated referred to the available fuel data that the design method starting point is depend on it. This algorithm includes important modules in it like aerodynamic model, propulsion, and 3D motion model. Each module needs more enhancements to make it more accurate and reliable. This Method is may use by engineers whom interests in space vehicles design and need to get a first estimation to make their task little easer

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