# Comparison of Prominent Launch Providers in the 2010s

COSC3000 Visualisation Project

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# 1 Introduction

The United States, being the most diverse space-hub in the world and one of the largest and most consistent in terms of orbital rocket launches [2], is a topic of keen interest in the space flight enthusiast community and companies alike. In the 2010s, there was a boom in the commercial rocket launch market, likely as a result of the decommission of the US Space Shuttle Program in 2011. With the United States left without a dedicated, NASA-based launch system, the government turned to commercial programs to launch satellites and humans alike. Most notable of these commercial launch providers were SpaceX, United Launch Alliance (ULA), and RocketLab.

Often better thought of as government contractors, commercial launch providers compete for government funding and launch opportunities based on payload capability, orbit destination and cost per mass to orbit. As a result, the provider which offers the most reliable, cost effective and versatile launch systems typically wins contracts from agencies and organisations wanting to send their satellite to space (typically these customers are military, government-science [ESA, NASA, NOAA, etc], private science [universities, research/RND organisations, etc], or telecommunications companies).

Due to the laws of orbital mechanics, the payload capability versus orbital height follows an inverse exponential trend, with the maximum payload mass to a higher orbit being far lower than that of a lower orbit. As a result, launching some constant mass to a higher orbit requires an exponentially larger launch system. This capability is famously offered by SpaceX's Falcon Heavy and ULA's Delta IV Heavy rockets. Medium launch capability is dominated by the SpaceX Falcon 9 rocket and ULA's Delta and Atlas rocket families, which low mass payload capability is a specialty of RocketLab, with their entire business philosophy currently centering on inexpensive, low-mass payload launches. This suits military and science payloads in particular, as these might include highly sensitive or classified payloads which may not be launched as a rideshare effort (launches of multiple payloads on the same rocket). This is reflected in the RocketLab Electron rocket's relatively low price point of approx. USD 8 million per launch, in contrast with heavier rockets such as the approx USD 62 million Falcon 9, and the USD 109 million Atlas V.

Notable initialisms used in this report were ULA (United Launch Alliance), RL (Rocket Lab), LEO (Low Earth Orbit), GTO (Geostationary Transfer Orbit), ISS (International Space Station).

# 2 Aims

The goal of this project was to analyse, visualise, and to some extent quantify the effect of new commercial launch providers and their impact on the U.S. launch market. This was interpreted via the comparison of key launch parameters, such as price per unit mass to orbit (units of USD/kg) segregated by orbit destination (LEO vs GTO), launches per year (to compare the share of the market), and the total launches per provider as a proportion of total launches across all providers. Through these visualisations, a clear trend was expected, showing the changing market as newer launch providers imbued competition to a stagnant market.

# 3 Methodology

## 3.1 Data Collection and Formatting

The majority of the data was sourced from Wikipedia pages related to the launches of each launch provider in the 2010s. Understandably this was not the ideal source of data, however the vast majority of entries had reputable sources, so for ease of data sourcing Wikipedia was deemed a suitable aggregate. The below picture shows an example of the typical table of which the data was sourced.

**2015** [ edit ]

With 7 launches in 2015, Falcon 9 was the second most launched American rocket behind Atlas V.[66]

