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Crowdfunding For Space Missions

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Abstract

Crowdfunding (via websites such as kickstarter.com) has become an increasingly popular method for funding projects and start-up companies for a wide range of terrestrial products and services. A small, but not insignificant number of space projects have also used this method of fundraising, and there is potentially much greater scope for this type of funding. This paper presents an analysis of crowd-funding campaigns that have been used to fund space-related projects, and in particular, spaceflight missions. It assesses the relative success of these campaigns and proposes some insights as to what makes a successful space crowdfunding campaign.

Keywords: Crowdfunding, Space, Mission

Acronyms/Abbreviations

CAT	Cubesat Ambipolar Thruster
ISS	International Space Station
LEO	Low Earth Orbit

1. Introduction

'Crowdfunding' is a process by which the creator of a product or service can appeal directly to the public for cash funding. It is important to note that the contributors, or 'funders', are not actually investing in the company or the product, and cannot expect any 'return on investment'. However, the creator of the project or service will typically offer some form of 'reward' in return for funding – this may be something as simple as access to a newsletter, or a certificate of thanks, or in the case where the money is intended to fund the development of an actual product, the funder may be offered a first edition of the final product, or an advanced opportunity to purchase one.

Crowdfunding was initially developed in the arts and music communities, and was used to fund bands and amateur film projects. However, in the last ten years, a number of crowdfunding websites have started operating, and now cover a wide variety of arts, services, products and even technology development. Some of the largest and best known crowdfunding websites are: Gofundme, Kickstarter [1], Crowdfunder & IndieGoGo. The Oculus Rift Virtual Reality headset is a relatively well known example of an engineering product whose development was initially funded via an extremely successful Kickstarter campaign (generating almost $2.5 million in 2012) [2]. This example serves to illustrate the enormous potential of crowdfunding as an alternative to traditional start-up investment options.

In recent years, there have been a number of space technologies, and even complete space missions, which have attempted to use crowdfunding as either their principle source of funding, or as a stepping stone to further progress their project. Kickstarter appears to be the most popular platform for space mission funding, although there have also been a small number of space projects on IndieGoGo, Rockethub and Gofundme.

In this paper a summary of space mission crowdfunding campaigns is presented, an assessment is made of the typical level of funding which individuals contribute, and the potential for scale-up to future space projects is discussed.

2. Crowdfunding Process

The approach for advertising a project is fairly similar across all of the big crowdfunding platforms. A search function on the website's homepage allows to search for projects based on keywords. A list of results is presented, each showing a picture, the project title and a brief (one or two line) description of the project. Each project is then linked to a dedicated page, which shows the funding target, the 'rewards' available (an unlimited number of reward 'tiers' can usually be created corresponding to different levels of funding), and then a space is available for a video clip and a more detailed explanation of the project, it's aims & goals, and what the money is expected to be used for.

Typically, a funding target has to be specified, and money is only paid if the target is reached within a certain period of time. If the target is not reached, then none of the financial pledges are paid.

An example of a typical Kickstarter funding page is shown below in Figure 1. (from the SkyCube project):

