EUROPEAN ASSOCIATION OF REMOTE SENSING COMPANIES

Copernicus Sentinel Benefits Assessment

SEBS Analyst Task 1.2

Innovation and Start-ups powered by Copernicus Sentinel data

Preliminary Report

June 2019

European Union

Innovation and Start-ups powered by Copernicus Sentinel data

Client: ESA

Client Representative: Alessandra Tassa

Date of Report: 28/06/2018

Version: Draft

Authors:

EARSC: Dimitrios Papadakis

Version	Date	Change
V01	17/01/2018	First version (TOC)
V02	11/04/2019	Draft report
V03	13/05/2019	First full report
V04	28/06/2019	Preliminary final draft

This activity was undertaken under a programme of, and funded by, the European Union (EU) and the European Space Agency (ESA). The views expressed in this publication are those of the Authors and can in no way be taken to reflect the official opinion of the European Union or the European Space Agency.

Table of Contents

1 Executive Summary

This report presents the result of a study on innovation and entrepreneurship driven or supported by data from the Copernicus Sentinel satellites.

Based on a survey of 97 individuals conducted during October 2018-April 2019, the study explored the characteristics of Sentinel-based start-ups, their business and revenue models, and entrepreneurial and technological maturity, as well as the challenges standing in the way of Sentinel-based entrepreneurship. The objective was to explore the dynamics of this ecosystem and the possible presence of patterns or trends, deriving a baseline for the number of new companies (i.e. start-ups) making use of Sentinel data.

A sample of enterprises was assembled from a range of sources within the existing entrepreneurship community surrounding the Sentinels and the Copernicus programme (such as the Copernicus Start-up Programme and the ESA Business Incubation Centres). A questionnaire was distributed in digital format and disseminated via email and social media, as well as being promoted in person through physical flyers distributed at events.

The concept framework for data-driven business models put forward by Hartman et al. (2014) was used as the basis for the identification of Sentinel-powered business models. The technological maturity of the product(s) or service(s) of the companies in the dataset were assessed within the questionnaire using the definitions of Technology Readiness Level proposed by ESA. Entrepreneurial maturity was elicited by means of questions on the legal status of respondents and the commercial readiness of their Sentinel-based products.

Deeper understanding of the challenges and obstacles was achieved by selecting a representative example of different analytical categories (e.g. different technological and entrepreneurial maturity) and requesting a short interview with a view to developing case studies.

The main business models in use by start-ups are Geospatial VAS, Software-as-a-Service, followed by Data-as-a-Service and Information-as-a-Service. For pre-commercial entities, Consulting and Data-as-a-Service are the most prevalent. Companies aiming at B2C are found mainly within the top four business models, whilst business models providing Information-as-a-Service are aimed purely at other businesses. Analytics, Aggregation and Visualisation activities are most common amongst start-ups, closely followed by Aggregation. The high degree of permutation of business model components amongst respondents may suggest increasing vertical integration across the four tiers.

Sentinels-1 and -2 clearly dominate as far as the choice of datasets is concerned. The main revenue model in use across the sample is subscription fees; the usage fee model is almost exclusively applied by pre-commercial entities. Extrapolating from text comments, consulting sales may also constitute a significant contributor to revenue.

Most of the respondents indicated that their business models could continue, less efficiently, without Sentinel data. However, some 30 start-ups indicated that Sentinel data provided the basis for a competitive advantage and/or that their business models would not be possible without Sentinel data.

For start-ups, the main challenges are sectoral knowledge, legal support, partnership opportunities and infrastructure, and although access to Sentinel data is not regarded as a challenge by the majority of respondents, access to finance is considered to be the most difficult challenge.

2 Introduction and Objectives

The launch of the first dedicated Copernicus satellite in April of 2014 heralded the beginning of a new era for the Copernicus programme: the "Sentinel" era. Satellite data from the family of Sentinel constellations would begin to flow into the Copernicus programme, fuelling its six service lines and providing European policy-makers with regular, high-quality information across a range of thematic areas.