| [hide] Flight No. | Date and time (UTC) | Version, Booster[b] | Launch site | Payload | Payload mass | Orbit | Customer | Launch outcome | Booster landing |
|---|---|---|---|---|---|---|---|---|---|
| 14 | 10 January 2015, 09:47[67] | F9 v1.1 B1012[8] | Cape Canaveral, LC-40 | SpaceX CRS-5[68] (Dragon C107) | 2,395 kg (5,280 lb)[69] | LEO (ISS) | NASA (CRS) | Success[70] | Failure (drone ship) |
| | Following second-stage separation, SpaceX attempted to return the first stage for the first time to a 90 m × 50 m (300 ft × 160 ft) floating platform — called the autonomous spaceport drone ship. The test achieved many objectives and returned a large amount of data, but the grid-fin control surfaces used for the first time for more precise reentry positioning ran out of hydraulic fluid for its control system a minute before landing, resulting in a landing crash.[71] | | | | | | | | |
| 15 | 11 February 2015, 23:03[72] | F9 v1.1 B1013[8] | Cape Canaveral, LC-40 | DSCOVR[68][73] | 570 kg (1,260 lb) | HEO (Sun–Earth $L_1$ insertion) | USAF NASA NOAA | Success | Controlled (ocean)[c] |
| | First launch under USAF's OSP 3 launch contract.[74] First SpaceX launch to put a satellite beyond a geostationary transfer orbit, first SpaceX launch into interplanetary space, and first SpaceX launch of an American research satellite. The first stage made a test flight descent to an over-ocean landing within 10 m (33 ft) of its intended target.[75] | | | | | | | | |
| 16 | 2 March 2015, 03:50[21][76] | F9 v1.1 B1014[8] | Cape Canaveral, LC-40 | ABS-3A Eutelsat 115 West B[68] | 4,159 kg (9,169 lb) | GTO | ABS Eutelsat | Success | No attempt[77] |
| | The launch was Boeing's first conjoined launch of a lighter-weight dual-commsat stack that was specifically designed to take advantage of the lower-cost SpaceX Falcon 9 launch vehicle.[78][79] Per satellite, launch costs were less than US$30 million.[80] The ABS satellite reached its final destination ahead of schedule and started operations on 10 September 2015.[81] | | | | | | | | |
| 17 | 14 April 2015, 20:10[21] | F9 v1.1 B1015[8] | Cape Canaveral, LC-40 | SpaceX CRS-6[68] (Dragon C108.1) | 1,898 kg (4,184 lb)[82] | LEO (ISS) | NASA (CRS) | Success | Failure[83] (drone ship) |
| | After second-stage separation, a controlled-descent test was attempted with the first stage. After the booster contacted the ship, it tipped over due to excess lateral velocity caused by a stuck throttle valve that delayed downthrottle at the correct time.[84][85] | | | | | | | | |
| 18 | 27 April 2015, 23:03[86] | F9 v1.1 B1016[8] | Cape Canaveral, LC-40 | TürkmenÄlem 52°E / MonacoSAT[68][87] | 4,707 kg (10,377 lb) | GTO | Turkmenistan National Space Agency[88] | Success | No attempt[89] |
| | Original intended launch was delayed over a month after an issue with the helium pressurisation system was identified on similar parts in the assembly plant.[90] Subsequent launch successfully positioned this first Turkmen satellite at 52.0° east. | | | | | | | | |
| 19 | 28 June 2015, 14:21[21][91] | F9 v1.1 B1018[8] | Cape Canaveral, LC-40 | SpaceX CRS-7[68] (Dragon C109) | 1,952 kg (4,303 lb)[92] | LEO (ISS) | NASA (CRS) | Failure[93] (in flight) | Precluded[94] (drone ship) |
| | Launch performance was nominal until an overpressure incident in the second-stage LOX tank, leading to vehicle breakup at T+150 seconds. Dragon capsule survived the explosion but was lost upon splashdown as its software did not contain provisions for parachute deployment on launch vehicle failure.[95](more details below) The drone ship *Of Course I Still Love You* was towed out to sea to prepare for a landing test so this mission was its first operational assignment.[96] | | | | | | | | |
| 20 | 22 December 2015, 01:29[97] | F9 FT B1019.1[98] | Cape Canaveral, LC-40 | Orbcomm-OG2-2 (11 satellites)[22][97] | 2,034 kg (4,484 lb) | LEO | Orbcomm | Success | Success[99] (ground pad) |
| | Payload included eleven satellites weighing 172 kg (379 lb) each,[24] and a 142 kg (313 lb) mass simulator.[52] First launch of the upgraded v1.1 version, with a 30% power increase.[100] Orbcomm had originally agreed to be the third flight of the enhanced-thrust rocket,[101] but the change to the maiden flight position was announced in October 2015.[100] SpaceX received a permit from the FAA to land the booster on solid ground at Cape Canaveral[102] and succeeded for the first time.[99] This booster, serial number B1019, is now on permanent display outside SpaceX's headquarters in Hawthorne, California, at the intersection of Crenshaw Boulevard and Jack Northrop Avenue.[98] (more details below) | | | | | | | | |

As can be seen, there were numerous sources for the majority of data points. The full Wikipedia lists are available at [11] through to [16], each with their own corresponding sources.
The data was manually retrieved from these tabulated lists and was typed into a .xlsx spreadsheet. The data was input under 7 categories; "Flight number", "Date", "Provider", "Rocket", "Payload Mass (kg)", "Orbit", and "Price per Kg (USD/kg)", of which they were discrete, discrete, categorical, categorical, continuous, categorical, and continuous variables respectively. The prices for each rocket were taken as the lowest quoted value, and were as follows:

| Provider | Rocket | Price (Million USD) | Source |
|---|---|---|---|
| SpaceX | F9 v1.0 | 59.5 | [6] |
| | F9 v1.1 | 61.2 | [7] |
| | F9 FT | 62 | [8] |
| | F9 B4 | 62 | [8] |
| | F9 B5 | 62 | [8] |
| | Falcon Heavy | 90 | [8] |
| ULA | Delta IV Heavy | 350 | [1] |
| | Delta IV | 192.14 | [10] |
| | Delta II | 137.3 | [4] |
| | Atlas V | 109 | [9] |
| Rocket Lab | Electron | 7.5 | [3] |

Table 1: Cost Price vs Analysed Rocket Models

where the price per kilo value for each launch was calculated based on the tabulated rocket price, and the launched payload mass (Price / Mass). This meant that higher payload mass for the same rocket would result in a lower price per kg.

## 3.2 Data Analysis and Programming

Using Matlab's `readtable` function, the .xlsv data was imported and assigned as array variables corresponding to launch provider. From there, the bulk of the plots were generated primarily by indexing the aforementioned arrays. A notable exception of this was the programming for Figure 7. Matlab does not have a dedicated stacked density plot function, and so a proportion-normalised area plot needed to be used. The total number of launches per provider up to a certain date had to be divided by the total number of launches by all providers up to said date, and added to a new matrix sorted by ascending time. This data was then input to the area plot function to yield Figure 7. The code is available to view in Appendix 1.

Figure 5 was created by merging the code to Figures 1 and 2, where the colours were made more translucent and darker for the histogram and line plots respectively to enhance visibility.