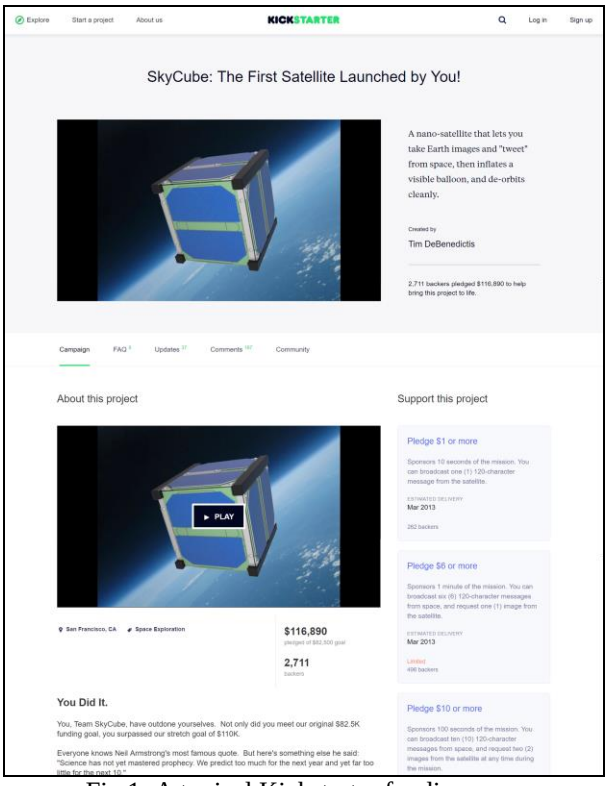

Fig 1. A typical Kickstarter funding page

3. Review of Space Mission Crowdfunding

A review of crowdfunded space missions across the major websites has been conducted, and a list of relevant projects identified is summarised in table 1 below.

Table 1. Summary of Crowdfunded Space Projects

Project	Funding Target	Funding Raised	Outcome	Number of Backers
SkyCube	$82,500	$116,890	Successful	2,711
KickSat	$30,000	$74,586	Successful	315
Lightsail	$200,000	$1,240,000	Successful	23,331
Arykd Space Telescope	$1,000,000	$1,505,366	Successful	17,614
ArduSat	$35,000	$106,330	Successful	676
Lunar Mission One	£600,000	£672,447	Successful	7,297
Pocket Spacecraft	£290,000	£69,079	Unsuccessful	414
Lunarsail	$11,000	$15,817	Successful	260
CAT Plasma Thruster	$200,000	$67,865	Unsuccessful	1,274
Moonspike	£600,000	£78,962	Unsuccessful	1,045

Each of these projects is assessed individually.

3.1 SkyCube

SkyCube was one of the first crowd-funded spacecraft. SkyCube was a nanosatellite (or cubesat) that was designed to take photos of the Earth and broadcast simple messages uploaded by funders. It was also intended to deploy an inflatable balloon after 90 days, partly to enable it to be seen from Earth, but also to ensure de-orbit.

13 different funding tiers were offered ranging from $1 to $10,000. The funding target was successfully achieved, raising over $100,000. The project team state that the final cost of the project was $273,000.

The satellite was successfully built and launched in January 2014, and deployed from the ISS in February.

The team initially struggled to make contact with the cubesat – partly due to uncertainty about which entry it was on Celestrak (several cubesats were released from the ISS simultaneously). However, they did eventually establish contact with the cubesat and confirmed that the processor had been running correctly since deployment. However it appeared that the solar panels did not deploy correctly, and this blocked deployment of the communications antenna and the balloon. The cubesat re-entered the atmosphere a few months later without further communication.

3.2 KickSat

The KickSat project called for a series of nano-spacecraft called SPRITEs, which were planned to be released from a cubesat and to transmit a few bits of data. Funders were able to purchase their own SPRITE and therefore claim to 'own' their own satellite:

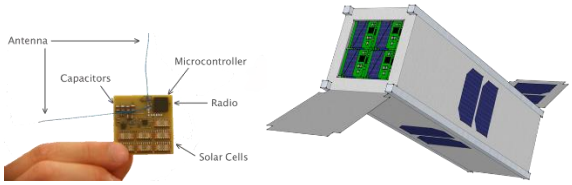

Fig. 2. Kicksat Overview (courtesy of Kickstarter)

6 different funding tiers were offered ranging from $25 to $10,000. The funding target was successfully achieved, raising $74,500.

The cubesat and SPRITEs were successfully built and launched on a Falcon 9 in April 2014. They were selected for a free launch under a NASA ELaNa program.

Communication was established with the cubesat, however the SPRITE deployment itself failed to occur. Suspected cause of failure was a reset of the main computer and associated countdown timer which would have pushed the automatic deployment beyond the time when the cubesat re-entered the atmosphere.

3.3 Lightsail

The Lightsail project is run by the Planetary Society in the US. Their Kickstarter project was intended to fund a cubesat with a test solar sail deployment system, as a demonstrator mission for a larger follow up mission.

43 different funding tiers were offered ranging from $1 to $10,000. The crowdfunding campaign was extremely successful, surpassing their initial target by a factor of more than six.

The test cubesat was successfully built and launched in May 2015, and operated successfully in orbit. The

project website states that the full project cost is $5.45 million, so it can be assumed that the crowdfunding campaign was not their only source of funding.