Five years later, the programme boasts seven orbiting satellites delivering some 20 Tb of data per day, a growing base of almost a third of a million users and claims to have brought over EUR 2,7 Bn of economic benefits to its end-users[1].

But this is only part of the story. The Copernicus programme's greater ambitions for job creation and growth lie in the "downstream" sector; the value-adding service industry which would emerge and develop from the release of the Sentinel satellite data under a full, free and open license. The first green shoots of this "Copernicus Economy" have already started to unfurl, but there has hitherto not been a comprehensive study of the nature of these new ventures.

The objective of this study is to explore the extent to which the Copernicus Sentinel data has enabled innovation and commercialisation, with a particular focus on the creation of new companies (start-ups). The aims are to characterise this emerging ecosystem of new micro/small commercial entities ("start-ups") basing their business model on the availability of free and open Sentinel data, chart the movement of ideas from research and development towards the open market, and take note of obstacles encountered along the way, as well as the effectiveness of supporting mechanisms.

Of interest are the dynamics of this ecosystem and the possible presence of patterns or trends. For example, is it possible to identify common or recurring business models that were enabled by the free availability of Sentinel data? If yes, to what extent did the data contribute towards propelling and shaping these business models? What factors contributed most strongly to their successes? We can hypothesis that a range of issues come into play, such as the free and open data policy, data quality and availability, the types of data available, the availability of additional funds (e.g. at regional or national level), participation in research projects, and the presence of close links with universities.

All start-ups must, at a certain point, face the possibility of the so-called "valley of death". This metaphoric neologism is a term popular within venture capitalist circles, and refers to the gap between initial financing and the generation of steady revenues; the "valley" is graphically formed by a line plotting the company's net cash flow.

[1] Copernicus Market Report (2019)

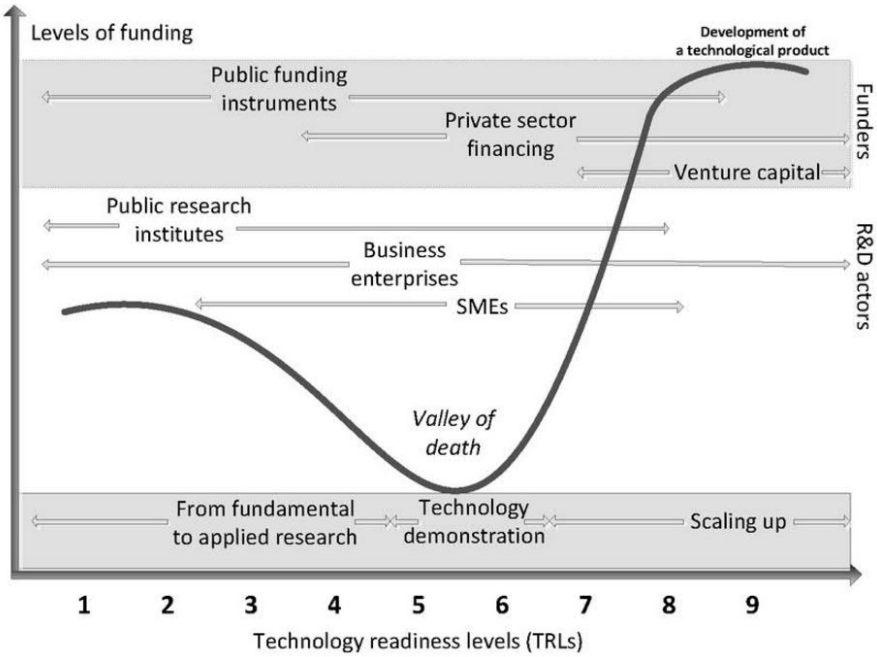

Figure 1: The "valley of death" Source: OECD (2016), therein adapted from Mankins (2009) "Technology readiness assessments: a retrospective".

This task targets the companies and individuals situated between the "demonstration" and "scaling-up" phases, between which the "valley of death" phenomenon is encountered. In the specific context of start-ups making use of Sentinel data, the question of what characterises the "valley of death" will be explored; what factors stand in the way of efforts to build businesses using Copernicus data?