# 4 Visualisations

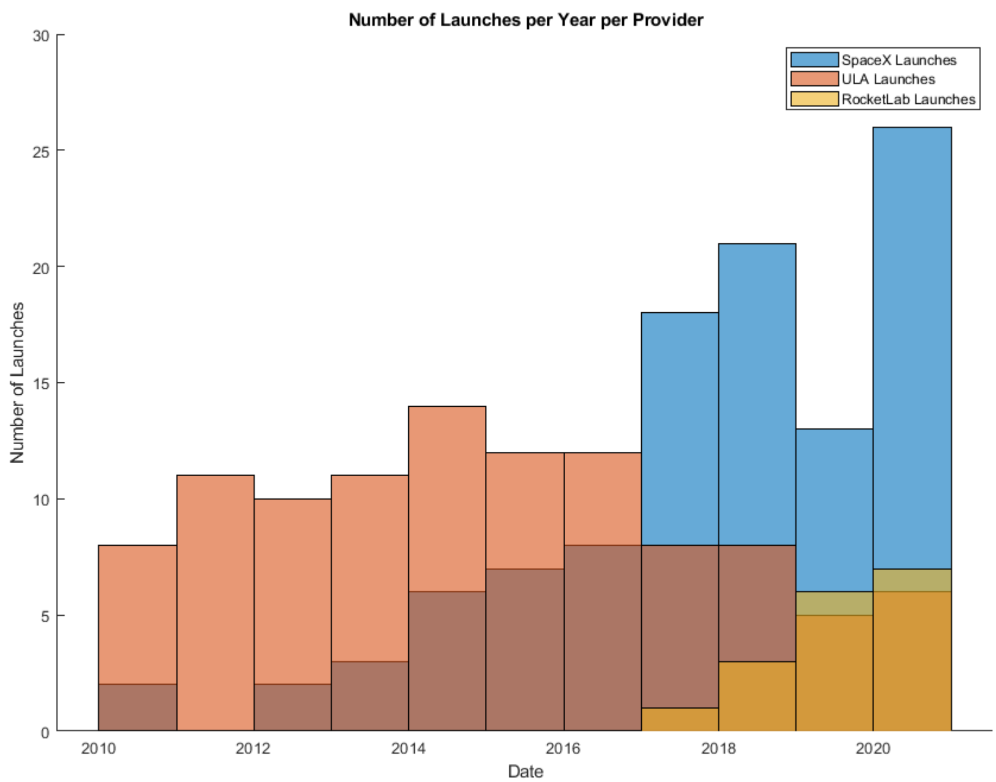


Figure 1: Number of Launches per Year by Provider

Total number of launchers each year, segregated by provider. Histogram bars were translucent, so the rise of SpaceX beginning in 2012, for example, was seen as a dark overlay onto ULA's larger bars - up until 2017 where SpaceX became the larger bar and ULA's value was the overlay. Also beginning 2017 was the presence of RocketLab in the launch market, where it is an overlay onto each of ULA and SpaceX's bars, until 2019 when it rose above ULA and ULA became an overlay onto RocketLab and SpaceX's bars.

Figure 1 shows the changing launch market in the 2010s by the number of rockets launched per year. At the beginning of the decade, there was a clear upwards launch trend for ULA due to their established presence pre-2010, where it had peaked in 2014 likely due to the increased market-share of SpaceX. Due to the low payload mass market of RocketLab, it was unclear whether they contributed to lowering ULA launches after 2017.

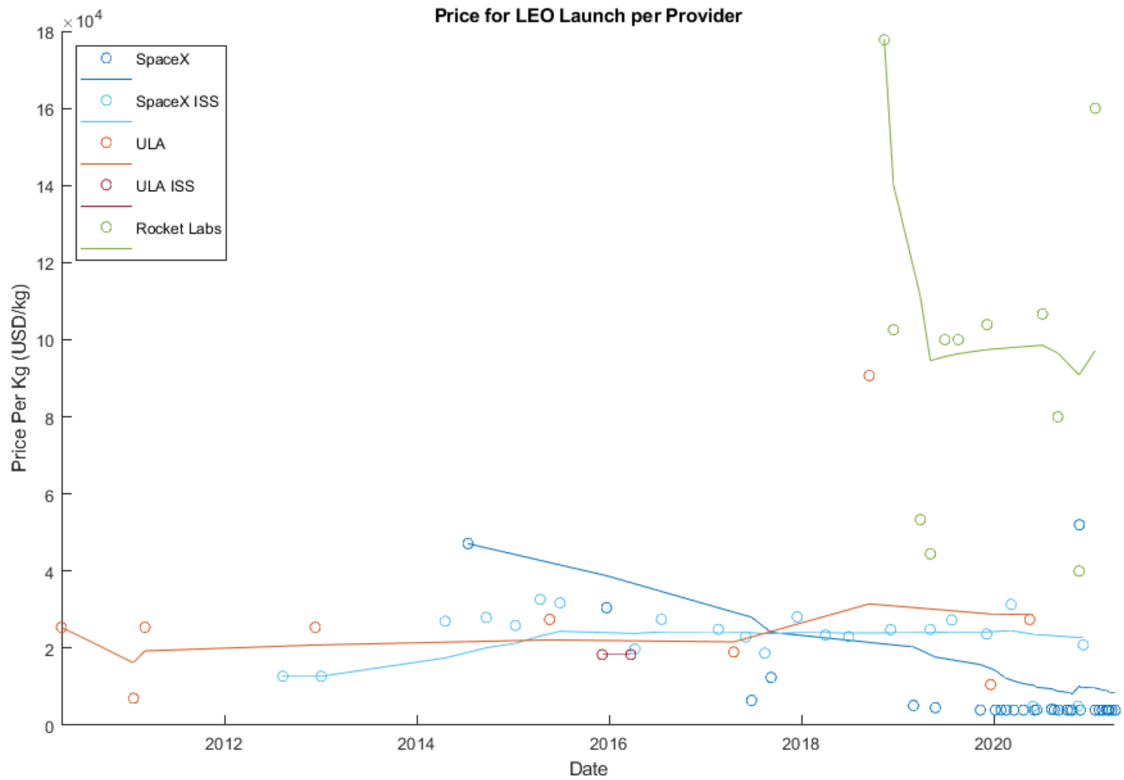


Figure 2: Price per Unit Mass to Low Earth Orbit by Provider

Price per Kilo values for each launch were calculated according to the formula in Section 3.1. Data was displayed only for launches to Low Earth Orbit, with SpaceX and ULA data partitioned if destination was specifically the International Space Station. The figure displays two types of data; a scatter plot for each provider's raw launch details, and a line plot for the rolling average of the Price per Kg for the respective category. Colours were chosen primarily for distinction between providers, where the ISS partition colours were chosen to be similar but distinct from the parent category. Some outliers were omitted from the figure (and rolling averages) due to both their infrequency and extremity. Outliers were likely present due to sensitive, lightweight payloads that could not be launched in a rideshare.