3.4 ARKYD Space Telescope

The ARKYD space telescope was one of a number of small spacecraft being developed by Planetary Resources. It was designed to test various technologies for their future spacecraft. In addition to its telescope function, the spacecraft was designed to take a 'selfie' of itself and a screen which could display a message from backers.

17 funding tiers were offered ranging from $10 to $10,000. The campaign was extremely successful, raising over $1.5 million (compared to an initial target of $1 million). However, in 2016, the project was cancelled. Planetary Resources was able to offer a full refund to all of its backers.

3.5 ArduSAT

ArduSAT was a 1U cubesat whose primary purpose was educational outreach. Schools and other education institutions were invited to create software code that would be uploaded and use the on-board suite of more than twenty-five sensors (including three cameras, a Geiger counter, spectrometer, magnetometer) to conduct experiments.

The satellite basic design had already been completed before the Kickstarter campaign and the project team (Nanosatisfi) had partnered with several other organisations to build and integrate the bus and various other payloads. The Kickstarter campaign was to fund the manufacture and assembly of the 1U cubesat. The initial plan was to apply for a free launch, however they stated that they also had funding in place from an another source to purchase a commercial launch if necessary, and it appears that this is what they eventually did.

In the end, they were able to build two 1U cubesats, both of which were successfully launched in 2013, and appear to have operated successfully in orbit.

15 funding tiers were offered ranging from $1 to $10,000. The campaign succeeded in raising over $100,000 (compared to the initial target of $35,000)

3.6 Lunar Mission One

Lunar Mission One was a project run by a British team planning to land a spacecraft at the lunar south pole. The project was several years in development before the Kickstarter campaign and was backed by a heavy promotional effort which featured a number of backers and 'celebrities' with a relatively high profile in the UK space industry. The project was also featured in a BBC article during the campaign. It was always clear that this fundraising was not intended to fund the full mission itself, but simply the next steps.

19 funding tiers were offered ranging from £15 to £5,000. The campaign succeeded in raising just over £672,000.

3.7 Pocket Spacecraft

The 'Pocket Spacecraft' project was run by a British team with the aim of sending a large number of nano-spacecraft to the moon. The nano-spacecraft design is a thin disc – slightly smaller than a CD:

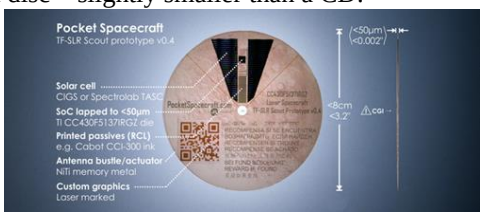

Fig 3. Pocket Spacecraft (courtesy of Kickstarter)

The 'discs' were planned to be loaded into a cubesat mothership which would deliver them to the moon. Relatively few specific technical details were provided (considering the technical difficulty of the proposal)

21 funding tiers were offered, ranging from £1 to £5,000. The funding campaign was not successful.

3.8 Lunarsail

The Lunarsail project planned to build and launch a cubesat with a solar sail which would be capable of flying to the moon. The funding target was extremely low in comparison to other missions of similar complexity ($11,000)

16 funding tiers were offered, ranging from $1 to $5,000. The funding target was successfully achieved, but there have not been any significant project updates publicised since then.

3.9 CAT Plasma Thruster

The CAT Plasma Thruster project was looking for funding to build a cubesat with a small plasma propulsion system. Launch cost was not included in the $200,000 target (a 'stretch' target of $500,000 was planned to include a commercial launch purchase).

12 funding tiers were offered, ranging from $5 to $10,000. The funding target was not achieved.

3.10 Moonspike

Moonspike was a proposal to build a rocket which be capable of sending a small capsule (basically just a metallic spike) onto a collision course with the moon. The team was made up of former members of the amateur rocket group 'Copenhagen Sub-orbitals' who have built several large hybrid and liquid rockets in their attempt to build a sub-orbital rocket large enough to carry a person.

It was stated in their advertising 'pitch' that this money was only to get the project started, and that

further funding rounds would be needed to fulfil the mission objective.

26 funding tiers were offered ranging from £3 to £4,999. The funding target was not achieved.

4. Analysis of Funding Tiers

The funding campaign for Lunar Mission One has been analysed in more detail, to investigate which of the funding tiers were the most popular, or 'successful' (in terms of money raised).

