



# SpaceX Falcon 9 first stage Landing Prediction

## Lab 1: Collecting the data

Estimated time needed: **45** minutes

In this capstone, we will predict if the Falcon 9 first stage will land successfully. SpaceX advertises Falcon 9 rocket launches on its website with a cost of 62 million

dollars; other providers cost upward of 165 million dollars each, much of the savings is because SpaceX can reuse the first stage. Therefore if we can determine if the first stage will land, we can determine the cost of a launch. This information can be used if an alternate company wants to bid against SpaceX for a rocket launch. In this lab, you will collect and make sure the data is in the correct format from an API. The following is an example of a successful and launch.

Several examples of an unsuccessful landing are shown here:



Most unsuccessful landings are planned. Space X performs a controlled landing in the oceans.

## Objectives

In this lab, you will make a get request to the SpaceX API. You will also do some basic data wrangling and formating.

- Request to the SpaceX API
- Clean the requested data

# Import Libraries and Define Auxiliary Functions

We will import the following libraries into the lab

```
In [6]: # Requests allows us to make HTTP
import requests
# Pandas is a software library written in Python
import pandas as pd
# NumPy is a library for the Python programming language, used for scientific computing
import numpy as np
# Datetime is a library that allows you to work with dates and times
import datetime

# Setting this option will print column names
pd.set_option('display.max_columns', None)
# Setting this option will print column widths
pd.set_option('display.max_colwidth', None)
```

```
In [9]: #Below we will define a series of functions to help us work with the data
#From the <code>rocket</code> column
```

```
In [10]: # Takes the dataset and uses the rocket column to filter the data
```

```
def getBoosterVersion(data):  
    for x in data['rocket']:  
        response = requests.get("https://api.spacex.com/v3/rockets/" + x + "/boosters")  
        BoosterVersion.append(response.json()['version'])
```

From the `launchpad` we would like to know the name of the launch site being used, the longitude, and the latitude.

```
In [11]: # Takes the dataset and uses the launchpad data to get launch site data  
def getLaunchSite(data):  
    for x in data['launchpad']:  
        response = requests.get("https://api.spacex.com/v3/launchpads/" + x + "/launches")  
        Longitude.append(response.json()['longitude'])  
        Latitude.append(response.json()['latitude'])  
        LaunchSite.append(response.json()['name'])
```

From the `payload` we would like to learn the mass of the payload and the orbit that it is going to.

```
In [12]: # Takes the dataset and uses the payload data to get payload data  
def getPayloadData(data):  
    for load in data['payloads']:  
        response = requests.get("https://api.spacex.com/v3/launches/" + load + "/payloads")
```

```
PayloadMass.append(response['payload_mass'])
Orbit.append(response['orbit'])
```

From `cores` we would like to learn the outcome of the landing, the type of the landing, number of flights with that core, whether gridfins were used, whether the core is reused, whether legs were used, the landing pad used, the block of the core which is a number used to separate version of cores, the number of times this specific core has been reused, and the serial of the core.

```
In [13]: # Takes the dataset and uses the core data to get core data
def getCoreData(data):
    for core in data['cores']:
        if core['core'] != None:
            response = request.get(url)
            Block.append(response['block'])
            ReusedCount.append(response['reused_count'])
            Serial.append(response['serial'])
        else:
```

```
Block.append(None)
ReusedCount.append
Serial.append(None)
Outcome.append(str(core
Flights.append(core['f
GridFins.append(core['
Reused.append(core['re
Legs.append(core['legs
LandingPad.append(core
```

Now let's start requesting rocket launch data from SpaceX API with the following URL:

```
In [14]: spacex_url="https://api.spacexdata
```

```
In [15]: response = requests.get(spacex_url)
```