Figure 2 clearly shows an increasingly cost effective SpaceX as time goes on, where ULA appears more or less stagnant in price (although very consistent). Interesting to note that ULA only had launched 2 payloads to the ISS, despite being almost half of the price of many ISS payloads from SpaceX. Also worth noting was the price of RocketLab payloads being an order of magnitude higher than their competitors. This is due to the lightweight nature of their services, and being a more cost effective option for sensitive or classified payloads that cannot rideshare (8 million USD rocket for RL vs 62 million USD rocket for SpaceX, etc). The comparatively low sample-size of RocketLab launches heavily emphasises anomalous data, which were not omitted due to said sample-size.
Worth noting that the model of rocket per provider (Table 1) was originally to be plotted as a variable in Figure 2. After doing this, the data was extremely difficult to follow, and the data points were isolated such

that overall trends could not be readily inferred. This choice was then omitted from the plot.

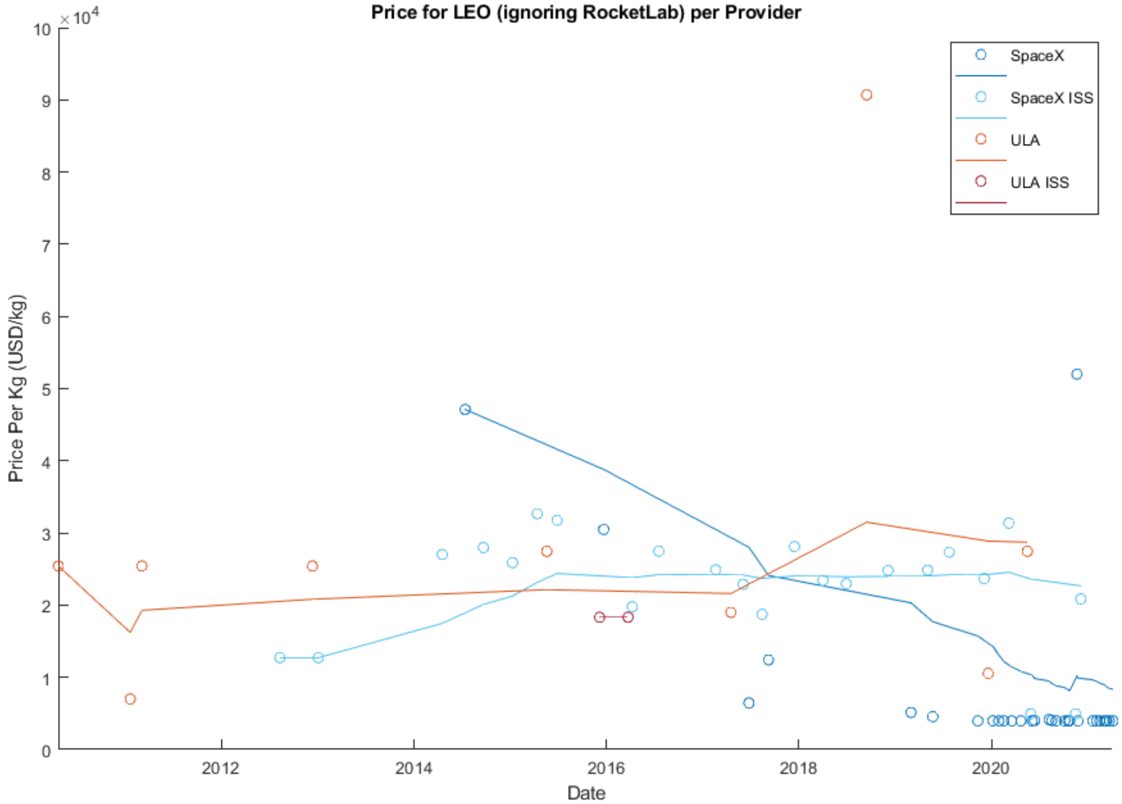


Figure 3: Price per Unit Mass to Low Earth Orbit by Provider (ignoring RocketLab)

Identical to Figure 2, bar the exclusion of RocketLab data. This was done to more effectively show the competition between SpaceX and ULA across a larger timescale than RocketLab was present. Due to the omission of RL data, the $y$-axis could be scaled to greater match the range of the data.

Figure 3 more clearly shows the cost-effectiveness of the launch providers over time. With the reduced scale, it's clear that, at least at the close of the decade, SpaceX offered the same service at as much as 1/3rd the price of ULA. This is in part due to a less expensive rocket (see Table 1) in conjunction with a more powerful rocket (22.8 Tonnes to LEO for SpaceX's F9 [8] vs 20.5 Tonnes for ULA's Atlas V [5]).

