Rocket and Launch Vehicles

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**Rockets and Launch Vehicles**

# Introduction

The research will dwell preliminary on identifying the types of rockets and launcher vehicles. Under this broad topic, the research will converge into specific details regarding; principles of rocket science, types of rocket systems and their operating principles, launch-vehicles subsystems and they design issues, and the principles that are utilized in rocket staging and how the velocity change is determined from a staged launch vehicle. The research will offer insightful and educative perception hence making it worth for the future researchers to utilize the same when it comes to gaining information regarding rockets and launch vehicles. Rockets are responsible for taking spacecraft to their final destinations in the space. Additionally, rockets are attached to forming some of the propulsion subsystems which are said to be available on fireworks, the space shuttles, and the star ships. The propulsion subsystems are responsible for doing the following; getting the spacecraft to the space, moving the spacecraft around after they getting to the space, and changing their directions whenever they deviate from the direction they are intended to face. The following picture gives a figurative explanation on the earlier statement;



# Briefing on Rocket Science

It is imperative to have a clear understanding on how a rocket functions and the elements encompassing rocket. A rocket is regarded to as system associated to taking mass and energy and then converts the same into force and ensures that it has moved a vehicle (Sellers, 2000). In a rocket, the mass that is input is referred to as a propellant and the force that the rocket emits is regarded to as the thrust. The core examination of the rocket system starts by a clear reflection of the thrust. For a rocket to move, it has to emit mass at a relatively higher speed in an opposite direction; this principle is based on the Newton’s third law which states that “for every action, there is an equal and opposite reaction (Gangopadhyaya, 2017).” A good example that can be used to illustrate this is by the use of a toy balloon. When the toy balloon is inflated it makes the pressure inside higher as compared to the one outside; hence, upon the release of the balloon, the pressure inside has an escape route.

# Types of Rockets

Bearing the basic operating techniques of a rocket it rightful to note the two major types of rockets where their classification is based on the form of energy taken to the propellant and later converted to a higher speed exhaust. The two core types of the rockets are the thermodynamics and the electrodynamics rockets (Lynch, 2018). The thermodynamics rockets mainly rely on the energy from heat and pressure which is transmitted to the propellant, on the other hand, electrodynamics rockets depend mainly on the electric charges and the magnetic fields.

## Thermodynamics rockets

These types of rockets are associated with the ultimate use of heat and pressure to the propellant. Research has shown that the pressure and the heat utilized in this context may vary from chemical reaction or from the external sources which include electricity, nuclear reaction or even the use of solar energy (Chatwin, 2017). Once these energies are pumped in the propellant, the result indicates that there will be a high pressure and temperature in the thrust; hence, giving the rocket enough power to reach the space.

## Electrodynamics rockets

This type of rocket is bound to depend on electrodynamics energies. The energies emanates from charged particles which move in electric and magnetic fields. The idea behind this type of rocket is that the ions have to be charged through stripping one or more electrons. The propellant therefore becomes more positive and the charges increase hence increasing the velocities of the thrust to enable the rocket travel to the space (Sellers, 2000). Electrodynamics rockets are low in velocity as compared to the thermodynamics rockets. However, the type of energies which are transferred to these propellants is determined by how it can be converted into relatively higher speed thrusts. Energies in the electrodynamics rockets are transferred to the exhaust by the use of two prime methods and these are the thermodynamic expansion “by the use of nozzles”, and electrodynamics acceleration “by the use of electric and the magnetic fields.”

# Analysis of rocket systems

It is clearly that the two core types or rockets have a functional and similar rocket system. The rocket system has two core processes that take place within the rocket (Sellers, 2000). Firstly, the energies generated must be transferred to the rocket’s propellant in various forms; for instance, heat, pressure, or even the charges in order for the rocket to realize motion and velocity. Secondly, the energies that are in the propellant must be energized in order to realize high velocities exhaust.