Check the content of the response

```
In [16]: print(response.content)
```

```
b' [{"fairings": {"reused": false, "recovery_attempt": false, "recovered": false, "ships": []}, "links": {"patch": {"small": "https://images2.imgbox.com/3c/0e/T8iJcSN3_o.png", "large": "https://images2.imgbox.com/40/e3/GypSkayF_o.png"}, "reddit": {"campaign": null, "launch": null, "media": null, "recovery": null}, "flickr": {"small": [], "original": []}, "presskit": null, "webcast": "https://www.youtube.com/watch?v=0a_00nJ_Y88", "youtube_id": "0a_00nJ_Y88", "article": "https://www.space.com/2196-spacex-inaugural-falcon-1-rocket-lost-launch.html", "wikipedia": "https://en.wikipedia.org/wiki/DemoSat"}, "static_fire_date_utc": "2006-03-17T00:00:00.000Z", "static_fire_date_unix": 1142553600, "net": false, "window": 0, "rocket": "5e9d0d95eda69955f709d1eb", "success": false, "failures": [{"time": 33, "altitude": null, "reason": "merlin engine failure"}], "details": "Engine failure at 33 seconds and loss of vehicle", "crew": [], "ships": [], "capsules": [], "payloads": ["5eb0e4b5b6c3bb0006eeb1e1"], "launchpad": "5e9e4502f5090995
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```
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m, Premature engine shutdown at T
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t, Failed to recover first stag
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12/417

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```
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Falcon 9 v1.1 flight, with improved 13-tonne to LEO capacity. Following second-stage separation from the first stage, an attempt was made to perform an ocean touchdown test of the discarded booster vehicle. The test provided good test data on the experiment-its primary objective-but as the booster neared the ocean, aerodynamic forces caused an uncontrollable roll. The center engine, depleted of fuel by centrifugal force, shut down resulting in the impact and destruction of the vehicle.", "crew": [], "ships": ["5ea6ed2d080df4000697c903"], "capsules": [], "payloads": ["5eb0e4bbb6c3bb0006eeb1ee"], "launchpad": "5e9e4502f509092b78566f87", "flight\_number": 11, "name": "CASSIOPE", "date\_utc": "2013-09-29T16:00:00.000Z", "date\_unix": 1380470400, "date\_local": "2013-09-29T09:00:00-07:00", "date\_precision": "hour", "upcoming": false, "cores": [{"core": "5e9e289ff359180ae23b262d", "flight": 1, "gridfins": false, "legs": false, "reused": false, "landing\_attempt": true, "landing\_success": false, "landing\_type": "Ocea



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hter-weight dual-commsat stack th
at was specifically designed to t
ake advantage of the lower-cost S
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ss than $30 million. The ABS sate
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on ahead of schedule and started
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ounced in October 2015. SpaceX received a permit from the FAA to land the booster on solid ground at Cape Canaveral, and succeeded.

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The rocket\'s first stage landed  
smoothly on SpaceX\'s autonomous  
spaceport drone ship 9 minutes af  
ter liftoff, making this the firs  
t ever successful landing of a ro  
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ing the rocket and mission costs. First stage landing attempt on drone ship failed on landing due to low thrust on one of the three landing engines.", "crew": [], "ships": ["5ea6ed2e080df4000697c906", "5ea6ed2f080df4000697c90b", "5ea6ed2f080df4000697c90c", "5ea6ed30080df4000697c913"], "capsules": [], "payloads": ["5eb0e4bfb6c3bb0006eeb203", "5eb0e4bfb6c3bb0006eeb204"], "launchpad": "5e9e4501f509094ba4566f84", "flight\_number": 31, "name": "ABS-2A / Eutelsat 117W B", "date\_utc": "2016-06-15T14:29:00.000Z", "date\_unix": 1466000940, "date\_local": "2016-06-15T10:29:00-04:00", "date\_precision": "hour", "upcoming": false, "cores": [{"core": "5e9e28a2f359184f403b2641", "flight": 1, "grid\_fins": true, "legs": true, "reused": false, "landing\_attempt": true, "landing\_success": false, "landing\_type": "ASDS", "landpad": "5e9e3032383ecb6bb234e7ca"}], "auto\_update": true, "tbd": false, "launch\_library\_id": null, "id": "5eb87cf8ffd86e000604b348"}, {"fairings": null, "links": {"patch": {"small": "https://images2.imgbox.com/b6/52/p5vdNEJF\_o.pn



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12) for the 11th time, and a refurbished capsule (C110 from CRS-8) for the third time. External payloads include a materials research platform MISSE-FF phase 3 of the Robotic Refueling Mission TSIS, heliophysics sensor several crystallization experiments, and the RemoveDebris spacecraft aimed at space junk removal. The booster was expended in order to test a new landing profile.", "crew": [], "ships": ["5ea6ed30080df4000697c912"], "capsules": ["5e9e2c5cf3591885d43b266d"], "payloads": ["5eb0e4c7b6c3bb0006eeb221"], "launchpad": "5e9e4501f509094ba4566f84", "flight\_number": 59, "name": "CRS-14", "date\_utc": "2018-04-02T20:30:41.000Z", "date\_unix": 1522701041, "date\_local": "2018-04-02T16:30:41-04:00", "date\_precision": "hour", "upcoming": false, "cores": [{"core": "5e9e28a4f3591884ee3b264d", "flight": 2, "grid\_fins": true, "legs": true, "reused": true, "landing\_attempt": false, "landing\_success": null, "landing\_type": null, "landpad": null}], "auto\_update": true, "tbd": false, "launch\_library\_id": null, "id": "5eb87d16ffd86e0