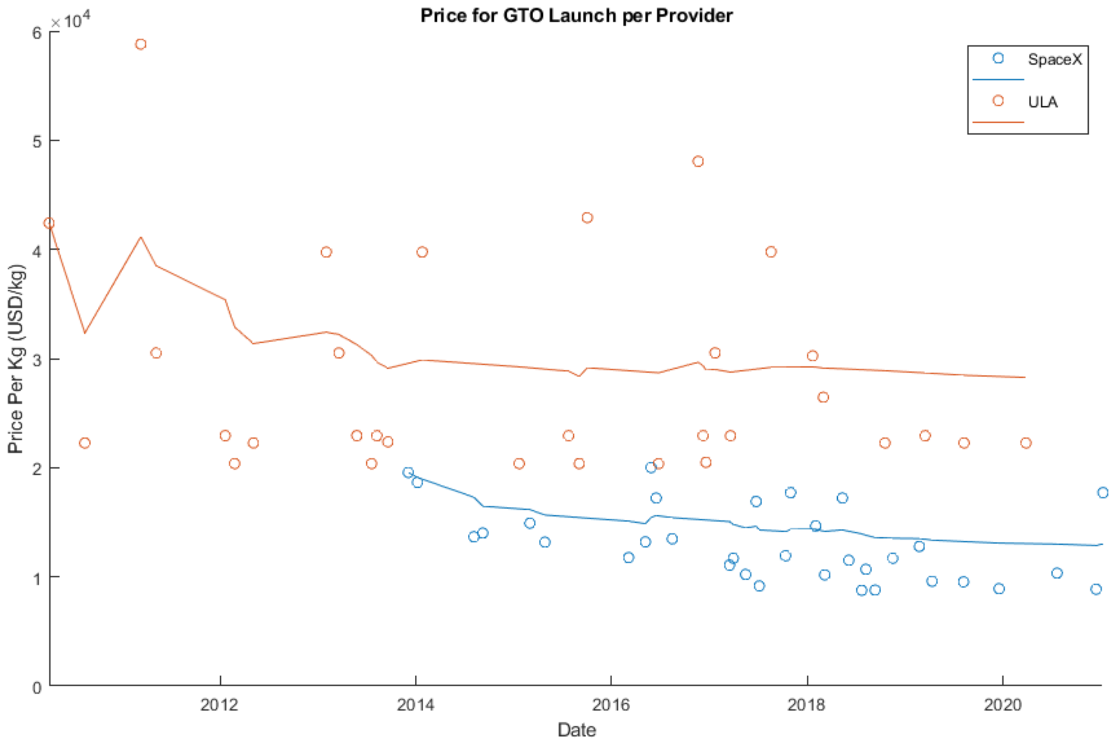


Figure 4: Price per Unit Mass to Geostationary Transfer Orbit by Provider

Price per Kilo values against time for solely ULA and SpaceX (RocketLab had no Geostationary Transfer Orbit launches in the 2010s). Figure details identical to that of Figures 2 and 3.

Figure 4 showed high variance in both ULA and SpaceX's prices for payloads to GTO. In any case, there was a clear steady downwards trend in price for each provider. That said, it was evident that SpaceX was consistently about half of the price per unit mass to launch a payload to geostationary transfer orbit.

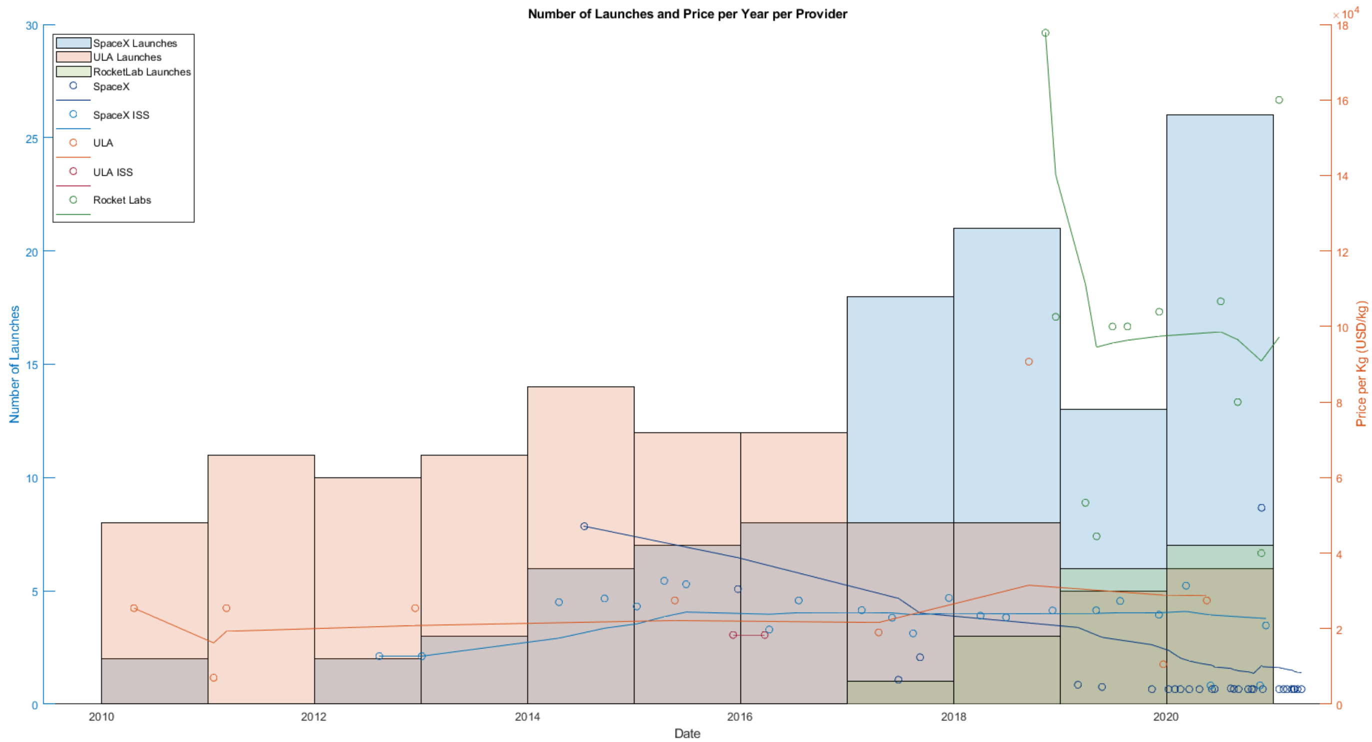


Figure 5: Relationship between LEO Price and Number of Launches

Figure 5 combines Figures 1 and 2, with the unitless $y$-axis for the histogram on the left, and the $y$-axis for the line/scatter plots (in units of USD/kg) on the right. Colours for the histogram bars were changed to more accurately reflect the line and scatter plots. The opacity of the bars was lowered to allow the lines to more easily be seen, and conversely the lines were darkened for the same effect.