Figure 4 shows the total money raised at each funding tier for Lunar Mission One:

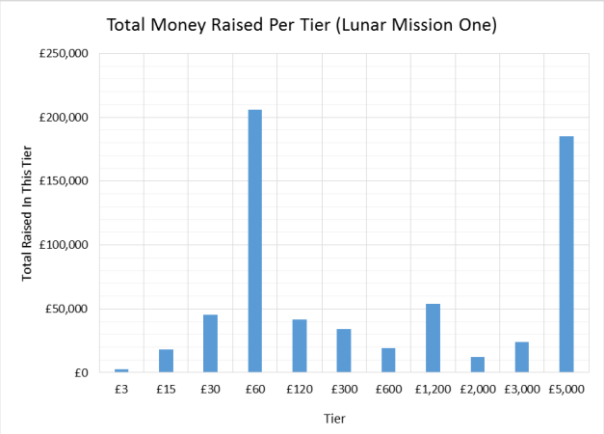

Fig. 4 Total Funding Per Tier (Lunar Mission One)

It can clearly be seen that the £60 price point was by the far the most successful, raising one third of the entire total. A small number of very large pledges (of £5,000) also provide another one third of the total.

This is a notable result, because Lunar Mission One was relatively unique among the projects in only offering one 'very cheap' tier (many other projects had reward tiers structures of $1, $3, $5, $10 etc.). Lunar Mission One did offer a £3 tier, but the reward associated to this tier was effectively nothing.

Although these low tiers may attract a larger number of backers, their relatively low value produces very little funding overall. Space projects, by their nature, are somewhat 'niche-interest' and are unlikely to generate the very large numbers of backers that would be required to generate useful funding from such a low value pledge. Lightsail, which was the most successful campaign, in terms of the number of individual contributors, still only attracted around 23,000 backers. By forcing backers to pledge a minimum of £15 in order to get any reward, Lunar Mission One may well have increased its overall funding total.

One other notable point to explain the popularity of the £60 tier, is that this tier allowed for participation in the project reviews and decision making process. The lower levels only provided rewards such as a certificate of thanks and access to information.

The same analysis was performed for Lightsail, shown in Figure 5. (note that several of the 43 funding tiers were actually the same value, so the numbers of funders have been combined as if there was only one tier at that value)

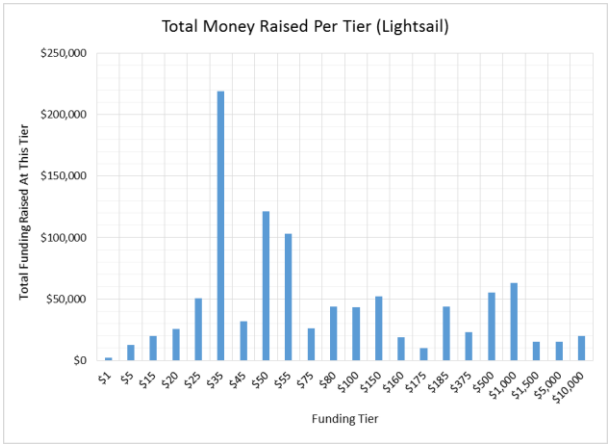

Fig. 5 Total Funding Per Tier (Lightsail)

For Lightsail, the single most lucrative tier was $35, although the $50 & $55 tiers, if taken together would represent an even more successful tier. The overall pattern is quite similar: the bulk of the overall funding comes from the mid-range tiers (between $35 and $55) and from a smaller number of relatively large pledges. The contribution of the low value tiers is almost negligible.

Analysis of SkyCube (shown in Figure 6) also shows a pattern very similar to Lunar Mission One with the largest amounts of money being raised by the $60, $100 and $6,000 tiers.