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course of two months, reach a stable, 2:1 resonant orbit with the Moon. In January 2018, SpaceX received NASA's Launch Services Program Category 2 certification of its Falcon 9 'Full Thrust', certification which is required for launching medium risk missions like TESS. It was the last launch of a new Block 4 booster, and marked the 24th successful recovery of the booster. An experimental water landing was performed in order to attempt fairing recovery.", "crew": [], "ships": ["5ea6ed2e080df4000697c90a", "5ea6ed2f080df4000697c90b", "5ea6ed2f080df4000697c90d", "5ea6ed30080df4000697c913"], "capsules": [], "payloads": ["5eb0e4c7b6c3bb0006eeb222"], "launchpad": "5e9e4501f509094ba4566f84", "flight\_number": 60, "name": "TESS", "date\_utc": "2018-04-18T22:51:00.000Z", "date\_unix": 1524091860, "date\_local": "2018-04-18T18:51:00-04:00", "date\_precision": "hour", "upcoming": false, "cores": [{"core": "5e9e28a5f35918863d3b2655", "flight": 1, "gridfins": true, "legs": true, "reused": false, "landing\_attempt": true, "landing\_succ

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will expand SES\'s cap
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flight of 2018 launched the Merah Putih (also known as Telkom-4) geostationary communications satellite for Telkom Indonesia. It marked the first reuse of any Block 5 first stage; the booster B1046 had previously launched Bangabandhu-1. The stage was recovered and is expected to become the first Falcon 9 booster to fly three missions.

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mmunications satellite delivering
television and internet to Qatar
and the surrounding region. It w
as launched into a geostationary
transfer orbit from LC-39A at Ke
nnedy Space Center. The booster l
anded on OCISLY.", "crew": [], "ship
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kely to be the third flight of core B1046 which previously flew Bangabandhu-1 and Merah Putih. If this happens it will be the first time a Falcon 9 has flown more than two missions. ", "crew": [], "ships": ["5ea6ed2f080df4000697c910", "5ea6ed30080df4000697c912", "5ea6ed30080df4000697c914", "5ea6ed2e080df4000697c908"], "capsules": [], "payloads": ["5eb0e4c9b6c3bb0006eeb22e"], "launchpad": "5e9e4502f509092b78566f87", "flight\_number": 71, "name": "SSO-A", "date\_utc": "2018-12-03T18:34:00.000Z", "date\_unix": 1543861920, "date\_local": "2018-12-03T10:34:00-08:00", "date\_precision": "hour", "upcoming": false, "cores": [{"core": "5e9e28a5f359182b023b2656", "flight": 3, "gridfins": true, "legs": true, "reused": true, "landing\_attempt": true, "landing\_success": true, "landing\_type": "ASDS", "landpad": "5e9e3033383ecbb9e534e7cc"}], "auto\_update": true, "tbd": false, "launch\_library\_id": null, "id": "5eb87d25ffd86e000604b370"}, {"fairings": null, "links": {"patch": {"small": "https://images2.imgbox.com/de/47/liJzNMRP\_o.png", "lar

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5/spacex-falcon-9-boosts-dragon-c
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ls":"SpaceX\'s 16th Crew Resupply
Mission on behalf of NASA, with a
total of 20 contracted flights. T
his will bring essential supplies
to the International Space Statio
n using SpaceX\'s reusable Dragon
spacecraft. The Falcon 9 will lau
nch from SLC-40 at Cape Canaveral
Air Force Station. During the lan
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\s twenty-first flight of 2018 launched the first of the new GPS III satellites (Block IIIA) for the United States Air Force and was SpaceX\s first EELV mission. The spacecraft was delivered to a MEO transfer orbit from SLC-40 at Cape Canaveral Air Force Station. This mission was the first to fly with the redesigned COPV on the first stage (B1054) as well as the second. The booster was expended.", "crew": [], "ships": [], "capsules": [], "payloads": ["5eb0e4cab6c3bb0006eeb230"], "launchpad": "5e9e4501f509094ba4566f84", "flight\_number": 73, "name": "GPS III SV01", "date\_utc": "2018-12-23T13:51:00.000Z", "date\_unix": 1545573060, "date\_local": "2018-12-23T08:51:00-05:00", "date\_precision": "hour", "upcoming": false, "cores": [{"core": "5e9e28a6f35918513b3b265b", "flight": 1, "gridfins": false, "legs": false, "reused": false, "landing\_attempt": false, "landing\_success": null, "landing\_type": null, "landpad": null}], "auto\_update": true, "tbd": false, "launch\_library\_id": null, "id": "5eb87d27ffd86e000604b372"},

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ls":"SpaceX will launch this ride  
share to GTO for Space Systems Lo  
ral (SSL). The primary payload fo  
r this mission is Nusantara Satu,  
a communications satellite built  
by SSL for the private Indonesia  
n company PT Pasifik Satelit Nusa  
ntara (PSN). Spaceflight Industri  
es\' GTO-1 mission consists of tw  
o secondary payloads. One of thos  
e is Beresheet, the lunar lander  