Although convoluted, Figure 5 helped show the relationship between the offered price per kilo and the consequent market share between launch providers. This was clearly evident in the year 2017 especially, there SpaceX both launched more LEO-bound payloads than ULA and for less than ULA in the same year. In this way, it's suggested that, at least for SpaceX, number of launches and price per mass followed an inversely proportional relationship in the 2010's. Figure 5 was the culmination of the data analysis and visualisation, despite it sinking into complexity. As such, this particular visualisation would not be recommended to a general audience to show relationship between launch parameters, and instead only to an audience with appropriate background knowledge.

The code that produces Figure 5 (and hence Figures 1 and 2) is shown in Appendix 2.

Instead of showing total number of launches per year by launch provider, it could also be useful to visualise the proportion per provider of the total launches for the decade. As such, a pie chart was created to show this.

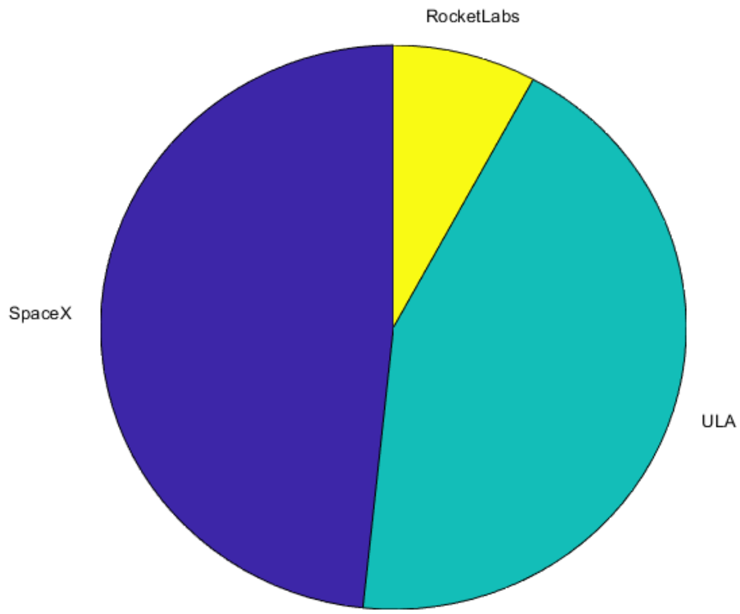


Figure 6: Launch Provider Proportion of Launches Between 2010-2020

The `pie` function in Matlab was extremely limited with simple parameters of the chart, such as sector colour, being tedious to customise. The exact values of the sectors could not easily be displayed in conjunction with the labels, and so it was decided to not pursue fixing the pie chart and instead opt for a different way of visualising proportion.

A stacked density plot (SDP) was subsequently chosen to display the proportion of launches for a number of reasons. Firstly, the SDP allowed for another dimension of data to be displayed; in this case, time. Due to this, relationships between providers were able to be inferred, and the change in market-share being able to be (somewhat) quantified. The plot in question was shown in Figure 7.