## Propulsion systems

Propulsion systems are technologies which are effective in allowing the rockets to execute their functions. The research indicates on the essential elements in a rocket and how to combine them in order to function (Fernandez, 2017). The following diagram gives a clear picture on how a complete propulsion subsystem looks like;



The designing of such system initializes with the adoption of the desired and rightful thrust which will be required to propel the rocket to the space. The propulsion system controller is attached to keying commands and taking inputs to the propellant personnel to either start or stop them. In some systems, it is the work of the propellant actuator to manage the flow of energy in the rocket (Sakaguchi, 2019). For instance, in the case of the electrodynamics rockets, the systems have to be attached with an interface connected to the spacecraft’s EPS which ensures the provision of the needed power. The controller is bound to utilize sensors in monitoring both pressure and temperatures of the propellant in the entire system. The sensitive and key inputs that are in a propellant are the management of the propellant and how to store both gases and liquid propellants (Sakaguchi, 2019). Nevertheless, the propulsion systems in the rocket are been studied every single day with the hope that the rockets scientists will someday discover an exotic concept which might take us far away to the stars.

# Propellant management

It is evident that all rockets require propellant for their function to be successful. The collective task attached to ensuring that the propellant is stored well and that it has gotten to the ultimate destination and time is regarded to as the propellant management (Tam, 2016). The propellant management is sub-divided into four main portions which include; the storage of a propellant, controlling of the pressure, controlling of the pressure, and the control of the flow in the propellant. In a nutshell, the collective responsibility of a propellant management is to ensure that the propellant flow is controlled and regulated. Chemical rockets are regarded to as the most recent and majorly in use. They are subdivided into three core types which is liquid, solid and hybrid. Some of the chemical rockets are regarded as toxic and are said to be the most expensive and effective than any other type of rocket. Toxic rockets have higher velocities than others (Tam, 2016). Despite their velocities, the propellant management for all the rockets is vital and should be done regularly in order to ascertain its effectiveness.

# Launch Vehicles

A launch vehicle requires the spacecraft in order to deliver the payload required to the orbit. It functions in the same way just as any vehicle; transferring a load from one point to another. The evident differences between the launch vehicle and the spacecraft are in the area of operation (Neuhold, 2019). The operation time between the two are diverse in that launch vehicle takes 10 minutes while the spacecraft takes 10 years and above for its operation to be done. Additionally, another distinguishing parameter between launch vehicles and spacecraft is their velocities; more than 8 kilometer per second versus 0-1 kilometer per second.



## The propulsion subsystems for launch vehicle

In this case, the launch vehicle propulsion subsystem has a number of challenges that are attached to it apart from subsystems on the spacecraft. The challenges presented in this case include; the thrust-to-weight ratio, the thrust and throttling vector control unit, and ultimately the nozzle design.

The thrust-to-weight ratio is a challenge in the launch vehicle which states that in order to ensure that the rocket has gotten off the ground, the thrust weight must be great than the weight of the vehicle. This therefore means that the launch vehicle’s propulsion system must be in a position to produce thrust-to-weight which is greater than 1 (Dupont, 2017). In so doing, the challenge will have been done away with; on the other hand, if the thrust-to-weight ratio is less than 1, then the launch vehicle will not be in a position to get the rocket off the ground to the orbit. It is imperative to ensure that the thrust-to-weight ratio is consistent throughout in ensuring that the rocket gets to the orbit.

Throttling and thrust-vector control upholds that basically all the spacecraft application, the engines for the rockets are either on or off. This therefore calls for no need of a continued thrusting of the engines by throttling (Zhu, 2017). Nevertheless, launch vehicles are said to be in need of throttling the engines which in most cases lead to the complexity and eventually adding up to costs of the propulsion subsystems in the launch vehicles. According to Sellers (2000), the throttling can be costly; hence, there should be a number of technologies and improvements which need to be proposed in the move to do away with the throttling process. One of the technology that need to be incorporated in this system includes the inclusion of an on and off switch in the launch vehicles. Though the on and off switch is available, but it need to be improvise in a way it trigger the throttling process only when it is needed. Throttling is associated in dealing with aerodynamic forces present on the vehicle as it flies to the space. It is viewed that within the first few minutes of the launch, the velocity of the vehicle is bound to increase rapidly while at this point there is low altitude (Zhu, 2017). When the launch vehicle passes the low altitude at relatively high velocity, it gets to a denser atmosphere where it then produces dynamic pressure on the launch vehicle. The design of the vehicle is done in a way that it might not rip off after passing through the difference types of atmospheres.