built by the Israeli non-profit  
organization, SpaceIL. Beresheet  
will make its own way to the moon  
from GTO. The other secondary is  
Air Force Research Lab\'s (Space  
Situational Awareness) S5 missio  
n, which hitches a ride to GEO ab  
oard Nusantara Satu. This mission
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ut of a total of 20 contracted fl
ights, this mission brings essent
ial supplies to the International
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sable Dragon 1 spacecraft. The external payloads for this mission include Orbital Carbon Observatory 3 and Space Test Program-Houston 6. The Falcon 9 launches from SLC-40 at Cape Canaveral AFS. The booster was expected to land at LZ-1, however, due to the ongoing investigation and clean-up following the Crew Dragon testing incident, it is likely to land on OCISLY instead.

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prototype satellites, Microsats 2 a and 2b, were launched from Vandenberg AFB in February 2018. The booster for this mission will land on OCISLY.", "crew": [], "ships": ["5ea6ed30080df4000697c913", "5ea6ed2f080df4000697c90c", "5ea6ed2f080df4000697c90e", "5ea6ed2f080df4000697c90b", "5ea6ed2e080df4000697c909"], "capsules": [], "payloads": ["5eb0e4cbb6c3bb0006eeb238"], "launchpad": "5e9e4501f509094ba4566f84", "flight\_number": 79, "name": "Starlink v0.9", "date\_utc": "2019-05-24T02:30:00.000Z", "date\_unix": 1558665000, "date\_local": "2019-05-23T22:30:00-04:00", "date\_precision": "hour", "upcoming": false, "cores": [{"core": "5e9e28a5f3591833b13b2659", "flight": 3, "gridfins": true, "legs": true, "reused": true, "landing\_attempt": true, "landing\_success": true, "landing\_type": "ASDS", "launchpad": "5e9e3032383ecb6bb234e7ca"}], "auto\_update": true, "tbd": false, "launch\_library\_id": null, "id": "5eb87d30ffd86e000604b378"}, {"fairings": {"reused": false, "recovery\_attempt": false, "recovered": null, "ships": []}, "links": {"patch":



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LightSail-B demonstrator cubesa  
t, and others. The third and fina  
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nal payload for this mission is International Docking Adapter 3, replacing IDA-1 lost in SpaceX's CRS-7 launch failure. This mission will launch from SLC-40 at Cape Canaveral AFS on a Falcon 9, and the first-stage booster is expected to land back at CCAFS LZ-1.", "crew": [], "ships": [], "capsules": ["5e9e2c5cf359188bfb3b266b"], "payloads": ["5eb0e4ceb6c3bb0006eeb24a"], "launchpad": "5e9e4501f509094ba4566f84", "flight\_number": 82, "name": "CRS-18", "date\_utc": "2019-07-25T22:01:00.000Z", "date\_unix": 1564092060, "date\_local": "2019-07-25T18:01:00-04:00", "date\_precision": "hour", "upcoming": false, "cores": [{"core": "5e9e28a7f3591809313b2660", "flight": 2, "gridfins": true, "legs": true, "reused": true, "landing\_attempt": true, "landing\_success": true, "landing\_type": "RTLS", "landpad": "5e9e3032383ecb267a34e7c7"}], "auto\_update": true, "tbd": false, "launch\_library\_id": null, "id": "5eb87d36fffd86e000604b37b"}, {"fairings": {"reused": false, "recovery\_attempt": true, "recovered": true, "ships": ["5ea6ed2e080df4000697

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NASA with a total of 20 contracted flights, this mission brings essential supplies to the International Space Station using SpaceX's reusable Dragon spacecraft. The external payloads for this mission include the Hyperspectral Imager Suite and a lithium-ion battery. Falcon 9 and Dragon will launch from SLC-40, Cape Canaveral AFS. The mission will be complete with return and recovery of the Dragon capsule and down cargo.

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al NASA CRS contract, this mission brings essential supplies to the International Space Station using SpaceX's reusable Dragon spacecraft. It is the last scheduled flight of a Dragon 1 capsule. (CRS-21 and up under the new Commercial Resupply Services 2 contract will use Dragon 2.) The external payload for this mission is the Bartolomeo ISS external payload hosting platform. Falcon 9 and Dragon will launch from SLC-40, Cape Canaveral Air Force Station and the booster will land at LZ-1.

The mission will be complete with return and recovery of the Dragon capsule and down cargo.", "crew": [], "ships": [], "capsules": ["5e9e2c5cf359185d753b266f"], "payloads": ["5eb0e4d0b6c3bb0006eeb253"], "launchpad": "5e9e4501f509094ba4566f84", "flight\_number": 91, "name": "CRS-20", "date\_utc": "2020-03-07T04:50:31.000Z", "date\_unix": 1583556631, "date\_local": "2020-03-06T23:50:31-05:00", "date\_precision": "hour", "upcoming": false, "cores": [{"core": "5e9e28a7f359187afd3b2662", "flight": 2, "gridfins": true

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ites are expected to utilize thei
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major milestone for certification of Crew Dragon. Initially the mission duration was planned to be no longer than two weeks, however NASA has been considering an extension to as much as six weeks or three months. The astronauts have been undergoing additional training for the possible longer mission."

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k launch overall. The satellites