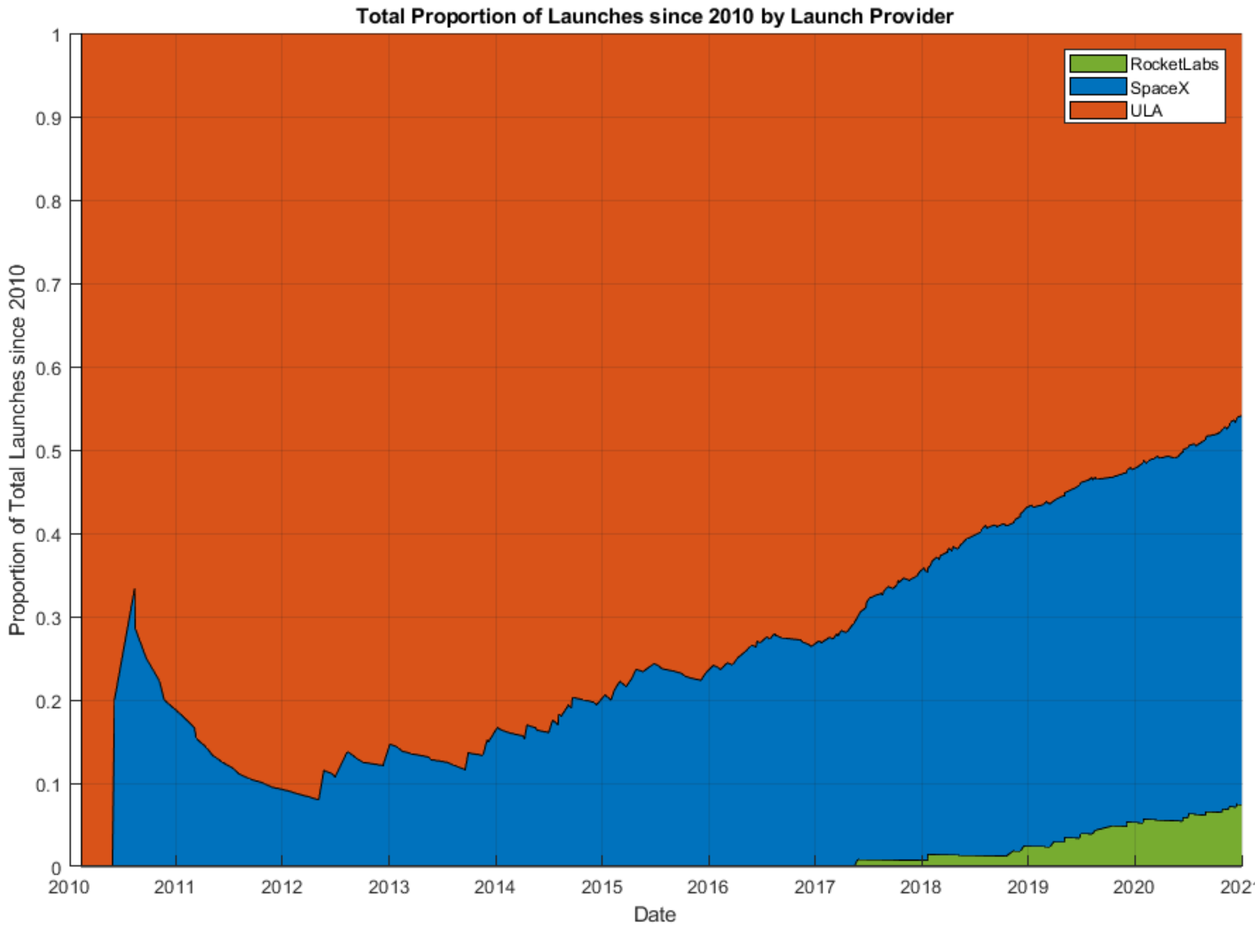


Figure 7: Total Proportion of Launches since 2010 by Launch Provider

Plot of effective cumulative market-share for each point in time since 2010, in the 2010s. Colours were chosen for consistency with previous figures, and opacity increased to 1. Proportions at each date took in to account all launches previous. Proportions between providers were updated for each new launch in the domain.

Although the code that produced Figure 7 was complex, the result was a simple to read and effective visualisation of the change of prominence in each launch provider. The added dimension of time (in comparison to Figure 6) conveyed far more data and allowed for more a more insightful visualisation; the relationship between each launch provider as a result was very easily seen - particularly the slow and steady rise of SpaceX and the comparatively quick advent of RocketLab's market share.

Worth noting was that the stacked density plot is essentially visualising the cumulative area of the bars of the histogram Figure 1, with each represented as a proportion instead of an absolute area.
The stacked density plot was originally plotted as a total number of launches (as the $y$-axis) vs date, however extremely large values towards the end of the decade made the values at the beginning hard to see. To rectify this, the $y$-axis was changed to represent the *proportion* of total launches vs date.

## 5 Discussion

The visualisations of the data set unquestionably show the relationship between price to orbit and consequent market share of US orbital launches. Figure 5 especially represents this, although convoluted in its representation. Easier to digest were Figures 1 and 2, which in cross reference to each other convey the same relationship as Figure 5. As such, the former figures were recommended to be shown as prerequisites to the latter Figure, as the brevity and self-completeness of Figure 5 could not be ignored. The histogram-line plot effectively showed the changing landscape of the US launch profile in direct relation to the price offered per provider - a metric which was not visualised with Figure 7.

Figure 7 excelled and was limited by its aims - to show the effective market share of the 2010s up to a date in that decade. The stacked density plot clearly showed the proportion of each provider as a function of time, although it failed in succinctly showing the shifting market due to the proportion of each provider being reliant on the total number of launches (from all providers) up to said date. That said, it was obvious that it more effectively conveyed the same (and more) data as Figure 6 - where the proportions at the end of Figure 7 were that shown in the aforementioned pie chart.

## 6 Conclusions

Through the visualisation of a constructed data set of number of launches and price per unit mass to orbit for 3 US rocket launch providers, a key relationship was found - although not quantified - between the two dependent variables. The market dominance of SpaceX was concluded to be the result of a constantly decreasing cost for payload mass to orbit, where ULA was found to have peaked in market share in 2015 (with a subsequent reduction thereafter) probably due to stagnant prices across the 2010 decade. Due to a niche market (lightweight payload launch to orbit) not quite capitalized on by SpaceX or ULA , RocketLab saw a steady rise from their first launch in 2017 to overtaking ULA in launches by 2021, the company that launched the most rockets in the 2010 decade.

Both SpaceX and RocketLab show no signs of slowing down in terms of annual launches, while ULA seemed to have passed its prime. Further analysis during (or after) the 2020-30 decade would help support these claims, and would be interesting to determine if SpaceX and RocketLab continue to grow and dominate the market.

# 7 Self-Evaluation

Due to a lack of data dimensions, the possible visualisations were limited in variety. That said, I believe that I used the available data reasonably effectively - particularly in Figure 5 which is arguably the most creative of the visualisations. Due to my programming skill, or lack thereof, I believe that the aforementioned Figure was not what it potentially could have been. I would have liked to have done adjoined stacked density plots based on each year, rather than the decade as a whole (think 10 stacked density plots segregated and plotted side by side by year). I believe this would have combined the best aspects of both the histogram and stacked density plot into a neat and visually impressive figure.
I had also expected to perform analysis based on the type of rocket being launched (see Table 1), but this data ended up only being used to calculated price per kilo for each individual launch.