Taking the above into account, this study will pursue the following specific objectives:

A. Derive a baseline for the number of new companies (i.e. start-ups) making use of Sentinel data as the basis for their market offering, as well as surveying the landscape of pre-market concepts, ideas and proposals (e.g. competitions, hackathons, incubators);
B. Characterise these enterprises in terms of their size, maturity, industry sector, their (current or proposed) business model and the manner in which this is supported by Sentinel data;
C. Outline the general characteristics of innovation and business models identified within the sample;
D. Understand the drivers and obstacles encountered in relation to commercial Sentinel data exploitation.

3 Methodology

3.1 Scope

In order to achieve the goals as set out above, the study is focused on eliciting information about the population of interest, which is defined as follows:

Enterprises (i.e. start-ups and established companies) and pre-market players (e.g. competition/hackathon entrants and winners) in Europe using Sentinel data in their (existing or proposed) products or services.

It is important to point out that the study does not aim to generalise its findings to a broader population based on the representativeness of the sample. Given the specificity of the phenomena under consideration, the study has an exploratory, rather than explanatory nature.

3.2 Activities

The methodology is comprised of the following activities:

1. Assembling a sample for analysis from various data sources;
2. Carrying out a survey on the above candidates;
3. Through the survey results, identifying the business model in use and classifying the activities according to their technological and entrepreneurial maturity;
4. Selecting a sub-set of companies representing a range of cases within the typologies identified above and obtaining qualitative data on the nature of the challenges and obstacles as well enablers they encountered, thus characterising the Sentinel "valley of death".
5. Analysing patterns and identifying trends across the dataset.

3.2.1 Identification of a relevant sample

The set of start-up companies at any particular moment is a vast and constantly changing collection. Finding those with particular characteristics is challenging, particularly where the phenomenon of interest – the use of Sentinel data - might be part of the company's internal production processes, and thus hidden from sight as far as the outside world is concerned.

The specialised nature of the Earth Observation sector – and the Copernicus microcosm within it - means that many of the start-ups which are the subject of this analysis are very likely to be aware of, and participate in, incentivisation schemes and entrepreneurship initiatives which have been launched within the Copernicus framework of the Copernicus programme. These include, inter alia, the Copernicus Masters competition, the Copernicus Accelerator programme, and the ESA Business Incubation Centres (BIC).

Based on this, there are two possible approaches:

1. "Top-Down": Identify data sources for start-ups (conferences, databases etc.) which are not specific to the remote-sensing/space sectors, and then drill down to find those related to Sentinels. There does not exist at this moment a publicly-available database of European start-ups, although there are several observatory-type initiatives in the making. Examples of these kinds of sources include:
    - The European Start-ups Network
    - Start-up Europe Map
    - TechCrunch CrunchBase

2. "Bottom-up": Use the known community around the Sentinels and Copernicus to identify start-ups. The initiatives mentioned above serve as a ready-made "breeding ground" for Sentinel-focused start-ups.

Whilst both have their pros and cons, it was decided to focus on the "bottom-up" sources first, which are considered to be potential "quick wins" in developing a suitable sample for analysis.

The relevant communities, programmes and initiatives which served as sources of respondents are listed below[2].

- The Copernicus Start-up Programme, comprising primarily
  - Copernicus Masters (applicants and winners since 2014)
  - Copernicus Incubator participants
  - Copernicus App Camp participants
  - Copernicus Hackathons
  - Copernicus Accelerator mentees
- Beneficiaries of EU funding under the Horizon 2020 SME Instrument
  - Topic SMEInst-06-2016-2017
- Participants (applicants and winners) in the ESA Space App Camp
- Participants (incubatees) of the ESA Business Incubation Centres
- Members of relevant industry associations, e.g.:
  - EARSC
  - EURISY
  - NEREUS
  - EUROGI
- Participants at relevant innovation-related events, such as:
  - ESA Phi-Week
  - ESA Space Hackathon
  - Other hackathons and competitions