Nozzle design is crafted in a way that it allows a series of expansions and contractions. It is clear that during the launch external pressure is bound to move from see level to almost zero or the vacuum in very few minutes. The main idea for this case is to allow the nozzle to realize a significant expansion or contraction ratio which will be found throughout the trajectory in order to alter the pressure which is exiting as there is a continued decrease in atmospheric pressure (Harroun, 2019). One of the prime indigenous nozzle design problem utilized is by the use of a completely different type or kind of nozzle. The conventional bell-shaped nozzles are the best to be used in this case; these nozzles are the best and their simplicity is defined by how well they are able to execute their mandates in the launch vehicles and the rockets.

## Navigation, guidance, and control subsystems

The launch vehicle is bound to deal with the same problems or a number of systems in a number of ways. In this case, Navigation, Guidance, and Control Subsystems which is formally referred to as the (NGC) is associated with keeping the launch vehicle in line with the thrust vector so as it helps in protecting the dangerous loads from spilling off (Sellers, 2000). The NGC also helps the thrust vector to keep pointed towards the flight profile. As any other control system, the NGC has the actuators and the sensors. In NGC the primary actuators are the engines which utilize the TVC and the throttling present in the launch vehicle.

## Communication and data handling

The vehicle must be in a consistent contact with the launch control center throughout the launch. The flight controllers at this juncture must ensure that the launch vehicle subsystems are in good condition and that are operating normally (Sellers, 2000). In order to accomplish the mission, the vehicle is required to communicate the data, while the data handling subsystem processes the same data and transmits it to the control center to countercheck the condition of the launch vehicle subsystems.

# Staging

The staging process refers to the act of getting the payload to the orbit. This process is sometimes hectic and cumbersome. The astronomers and the rocket scientists have to ensure that they have an accurate way in doing so. One of the prime way to which the staging can be made easier is by establishing and having an accurate figure when it comes to thrust-to-weight ratio (Walter, 2018). The concept behind the staging process is for instance; when the planes are flying, they may end up dropping the empty tanks which they had placed planes in them. The dropping of these tanks ensures that the planes have become light and hence realizing the streamline.

The stages encompasses the propellant tanks, the engines of the rockets, and any other supporting subsystem which are dropped off to ensure that the launch vehicle is lighten on its way to the space (Walter, 2018). The propellant in every stage is used up and then dropped; the subsequent propellant engine is ignited and so on and so forth till the ultimate target of the launch vehicle.

## Advantages and disadvantages associated to Staging

Staging has a number of advantages; for instance, it increases the overall mass of the spacecraft which is to be delivered to the space for the similar size of the vehicle (Sellers, 2000). This is imperative in noting since it is nearly impossible to take the same size of the car manually to the space. Additionally, it helps in increasing the total velocity of the same sized vehicles.

Staging is also associated to a number of disadvantages which are outlined as follows

* It has a significant increased complexity; this is due to the fact that the vehicle is entitled to having extra engines and the plumbing systems throughout.
* It is also attached to realize a decreased reliability; this comes in as a result of adding up some extra sets of engines and plumbing systems which will then be used in the latter and upper stages during the staging process (Sellers, 2000).
* It is associated to having an increased total cost as a result of the inclusive of more complex vehicles which would call for extra costs to build and launch.

# Conclusion

In conclusion, rockets and launch vehicles is a broad topic to research and investigate on; this is due to the fact that new technologies are emerging on a daily basis. Nevertheless, it is vital for a rocket scientist and an astronomer to have the idea and be conversant with the ideas behind rockets and launch vehicles. The different types of rockets are imperative to be understood since they have distinctive features and are used for specific tasks. Additionally, a clear understanding of staging and launching is crucial for the rocket scientists; this gives a clear indication on whether the transmission and communication between the vehicle, the NGC and the control center has attained its success. If it happens that there is no such clear understanding, it would mean that the transmission of the signals to confirm whether or not they are operating normally might not be realized. Nevertheless,, more and more research regarding rockets and launch vehicles ought to be conducted to boost on the same concept.

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