As a whole, I feel as though the visualisations were rather simple in comparison with those in the sample visualisation projects, despite them conveying meaningful data and relationships between variables. The visualisations were limited by the range of data collection, and could have been improved by a broader categorical scope. I believe that the report, however, was formatted well and gave insightful comments and exposition of the visualisations, with details of how and why certain choices were made.

All in all, I believe that the report as a whole is deserving of a grade of 6 ($\approx$P+10), largely for the text and supporting descriptions, with the lack of visualisation aesthetic contributing negatively towards the grade.

# 8 Appendices

## Appendix 1: MATLAB Code for Figure 7

```
hold on
XT = []; UT = []; RT = [];
for i = 1:length(X.Date)
    XT(i, :) = [datenum(X.Date(i)), i, 1]; %assign date to ith row, then launch number, and 1 for
        spaceX
end
for i = 1:length(ULA.Date)
    UT(i, :) = [datenum(ULA.Date(i)), i, 2];%assign date to ith row, then launch number, and 2 for
        ULA
end
for i = 1:length(RL.Date)
    RT(i, :) = [datenum(RL.Date(i)), i, 3];%assign date to ith row, then launch number, and 3 for
        Rocket Lab
end
TotData = sortrows([XT; UT; RT], 1); %append all matrices together, then sort by ascending date
newData = zeros(size(TotData, 1), 4);
xtot = 0; utot = 0; rtot = 0; %variables for total launches thus far in loop, for SX, ULA, RL
    respectively
for i = 1:size(TotData, 1)
    if TotData(i, 3) == 1 %if spacex rocket, then
        xtot = TotData(i, 2); %number of spacex launches so far
    elseif TotData(i, 3) == 2 %if ula rocket, then
        utot = TotData(i, 2);
    else   %if rocketlab rocket, then
        rtot = TotData(i, 2);
    end
    xnorm = (xtot)/sum([xtot utot rtot]); %proportion of spacex rockets vs all rockets so far
    unorm = (utot)/sum([xtot utot rtot]);
    rnorm = (rtot)/sum([xtot utot rtot]);
    newData(i, :) = [TotData(i, 1), rnorm, xnorm, unorm]; %assign proportions of each provider to
        row of time i
end
area(newData(:, 1), newData(:, 2:end)) %plot time vs provider proportions
colororder([0.4660 0.6740 0.1880; 0 0.447 0.741; 0.8500 0.3250 0.0980])
axis([newData(1, 1) datenum('31-Dec-2020', 'dd-mmm-yyyy') 0 1]); %set axis as 1/1/2010 to
    31/12/2020
legend("RocketLabs", "SpaceX", "ULA")
ylabel('Proportion of Total Launches since 2010')
title('Total Proportion of Launches since 2010 by Launch Provider')
xlabel('Date')
datetick('x', 'yyyy') %make x axis datetime instead of days since 1/1/0000
grid ON
set(gca, 'layer', 'top');
```

## Appendix 2: MATLAB Code for Figure 5

```
figure
hold on
yyaxis left
%plot histograms of SpaceX, ULA and RocketLab respectively
histogram(X.Date, 'binmethod', 'year', 'BinLimits', [datetime(2010,1,1), datetime(2020,12,31)],
    'FaceAlpha', 0.2, 'FaceColor', [0 0.44 0.714])
histogram(ULA.Date, 'binmethod', 'year', 'BinLimits', [datetime(2010,1,1), datetime(2020,12,31)],
    'FaceAlpha', 0.2, 'FaceColor',[0.8500 0.3250 0.0980])
histogram(RL.Date, 'binmethod', 'year', 'BinLimits', [datetime(2010,1,1), datetime(2020,12,31)],
    'FaceAlpha', 0.2, 'FaceColor',[0.4660 0.6740 0.1880])
xlabel('Date')
ylabel('Number of Launches')
title('Number of Launches and Price per Year per Provider')
yyaxis right  %change y-axis
scatter(xleodate(xi), xleoprice(xi), [], [0 0.2 0.5]) %plot spacex leo raw data
plot(xleodate(xi), movmean(xleoprice(xi), [length(xleoprice(xi))-1 0]),'-', 'Color', [0 0.2 0.5])
    %plot SpaceX leo rolling average
scatter(xissdate(xxi), xissprice(xxi), [], [0 0.44 0.714]) %plot SpaceX ISS raw data
plot(xissdate(xxi), movmean(xissprice(xxi), [length(xleoprice(xxi))-1 0]), '-', 'Color', [0 0.44
    0.714])
scatter(uleodate(ui), uleoprice(ui), [], [0.8500 0.3250 0.0980]) %plot ULA leo raw data
plot(uleodate(ui), movmean(uleoprice(ui), [length(uleoprice(ui))-1 0]),'-', 'Color', [0.8500
    0.3250 0.0980]) %plot ULA leo rolling average
scatter(uissdate(uii), uissprice(uii), [], [0.6350 0.0780 0.1840]) %plot ULA ISS raw data
plot(uissdate(uii), movmean(uissprice(uii), [length(uissprice(uii))-1 0]),'-', 'Color', [0.6350
    0.0780 0.1840])
scatter(rlleodate(ri), rlleoprice(ri), [], [0.1660 0.5 0.1880]) %plot RocketLab LEO raw data
plot(rlleodate(ri), movmean(rlleoprice(ri), [length(rlleoprice(ri))-1 0]), '-', 'Color', [0.1660
    0.5 0.1880]) %plot Rocket Lab rolling average
ylabel('Price per Kg (USD/kg)')
legend("SpaceX Launches", "ULA Launches", "RocketLab Launches", "SpaceX", '', "SpaceX ISS", '',
    "ULA", '', "ULA ISS", '', "Rocket Labs", '', 'Location', 'northwest');
hold off
```

## References


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