Data sources considered for analysis, but not included for various reasons, are listed in the table below:

Data source	Description	Rationale for exclusion
INNOSpace Masters Competition	The competition promotes innovative ideas for the next space generation. Submissions should transfer expertise and technologies from other sectors to the space sector (spin-ins) or open up new terrestrial opportunities for space technologies, services or data (spin-offs).	The focal topics are primarily hardware-related: Materials, Components and Production; Sensor Technology & Miniaturisation; Communication & Network; Propulsion Technology, E-Mobility & Energy Storage; Simulation & Testing

Figure 2: Excluded data sources

3.2.2 Survey on Sentinel-powered innovation and start-ups

A survey of candidate enterprises and individuals was carried out between October 2018 and April 2019, taking the form of an electronic questionnaire. The questionnaire comprised 15 questions addressing (1)

[2] In all cases, data was collected, if available, from 2014 onwards – being the first year in which Copernicus Sentinel data was available for commercial exploitation.

the business, (2) the product, (3) the use of Sentinel data, and (4) challenges and incentive schemes. The full list of questions is provided in Annex 1.

The survey was delivered electronically and in physical copy during the period October 2018 - April 2019. It was disseminated via the following channels:

- Email to potential respondents (either directly or via facilitators): approximately 300 reached.
- Appearance in newsletters: approximately 2000 readers reached.
- Distribution of physical flyers: approximately 250
- Over 5000 impressions on social media

The survey was promoted on social media by EARSC and Evenflow. EARSC also promoted the survey through its Portal and via its "eomag" newsletter.

3.2.3 Identification of business models and assessment of technological and entrepreneurial maturity

The business models underpinning the companies' offering were analysed using the conceptual framework for data-driven business models put forward by Hartman et al. (2014), the aim being to arrive at a taxonomy suitable for describing the range of observed cases in the context of Sentinel data. The technological maturity of the product(s) or service(s) of the companies in the dataset were assessed within the questionnaire using the definitions of Technology Readiness Level proposed by ESA. Entrepreneurial maturity was elicited by means of questions on the legal status of respondents and the commercial readiness of their Sentinel-based products.

3.2.4 Case studies: Challenges, obstacles and enabling factors

The questionnaire included questions aimed at identifying the main challenges faced by start-ups, as well as identifying the impact (on headcount, profit and turnover) of a range of known support schemes, most of which funded directly by the Copernicus programme.

Deeper understanding of the challenges and obstacles was achieved by selecting a representative example of different analytical categories (e.g. different technological and entrepreneurial maturity) and requesting a short interview with a view to developing deep-dive case studies. The case studies aim to uncover additional information, such as:

1. The rationale or motivation behind the decision to start up;
2. The extent to which the cost or capabilities of the Sentinels factored into the decision;
3. The extent to which products and services offered depend on Sentinel data;
4. The obstacles faced by the company in relation to the acquisition or utilisation of Sentinel data, and how they were overcome.

At the time of writing, one interview has been carried out, and an additional case study has been assembled based on openly available data.

3.2.5 Analysis of patterns and trends

Steps were taken to attempt to identify patterns and trends of interest in supporting the study objectives, such as the following phenomena:

- Geographical or thematic clustering;
- An understanding of which types of Sentinel data are best represented amongst new commercial ventures;
- Common features and patterns in the business models;
- Common obstacles or challenges and how they were addressed;
- Trends over time of start-ups being founded, in relation to the Sentinel launches.

Statistical techniques for cluster analysis (k-modes, principal component analysis) were evaluated for their efficacy in identifying commonalities or explaining variance across the dataset; however, this proved unsuccessful due to the heterogeneity of the data. Instead, analysis of patters and trends within the data was carried out by comparing parameters in cross-tabulations (see Annex 1) and by performing structured queries on subsets of interest.

3.3 Technical notes

3.3.1 Re-coding of multi-choice, multi-selection data

Many questions in the questionnaire took the form of multiple-choice answers with multiple selections possible. The results in some cases yielded a great deal of variability (e.g. Q4 yielded 45 combinations of responses, of which 31 made up a “long tail” of “unique” combinations, with only one respondent each).

