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**Reusable Rocket System**

* Definition
  + A reusable version of a space vehicle
  + Some or all the system can be recovered
  + Can be sub-orbital or fully orbital
  + no fully reusable **orbital** has been launched
  + can land vertically (falcon 9) or horizontally (space shuttle **Discovery**)
  + Either a hybrid or reusable
    - hybrid = falcon 9 & falcon heavy
      * by mid-2020, they will become fully reusable launch systems along with the BFR
* How it Works
* Rockets would usually have their thrusters just drop back in the ocean, but reusable rockets would have these thrusters stay attached all the time and attempt a safe landing as one piece
* This landing would take place on land instead of the ocean because getting an estimation of where the rocket would exactly land is extremely difficult.
* After a rocket has reached orbit and is ready for descent there would be a controlled blast to turn the rocket around.
* The rocket wouldn’t fall back down the way it came up it would do an arch, as if the rocket is falling backwards towards the earth.
* Therefore, the landing spot for the rocket is hard to estimate and is on the land
* While the rocket is falling three of the rockets start up to slow down the descent of the rocket
* Also, while the rocket is falling grid fins extend out of the thrusters and act as wings in order to try and steer the rocket
* Something that could affect the landing is natural factors such as wind and rain, therefore, the rocket has an onboard computer which can sense, change the amount of thrust, and the grid fins in a fraction of a second
* The legs required for the landing would only extend out right before the landing in order to avoid complications
* The falcon 9 has two stages of launches, after the first thruster is used it detaches, it saves some of its fuel in order to do a blast to turn itself around and slow down. The rest of the rocket would do the same.
* Rockets would only need to be refueled and cleaned with maintenance checks before they are usable once again.
* Pros
* It reduces the amount of rocket waste building up at the bottom of the ocean
* Significant launch cost reduction (62M vs 171M)
* The falcon 9 only uses $200,000 for refuel and repairs, while a new rocket costs around $60 million due to having to remake the rocket every launch
* Lessen debris accumulation in space
* Faster space science discoveries due to more launches
* Faster space exploration (BFR potentially going to mars)
* If more research is done, we could have more and more rockets flying
* Space travel can become more and more common
* Testing for other parts of a rocket can be done much more frequently and efficiently because they wouldn’t need to build a whole new rocket for one trial
* Faster design cycle which means scientist can test, modify, and improve much faster
* Cons
  + Expensive R&D ($846M vs $300M (Falcon 9 vs Delta IV Medium+ 5.4) (rough estimates)
    - More durable materials
    - More thought into re-entry of the rocket components
      * SpaceX uses toss-back trajectory (uses another rocket to land safely near original position). Less costly and less components needed to be added (compared to wings)
    - More testing on the longevity of the system
    - Has a performance hit due to weight being added for reusability
  + Speeding climate change due to more launches per year
  + The spaceship must be much bigger because of the required extra gear and hardware
  + A lot of maintenance before launch to ensure all systems work as expected
  + Predicted 400% performance hit in 2004 in first stage, 300% in second stage
    - Actual performance hit: 3.114 lbs/ft/kg vs 1.755 lbs/ft /kg (+236%) (Falcon 9 vs Delta IV Medium+ 5.4
  + So far, reusable rockets have been only able to reach just out of earths orbit and no further such as the moon or mars
  + There must be more research and testing for the landing portion which would cost much more
  + If there’s more testing because of faster design cycles that means more fuel would be burned and rockets use a lot of fuel which would harm the environment

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