will be delivered to low Earth o
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orbit and will spend a few weeks  
maneuvering to their operational  
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The satellites will be delivered to low Earth orbit and will spend a few weeks maneuvering to their



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Didymos, 780 meters in diameter, and its moonlet Dimorphos, 160 meters. The DART spacecraft will intercept the double asteroid, using autonomous guidance to crash into the smaller one. Moving at about 6 km/s, the transferred momentum should alter Dimorphos's 12 hour orbital period around its companion by several minutes. The mission tests several technologies, including the Small-body Maneuvering Autonomous Real-Time Navigation (SMART Nav) used to differentiate and steer toward the target body and Roll-Out Solar Arrays (ROSA) with Transformational Solar Array concentrators. NASA's Evolutionary Xenon Thruster Commercial (NEXT-C) ion engine will also be demonstrated, although the spacecraft's primary propulsion is hydrazine thrusters. DART should arrive at Didymos in late September 2022, when it is about 11 million kilometers from Earth. Ten days before impact, the Italian Space Agency's cubesat LICIACube will be deployed to observe the

collision and ejecta with its two cameras. Earth-based telescopes will be used to measure the altered orbit.", "crew": [], "ships": ["5ea6ed30080df4000697c913", "5ea6ed2f080df4000697c90b", "5ea6ed30080df4000697c912"], "capsules": [], "payloads": ["5fe3c4a6b3467846b3242192"], "launchpad": "5e9e4502f509092b78566f87", "flight\_number": 138, "name": "DART", "date\_utc": "2021-11-24T06:20:00.000Z", "date\_unix": 1637734800, "date\_local": "2021-11-23T22:20:00-08:00", "date\_precision": "hour", "upcoming": false, "cores": [{"core": "5f57c54a0622a633027900a1", "flight": 2, "gridfins": true, "legs": true, "reused": true, "landing\_attempt": true, "landing\_success": true, "landing\_type": "ASDS", "launchpad": "5e9e3032383ecb6bb234e7ca"}], "auto\_update": true, "tbd": false, "launch\_library\_id": "c4b2f90e-3385-4cbe-a89f-fc5f57da1bfb", "id": "5fe3b107b3467846b324216b"}, {"fairings": {"reused": null, "recovery\_attempt": true, "recovered": null, "ships": ["618fad7e563d69573ed8caa9"]}, "links": {"patch": {"small": "https://imgur.com/BrW201S.pn

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```

B will provide TV broadcasting and data communication services over a wide coverage area that reaches the entire Middle East, the Persian Gulf, the Red Sea, the Mediterranean, North Africa, East Africa, South Africa and Nigeria. Apart from that, the satellite will also provide customized services for airlines and commercial ship operators around the world thanks to the fact that it operates in Ka-Band.

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essential supplies to the International Space Station using the cargo variant of SpaceX's Dragon 2 spacecraft. Cargo includes several science experiments. The booster for this mission is expected to land on an ASDS. The mission will be complete with return and recovery of the Dragon capsule and down cargo.", "crew": [], "ships": ["5ea6ed2f080df4000697c910", "614251b711a64135defb3654"], "capsules": ["60b803421f83cc1e59f1644d"], "payloads": ["6161d22a6db1a92bfba85357"], "launchpad": "5e9e4502f509094188566f88", "flight\_number": 143, "name": "CRS-24", "date\_utc": "2021-12-21T10:06:00.000Z", "date\_unix": 1640081160, "date\_local": "2021-12-21T05:06:00-05:00", "date\_precision": "hour", "upcoming": false, "cores": [{"core": "61c1ef45a4a2462678cbf45d", "flight": 1, "gridfins": true, "legs": true, "reused": false, "landing\_attempt": true, "landing\_success": true, "landing\_type": "ASDS", "landpad": "5e9e3033383ecbb9e534e7cc"}], "auto\_update": true, "tbd": false, "launch\_library\_id": "878ba32c-5e93-4d2b-95c3-24b60c8b05e



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ores": [{"core": "5f57c5440622a633027900a0", "flight": 6, "gridfins": true, "legs": true, "reused": true, "landing_attempt": true, "landing_success": true, "landing_type": "ASDS", "landpad": "5e9e3033383ecbb9e534e7cc"}], "auto_update": true, "tbd": false, "launch_library_id": "b79a9332-4c0c-42a2-a59b-aafcd5d4721d", "id": "62582a6f5988f159024b964b"}, {"fairings": {"reused": null, "recovery_attempt": null, "recovered": null, "ships": []}, "links": {"patch": {"small": "https://imgur.com/BrW201S.png", "large": "https://imgur.com/573IfGk.png"}, "reddit": {"campaign": "https://www.reddit.com/r/spacex/comments/jhu37i/starlink_general_discussion_and_deployment_thread/", "launch": "https://www.reddit.com/r/spacex/comments/uj5ina/rspacex_starlink_417_launch_discussion_and/", "media": null, "recovery": "https://www.reddit.com/r/spacex/comments/k2ts1q/rspacex_fleet_updates_discussion_thread/"}, "flickr": {"small": [], "original": []}, "presskit": null, "webcast": "https://youtu.be/KzpVUXxdc68", "youtube_id": "KzpVUXxdc68", "article": n
```



```