This complexity necessitated some degree of re-coding of the data, in order to render it manageable for the process of analysis. The following steps were carried out:

- To enable a better understanding of the distribution of option combinations, the highest-frequency combinations were encoded as new descriptive variables (e.g. Analytics-Aggregation-Visualisation) and appended to the individual responses in the dataset, allowing analysis based on combinations rather than individual responses to separate question variables.
- In some cases, related categories were merged into more general ones. For example, the legal status (Q1) was simplified into three categories, merging the responses from the four “no legal entity” options. The recoding rules applied to each question are shown along with the distribution of responses.
- Where respondents selected a particular option in combination with the “none of the above/other” option, the data was recoded to represent the first choice only, to simplify interpretation and visualisation. All related notes provided in free text were captured and analysed qualitatively.
- Finally, in a couple of cases, an additional merging of the remaining options was carried out to further reduce the wide spread of distribution across answers; this is described in Section 4.1.3 Business and Revenue models.

3.3.2 Valid and excluded responses

Under each graph, the number of "valid" responses depicted is shown. This number is the difference between the total respondents, and the sum of the following cases:

- Duplicate responses, which were automatically detected and manually excluded from the dataset (1 such instance was detected);
- Respondents who skipped the question (in cases where two variables are compared, respondents who skipped either question were excluded);
- In some cases, respondents who answered "None of the Above" were also excluded – but only after careful examination of the contents of the comments. The decision to exclude these answers was question-dependent. For example, in Q6 on revenue models, it was discovered that these responses actually contained a strong signal about options which were not presented in the questionnaire (namely, consulting service fees, freemium revenue models, and data sales) – and therefore should not be excluded.
- Finally, to facilitate readability, in some charts the "long tail" of single-response categories were excluded, showing only cases where at least two respondents answered. The number of single responses not shown is mentioned in the captions.

3.3.3 Units measured

The title of the X axis shows whether the variable counts "instances" of responses to specific options (which, for multiple-response, multiple-choice data, can add up to more than the number of respondents) or "respondents", referring to the questions in which a one-to-one relationship exists between responses and respondents. Note that the first step of the process described in 3.3.1 transforms the response data from instance-based to respondent-based.

4 Results and Analysis

This chapter presents the results of both the survey and the interviews organised according to the research themes and questions, followed by a discussion of the results.

4.1 Responses

4.1.1 Characteristics of Sentinel-powered businesses

The first issue at stake is the legal status of the respondents' activities. Since the targeted demographic included a significant proportion of participants in 'pre-commercial' incentive schemes, it was necessary to differentiate the active entrepreneurs from those without a legal entity.

Q1. Which of the following best describe(s) the legal status of your activity?

The following responses were possible (multiple choice, multiple selection):

1. No dedicated legal entity: (informal group of) companies or individual(s)
2. No dedicated legal entity: group bound by an agreement (e.g. a consortium agreement)
3. No dedicated legal entity: IP (e.g. trademark) registered to existing legal entity(/ies)
4. No dedicated legal entity: activity taking place in the context of a research institute or university

5. Dedicated legal entity: start-up (founded less than 5 years ago)
6. Dedicated legal entity: founded more than 5 years ago
7. None of the above is an appropriate description.

1	2	3	4	5	6	7
No entity - informal group	No entity - agreement	No entity - IP registered	No entity - research institute	Start-up	Established company	None of the above
15%	2%	1%	16%	52%	15%	9%
Precommercial status				Start-up	Established company	None of the above

Figure 3: Legal status - distribution of responses. Re-coding logic shown in the last row.

Just over half the respondents represent start-ups, with 15% being established companies. A third (33%) of the respondents did not have a legal entity, of which the majority (16% of the total) represent initiatives arising from research institutes.