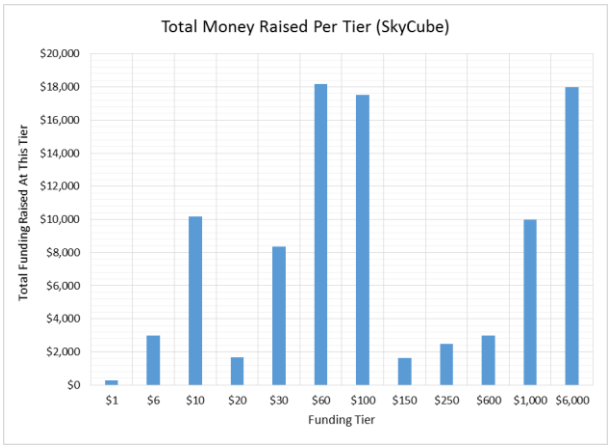

Fig. 6 Total Funding Per Tier (SkyCube)

The analysis of the Arkyd Space Telescope (shown in Figure 7) shows similar high fundraising at the $65 and $99 levels.

However, in this case, the $25 and $200 tiers also produced notably large total contributions, in comparison to the other campaigns analysed here. This is almost certainly due to the rewards offered at these levels: the $25 reward was the first level at which a funder would be entitled to take a 'selfie' of the spacecraft with their own message displayed, and the $200 reward allowed a funder to re-point the telescope to image any point in the sky. Both of these rewards are particularly unique, and would have certainly been first-of-a-kind experiences, if the project had successfully launched.

This indicates that the reward offered certainly has a large impact in terms of attracting potential funders, and that there is certainly scope to try and 'drive' people towards particular funding tiers.

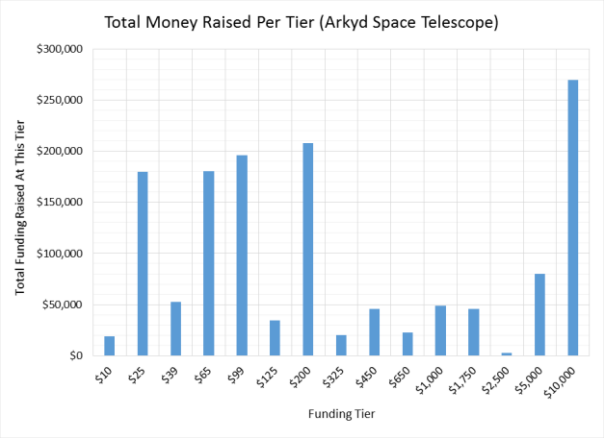

Fig. 7 Total Funding Per Tier (Arkyd Space Telescope)

5. Analysis of Funding Campaigns Success

There are many lessons to be learnt from the above review. The most important conclusion is that it is certainly possible to raise substantial funding via Kickstarter, sufficient to fund a small cubesat-type space mission. The fact that small projects such as SkyCube and KickSat both managed to put spacecraft into orbit almost entirely based on crowdfunding, shows that this is a viable funding method, and that there is sufficient public interest to generate the money needed (even if both of these examples unfortunately did not operate correctly in space) .

Based on the review conducted, a number of key success factors have been identified as follows. Each of these factors is discussed in more detail in the following section:

- Feasibility / plausibility of the project
- Technical & financial detail in the proposal
- Marketing & publicity
- Reward tier structure
- Access to a large pool of existing supporters
- Links with other established organisations

The **feasibility and plausibility** of the project is clearly an important factor in terms of fundraising success. Successful projects such as SkyCube, KickSat and Lightsail were all proposing standard LEO cubesat missions. Each carried a unique payload that was novel and interesting in its own way, but the spacecraft themselves were based on well-known and well-understood technology. Pocket Spacecraft, on the other hand, was proposing a lunar mission which was clearly well beyond the current 'state-of-the-art' for a cubesat mission and Moonspike was proposing a rocket building project which they freely acknowledged would require substantially more funding than they were aiming for. It is highly likely that potential backers realised that both of these missions were very unlikely to succeed and that that deterred many pledges.

Lunar Mission One is a notable exception to this, in that the project being proposed was also extremely complex and they exceeded their (relatively high) funding target despite clearly stating that the requested funding would not come close to funding the actual mission. The success of this project was more likely due to their excellent marketing and publicity campaign which shall be discussed later.