ull,"wikipedia":null},"static_fire_date_utc":null,"static_fire_date_unix":null,"net":false,"window":null,"rocket":"5e9d0d95eda69973a809d1ec","success":true,"failures":[],"details":null,"crew":[],"ships":[],"capsules":[],"payloads":["62582aad5988f159024b964e"],"launchpad":"5e9e4502f509094188566f88","flight_number":161,"name":"Starlink 4-17 (v1.5)","date_utc":"2022-05-06T09:42:00.000Z","date_unix":1651830120,"date_local":"2022-05-06T05:42:00-04:00","date_precision":"hour","upcoming":false,"cores":[{"core":"5e9e28a7f3591817f23b2663","flight":12,"gridfins":true,"legs":true,"reused":true,"landing_attempt":true,"landing_success":true,"landing_type":"ASDS","landpad":"5e9e3033383ecb075134e7cd"}],"auto_update":true,"tbd":false,"launch_library_id":"4f25c927-6a49-4472-814f-4f1a20d93604","id":"62582a855988f159024b964c"},{"fairings":{"reused":null,"recovery_attempt":null,"recovered":null,"ships":[]},"links":{"patch":{"small":"https://imgur.com/BrW201S.png","large":"h
```

```
https://imgur.com/573IfGk.png"}, "reddit": {"campaign": "https://www.reddit.com/r/spacex/comments/jhu37i/starlink_general_discussion_and_deployment_thread/", "launch": null, "media": null, "recovery": "https://www.reddit.com/r/spacex/comments/k2ts1q/rspacex_fleet_updates_discussion_thread/"}, "flickr": {"small": [], "original": []}, "presskit": null, "webcast": "https://youtu.be/bG6AwvGPd-E", "youtube_id": "bG6AwvGPd-E", "article": null, "wikipedia": null}, "static_fire_date_utc": null, "static_fire_date_unix": null, "net": false, "window": null, "rocket": "5e9d0d95eda69973a809d1ec", "success": true, "failures": [], "details": null, "crew": [], "ships": [], "capsules": [], "payloads": ["625829d75988f159024b9649"], "launchpad": "5e9e4502f509092b78566f87", "flight_number": 162, "name": "Starlink 4-13 (v1.5)", "date_utc": "2022-05-13T22:07:00.000Z", "date_unix": 1652479620, "date_local": "2022-05-13T15:07:00-07:00", "date_precision": "hour", "upcoming": false, "cores": [{"core": "5f57c54a0622a633027900a1", "flight": 5, "gridfins": true, "legs": t
```

```
rue,"reused":true,"landing_attempt":true,"landing_success":true,"landing_type":"ASDS","landpad":"5e9e3032383ecb6bb234e7ca"}], "auto_update":true,"tbd":false,"launch_library_id":"0bc91464-1d61-4545-95c8-01040dc5eec9","id":"6258290d5988f159024b9644"}, {"fairings":{"reused":null,"recovery_attempt":null,"recovered":null,"ships":[]},"links":{"patch":{"small":"https://imgur.com/BrW201S.png","large":"https://imgur.com/573IfGk.png"},"reddit":{"campaign":"https://www.reddit.com/r/spacex/comments/jhu37i/starlink_general_discussion_and_deployment_thread/","launch":"https://www.reddit.com/r/spacex/comments/upk6t3/rspacex_starlink_415_launch_discussion_and/"},"media":null,"recovery":"https://www.reddit.com/r/spacex/comments/k2ts1q/rspacex_fleet_updates_discussion_thread/"},"flickr":{"small":[],"original":[]},"presskit":null,"webcast":"https://youtu.be/nFDkWL2Hmh8","youtube_id":"nFDkWL2Hmh8","article":null,"wikipedia":null},"static_fire_date_utc":null,"static_fire_date_unix":null,"net":false
```

```
e,"window":null,"rocket":"5e9d0d95eda69973a809d1ec","success":true,"failures":[],"details":null,"crew":[],"ships":[],"capsules":[],"payloads":["625829cf5988f159024b9648"],"launchpad":"5e9e4501f509094ba4566f84","flight_number":163,"name":"Starlink 4-15 (v1.5)","date_utc":"2022-05-14T20:40:00.000Z","date_unix":1652560800,"date_local":"2022-05-14T16:40:00-04:00","date_precision":"hour","upcoming":false,"cores":[{"core":"627843db57b51b752c5c5a54","flight":1,"gridfins":true,"legs":true,"reused":false,"landing_attempt":true,"landing_success":true,"landing_type":"ASDS","landpad":"5e9e3033383ecbb9e534e7cc"}],"auto_update":true,"tbd":false,"launch_library_id":"b418d984-a9d1-4fa3-953d-c684a079714c","id":"625828f25988f159024b9643"},{"fairings":{"reused":null,"recovery_attempt":null,"recovered":null,"ships":[]},"links":{"patch":{"small":"https://imgur.com/BrW201S.png","large":"https://imgur.com/573IfGk.png"},"reddit":{"campaign":"https://www.reddit.com/r/spa
```

```
cex/comments/jhu37i/starlink_general_discussion_and_deployment_thread/", "launch": "https://www.reddit.com/r/spacex/comments/urv8l4/rspacex_starlink_418_launch_discussion_and/", "media": null, "recovery": "https://www.reddit.com/r/spacex/comments/k2ts1q/rspacex_fleet_updates_discussion_thread/"}}, "flickr": {"small": [], "original": []}, "presskit": null, "webcast": "https://youtu.be/dQTgX40R-IQ", "youtube_id": "dQTgX40R-IQ", "article": null, "wikipedia": null}, "static_fire_date_utc": null, "static_fire_date_unix": null, "net": false, "window": null, "rocket": "5e9d0d95eda69973a809d1ec", "success": true, "failures": [], "details": null, "crew": [], "ships": [], "capsules": [], "payloads": ["62615ee40ec008379be596fd"], "launchpad": "5e9e4502f509094188566f88", "flight_number": 164, "name": "Starlink 4-18 (v1.5)", "date_utc": "2022-05-18T10:40:00.000Z", "date_unix": 1652870400, "date_local": "2022-05-18T06:40:00-04:00", "date_precision": "hour", "upcoming": false, "cores": [{"core": "5e9e28a6f359183c413b265d", "flight":
```

```
5, "gridfins": true, "legs": true, "re  
used": true, "landing_attempt": tru  
e, "landing_success": true, "landing  
_type": "ASDS", "landpad": "5e9e3033  
383ecb075134e7cd"}], "auto_updat  
e": true, "tbd": false, "launch_libra  
ry_id": "27795b91-eb0e-43f1-898b-a  
23d9ff332db", "id": "62615ebc0ec008  
379be596fa"}]'
```