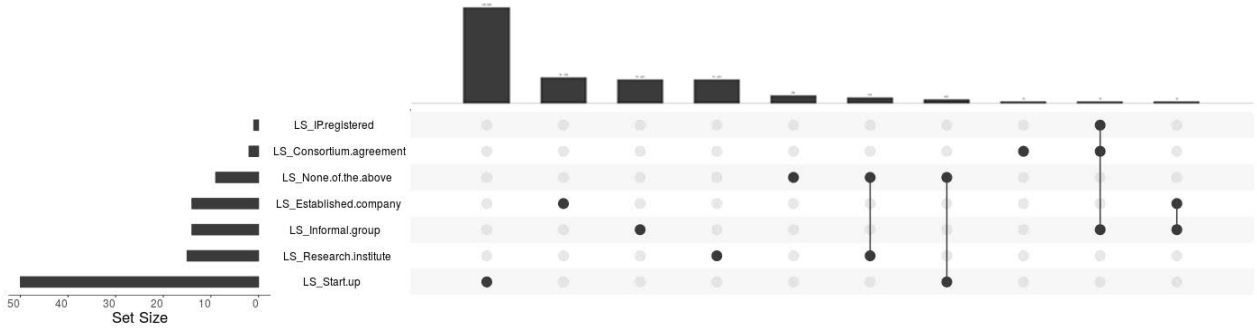

Figure 4: Legal status - intersection frequency (raw data)

Comments received against the None of the Above/Other category included the following:

- "Currently in the process for start-up incorporation, right now at research and development institute Fraunhofer."
- "I was a semi-finalist in Copernicus Masters in 2015"
- "We are part of the Copernicus Accelerator and we will develop into a start-up company"
- "I am doing my PhD doctoral studies in the ECPD university for peace and development in Belgrade Serbia, these images I need for multispectral analysis in software Remote Sensing with TerrSet/Idrisi"
- "20 years of scientific pre preparation"
- "Freelancer / research activities within MSc studies context/ searching for an innovative idea to be developed through a PhD research Programme so as to develop an EO product based on free and open Copernicus data"
- "It is a project with various entities on board"
- "I work in the Venezuelan Foundation of Seismological Research, government entity in Venezuela"

Q2. If you have a start-up or legal entity - what was its launch date?

This question was focused on respondents who declared themselves as having a start-up. Established companies also responded to the question, but only the responses from start-ups are shown here.

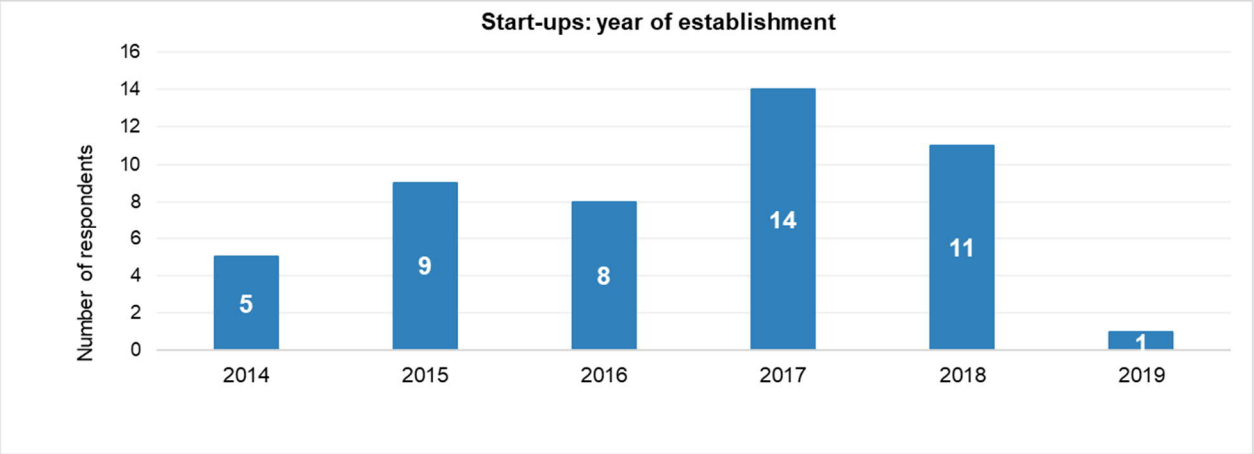

Figure 5: Year of establishment of start-ups

The majority of the start-up respondents were founded within the last two years. The small size of the sample precludes considerations of frequency trends across the period.