The level of **technical and financial detail** provided on the dedicated project page is another important factor. It is likely that the type of people potentially interested in backing space projects, are reasonably well informed about the challenges and difficulties that may be encountered. To address this a reasonable level of technical detail is required. The Lunarsail, Pocket Spacecraft and CAT Plasma Thruster projects all appear to have suffered in this respect (Lunarsail did in fact achieve its target, but the amount raised was very small in comparison to several other projects). All three teams proposed complex projects (in two cases: a lunar mission, and in the CAT Plasma Thruster case: the development of an entirely new thruster). None of the projects satisfactorily addressed how the numerous technical challenges would be dealt with. Lightsail and the ARKYD Space Telescope, on the other hand both provided extensive information on their spacecraft designs, and were able to show video clips and images of the hardware being developed.

Financial details in the project page are also needed to demonstrate both that the project is financially viable, but also to show that the *sufficient* funding is being requested. Again, looking at Lightsail, the amount requested (and achieved) seems to be far too small to achieve the desired goal, and this may well explain why

the project does not seem to have progressed since the conclusion of the funding campaign.

Marketing & publicity is undoubtedly a key factor in the success of a crowdfunding campaign, and in this case Lunar Mission One is the obvious example of a successful campaign. As mentioned in the previous section, the project team were able to get a number of high profile backers to participate in the advertisement video, and they were featured in an article on the BBC, after which there was dramatic and noticeable surge in the pledges to their project. The Planetary Resources team behind the Arkyd Space Telescope were also very effective at getting their project mentioned in the space news websites.

The ability to draw potential backers to your funding page is essential, particularly given the large number of projects which are now to be found on the major crowdfunding platforms.

The **reward tier structure** can also have an impact on the success or failure of a crowdfunding campaign. Most of the projects reviewed here have tended towards quite complex tier structures, although as discussed in the previous section, the Lunar Mission One campaign indicates that there may be some value in not providing too many tiers, particularly at the lower end of the spectrum, as these tiers generate very little money in the end. There could well be an argument for forcing backers to back the project at a slightly higher minimum level.

In addition, the rewards themselves can be used to draw backers towards a particular 'target' funding tier, which appears to be what the Lunar Mission One team did (driving backers towards the £60 tiers which provided the bulk of their funding).

From the analysis shown in section 4, there is clear evidence that the most common level of funding is around the $50 to $100 level. In almost all funding campaigns, tiers of this level have produced the majority of the total funding. It therefore seems to be critical to have a funding tier at this level, and to ensure that the associated reward is particularly attractive, so that people are 'driven' towards this tier.

Access to a large pool of existing supporters can also be seen to improve the crowdfunding performance. This is evident in the performance of Lightsail, which was backed by the Planetary Society, which can be assumed to have a very large database of supporters who could have been contacted to get the funding campaign started. The number of individual backers for both Lightsail (23,331) and Arkyd Space Telescope (17,614) (run by Planetary Resources, who are also assumed to have a large existing database of supporters) is significantly above almost all the other projects in this review. Lunar Mission One received backing from 7,297 individual backers, but all other projects were backed by less than 3,000 people.

Finally the tremendous success of the ArduSAT program suggests that **links with other established organisations** was a beneficial factor. The ArduSAT team had already established, and heavily promoted, links with an existing spacecraft manufacturer and a number of Universities as part of their outreach programme. It is likely this helped to demonstrate the credibility of the project, as well as giving them access to established support

6. Conclusions & Future Work

The use of crowdfunding as a means of funding space missions has clearly been established. A review of crowdfunded space missions to date has been conducted, and based on that review a set of key factors for a successful space mission crowdfunding campaign has been established.

The maximum reasonable target for a campaign appears to be on the order of $1 – $2 million, if a campaign is particularly well conducted, but a target on the order of $100,000 - $200,000 appears to be very achievable for any start-up company. $200,000 is typically the very lowest end of what is required to launch a space mission, but there are examples of at least two projects that have successfully put spacecraft into orbit with this approach.

6.1 Future Work

An area which is still to be investigated is to review successful crowdfunding campaigns for terrestrial, technical projects, in order to determine factors that have made those campaigns successful and to determine how that could be applied to space mission funding campaigns.

The author is currently applying the results of this research to a space mission crowd-funding campaign which will be presented at the IAC.

References

[1] Kickstarter, www.kickstarter.com
[2] Oculus Rift Funding page, https://www.kickstarter.com/projects/1523379957/oculus-rift-step-into-the-game?ref=nav_search (accessed 29.05.2017)

Note: all other referenced projects can be found via the Kickstarter search function.