You should see the response contains massive information about SpaceX launches. Next, let's try to discover some more relevant information for this project.

## Task 1: Request and parse the SpaceX launch data using the GET request

To make the requested JSON results more consistent, we will use the following static response object for this project:

```
In [17]: static_json_url='https://cf-courses
```

We should see that the request was successful with the 200 status response code

```
In [18]: response.status_code
```

```
Out[18]: 200
```

Now we decode the response content as a Json using `.json()` and turn it into a Pandas dataframe using `.json_normalize()`

```
In [36]: # Use json_normalize method to convert response to dataframe
# data = response.json()
# pd.json_normalize(data)
data = pd.json_normalize(response.json())
```

Using the dataframe `data` print the first 5 rows

```
In [37]: # Get the head of the dataframe  
data.head()
```



Out[37]:

	static_fire_date_utc	static_fire_date_un
--	----------------------	---------------------

---

0	2006-03-17T00:00:00.000Z	1.142554e+0
---	--------------------------	-------------

1	None	Na
---	------	----

$N\epsilon$

static\_fire\_date\_utc    static\_fire\_date\_un

3	2008-09-20T00:00:00.000Z	1.221869e+0
---	--------------------------	-------------

4                            None                            Na

You will notice that a lot of the data are IDs. For example the rocket column has no information about the rocket just an identification number.

We will now use the API again to get information about the launches using the IDs given for each launch. Specifically we will be using columns `rocket`, `payloads`, `launchpad`, and `cores`.

```
In [38]: # Lets take a subset of our datafr  
data = data[['rocket', 'payloads',  
  
# We will remove rows with multipl  
data = data[data['cores'].map(len)  
data = data[data['payloads'].map(  
  
# Since payloads and cores are lis  
data['cores'] = data['cores'].map(  
data['payloads'] = data['payloads']
```

```
# We also want to convert the date  
data['date'] = pd.to_datetime(data  
  
# Using the date we will restrict  
data = data[data['date'] <= dateti
```

- From the `rocket` we would like to learn the booster name
- From the `payload` we would like to learn the mass of the payload and the orbit that it is going to
- From the `launchpad` we would like to know the name of the launch site being used, the longitude, and the latitude.
- From `cores` we would like to learn the outcome of the landing, the type of the landing, number of flights with

that core, whether gridfins were used, whether the core is reused, whether legs were used, the landing pad used, the block of the core which is a number used to separate version of cores, the number of times this specific core has been reused, and the serial of the core.

The data from these requests will be stored in lists and will be used to create a new dataframe.

```
In [39]: #Global variables  
BoosterVersion = []  
PayloadMass = []  
Orbit = []  
LaunchSite = []  
Outcome = []  
Flights = []  
GridFins = []  
Reused = []
```

```
Legs = []  
LandingPad = []  
Block = []  
ReusedCount = []  
Serial = []  
Longitude = []  
Latitude = []
```

These functions will apply the outputs globally to the above variables. Let's take a look at `BoosterVersion` variable. Before we apply `getBoosterVersion` the list is empty:

```
In [40]: BoosterVersion
```

```
Out[40]: []
```

Now, let's apply `getBoosterVersion` function method to get the booster version

```
In [41]: # Call getBoosterVersion  
getBoosterVersion(data)
```

the list has now been update

```
In [42]: BoosterVersion[0:5]
```

```
Out[42]: ['Falcon 1', 'Falcon 1', 'Falcon 1', 'Falcon 1', 'Falcon 9']
```

we can apply the rest of the functions here:

```
In [43]: # Call getLaunchSite  
getLaunchSite(data)
```

```
In [44]: # Call getPayloadData  
getPayloadData(data)
```

```
In [45]: # Call getCoreData  
getCoreData(data)
```