4.1.2 Geographic spread

Q3. In which country is your business based?

Responses to the survey came from 30 countries, with 84 out of 96 respondents coming from the European Union[3]. Italy, France and the UK each had 12 respondents, followed by Spain and the Netherlands with 7. Italy and France provided the most start-ups (7), followed by the UK and the Netherlands (6 each).

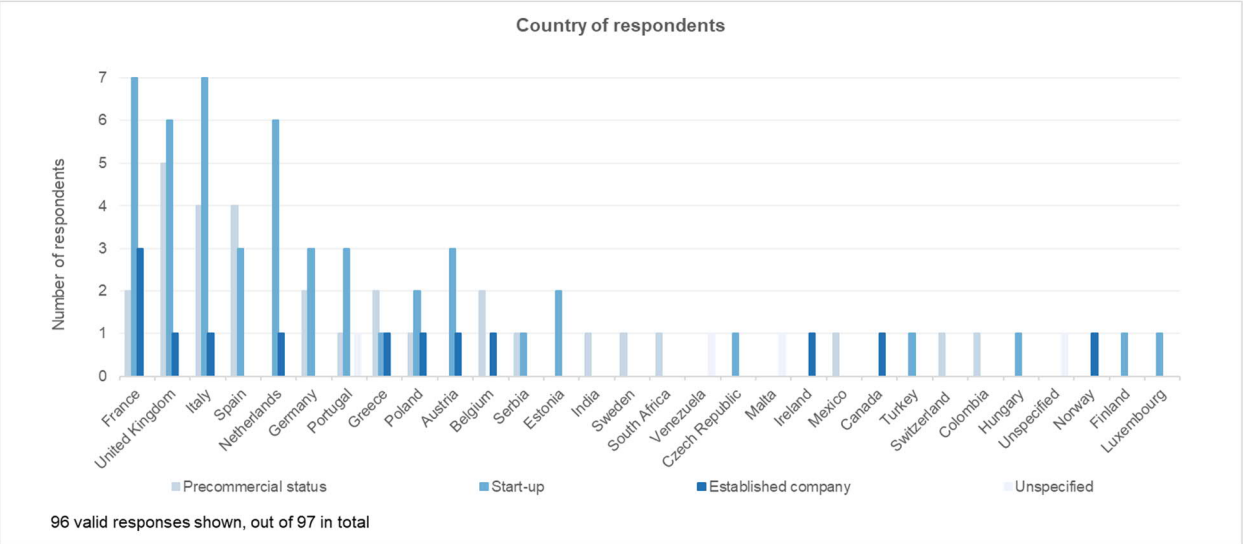

Figure 6: Geographic spread vs. legal status

4.1.3 Business and revenue models

Q4. Which of the following best describe(s) the elements of your Sentinel-based business model?

[3] Note: At the time of this writing, the United Kingdom is still a member of the European Union.

The following responses were possible (multiple choice, multiple selection):

1. Data-as-a-Service (DAAS): Provides easy, timely and protected access to raw or processed Earth Observation data (space-borne, air-borne, in-situ)
2. Platform-as-a-Service (PAAS): Provides users with an environment (incl. tools and software) where they can discover, visualise and process Earth Observation data (e.g. EOS Platform)
3. Information-as-a-Service: On-line service providing customers with information (e.g. reports, maps or business intelligence) extracted from the analysis and processing of Earth Observation data (e.g. Satagro)
4. Software-as-a-Service (SAAS): A method of licensing and delivering software in which centrally-hosted software is supplied to users, usually on the basis of subscriptions.
5. Software products: Provision of software under a more traditional model involving the supply of binary files (executables)
6. Provision of value-added geospatial information product(s): Products such as static and dynamic maps, indices, alerts, and other information products with a geospatial component.
7. Provision of other (non-geospatial) information product(s): Information products without a geospatial component
8. Consulting: Provision of expertise in the form of advice, analysis and/or recommendations
9. None of the above is an appropriate description / Other.