Finally lets construct our dataset using the data we have obtained. We we combine the columns into a dictionary.

```
In [53]: launch_dict = {
```



```
'FlightNumber': list(data['flight_
'Date': list(data['date']),
'BoosterVersion':BoosterVersion,
'PayloadMass':PayloadMass,
'Orbit':Orbit,
'LaunchSite':LaunchSite,
'Outcome':Outcome,
'Flights':Flights,
'GridFins':GridFins,
'Reused':Reused,
'Legs':Legs,
'LandingPad':LandingPad,
'Block':Block,
'ReusedCount':ReusedCount,
'Serial':Serial,
'Longitude': Longitude,
'Latitude': Latitude}
```

Then, we need to create a Pandas data frame from the dictionary launch\_dict.

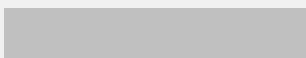
```
In [54]: # Create a data from launch_dict
df = pd.DataFrame.from_dict(launch
```

Show the summary of the dataframe

```
In [55]: # Show the head of the dataframe  
df.head()
```

```
Out[55]:
```

	FlightNumber	Date	BoosterVersion
0	1	2006-03-24	Falcon 1
1	2	2007-03-21	Falcon 1
2	4	2008-09-28	Falcon 1
3	5	2009-07-13	Falcon 1
4	6	2010-06-04	Falcon 9



## Task 2: Filter the dataframe to only include Falcon 9 launches

Finally we will remove the Falcon 1

launches keeping only the Falcon 9 launches. Filter the data dataframe using the `BoosterVersion` column to only keep the Falcon 9 launches. Save the filtered data to a new dataframe called `data_falcon9`.

```
In [56]: # Hint data['BoosterVersion']!= 'Falcon 9'
data_falcon9 = df[df['BoosterVersion'] != 'Falcon 9']
```

Now that we have removed some values we should reset the `FlightNumber` column

```
In [ ]: data_falcon9.loc[:, 'FlightNumber'] = 1
data_falcon9
```

## Data Wrangling

We can see below that some of the rows are missing values in our

dataset.

```
In [57]: data_falcon9.isnull().sum()
```

```
Out[57]: FlightNumber      0
Date                    0
BoosterVersion          0
PayloadMass             5
Orbit                   0
LaunchSite              0
Outcome                 0
Flights                 0
GridFins                0
Reused                  0
Legs                    0
LandingPad             26
Block                   0
ReusedCount             0
Serial                  0
Longitude               0
Latitude                0
dtype: int64
```

Before we can continue we must deal with these missing values. The `LandingPad` column will retain

None values to represent when landing pads were not used.

## Task 3: Dealing with Missing Values

Calculate below the mean for the `PayloadMass` using the `.mean()`. Then use the mean and the `.replace()` function to replace `np.nan` values in the data with the mean you calculated.

```
In [59]: # Calculate the mean value of PayloadMass
payloadmassavg = data_falcon9['PayloadMass'].mean()
# Replace the np.nan values with the calculated mean
data_falcon9['PayloadMass'].replace(np.nan, payloadmassavg, inplace=True)
# Replace the np.nan values with the calculated mean
```

```
/home/jupyterlab/conda/envs/python/lib/python3.7/site-packages/pandas/core/generic.py:6619: SettingWithCopyWarning:
```

A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: [https://pandas.pydata.org/pandas-docs/stable/user\\_guide/indexing.html#returning-a-view-versus-a-copy](https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy)

```
    return self._update_inplace(result)
```

You should see the number of missing values of the

`PayloadMass` change to zero.

Now we should have no missing values in our dataset except for in `LandingPad`.

We can now export it to a **CSV** for the next section, but to make the answers consistent, in the next lab

we will provide data in a pre-selected date range.

```
data_falcon9.to_csv('dataset_pa  
index=False)
```

In [60]: `data_falcon9.isnull().sum()`

Out[60]:

FlightNumber	0
Date	0
BoosterVersion	0
PayloadMass	0
Orbit	0
LaunchSite	0
Outcome	0
Flights	0
GridFins	0
Reused	0
Legs	0
LandingPad	26
Block	0
ReusedCount	0
Serial	0
Longitude	0
Latitude	0
dtype:	int64

# Authors


[Joseph Santarcangelo](#) has a PhD in Electrical Engineering, his research focused on using machine learning, signal processing, and computer vision to determine how videos impact human cognition. Joseph has been working for IBM since he completed his PhD.

## Change Log

Date (YYYY-MM-DD)	Version	Changed By	Change Description
2020-09-20	1.1	Joseph	get result each time you run



Date (YYYY-MM-DD)	Version	Changed By	Change Description
2020-09-20	1.1	Azim	Created Part 1 Lab using SpaceX API
2020-09-20	1.0	Joseph	Modified Multiple Areas



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