1	2	3	4	5	6	7	8	9
Data-as-a-Service	Platform-as-a-Service	Information-as-a-Service	Software-as-a-Service	Software products	Geospatial VAS	Non-geo VAS	Consulting	None of the above
29%	22%	32%	22%	10%	51%	14%	47%	7%

Figure 7: Business model - distribution of responses[4]

The distribution of responses shows the dominant role that geospatial value-adding services (VAS) and consulting play for (at least part of) the business model of half of the sample. The four "as-a-service" models form a cluster with Information-as-a-Service in the lead (32%), and there is much less attention to non-geospatial VAS (14%) or software development (10%).

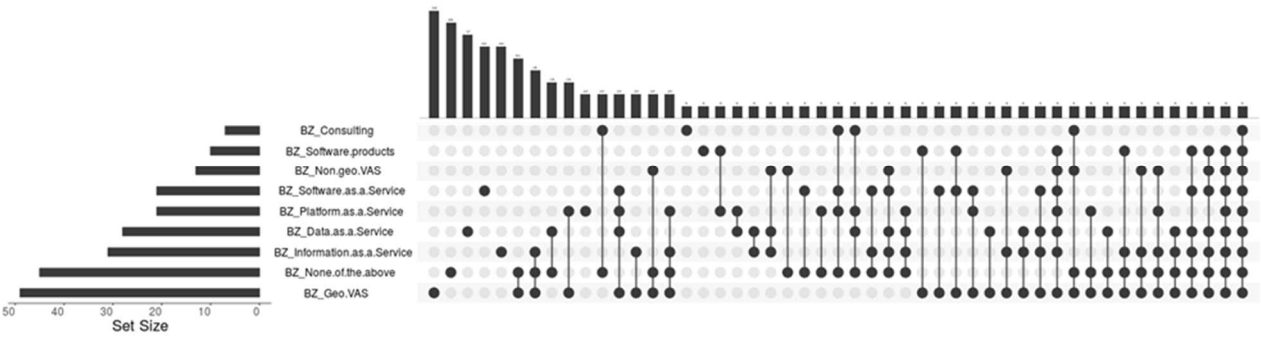

Figure 8: Business models - intersection frequency (raw data)

Examining the overlap of options, the picture is one of five top individual options (four, since one of them is actually "None of the above"), followed by another four combined options, before the "long tail" of re-

[4] It is necessary to recall that since the question allowed more than one option to be selected, the total of the percentages does not equal 100%.

combinations begins. Clarifications were provided for some of the answers in the "none of the above" category (a selection is presented here):

- "User tailored consultancy for organisations in the field of development cooperation; including (ex-post) project evaluation schemes based on EO data"
- "Provision of hardware and provision of out of orbit e.g. cosmic radiation data in comparison to the SOFIA project. Reduction of Space Scrap"
- "Advanced mathematical optimisation based on new mathematics"
- "Robot use CO2 pollution to recycle and build smart tree, hyperloop"

It is not clear from these responses whether the business models in question do not fit one of the other categories; it seems that in some cases this is certainly the case.

To better understand the frequencies of combinations of options, the options were coded and re-assigned to the individual responses (as described in Section 3.3.1). As signalled above, considerable heterogeneity in the combinations of responses was noted (45 answer combinations, of which 31 with a single response each). Therefore, re-coding was carried out to assign any option which was combined with "Consulting" or "None of the above / Other" to the value of the other option only.

The reasoning is that pure consulting businesses (i.e. those not offering other types of services) should be differentiated from those which include consulting as an adjunct to the other activities specified by the business model. This allowed for the capture of 80% of the respondents within 14 combinations[5], which are shown in the chart below (the hidden "long tail" contains 21 single-response entries).

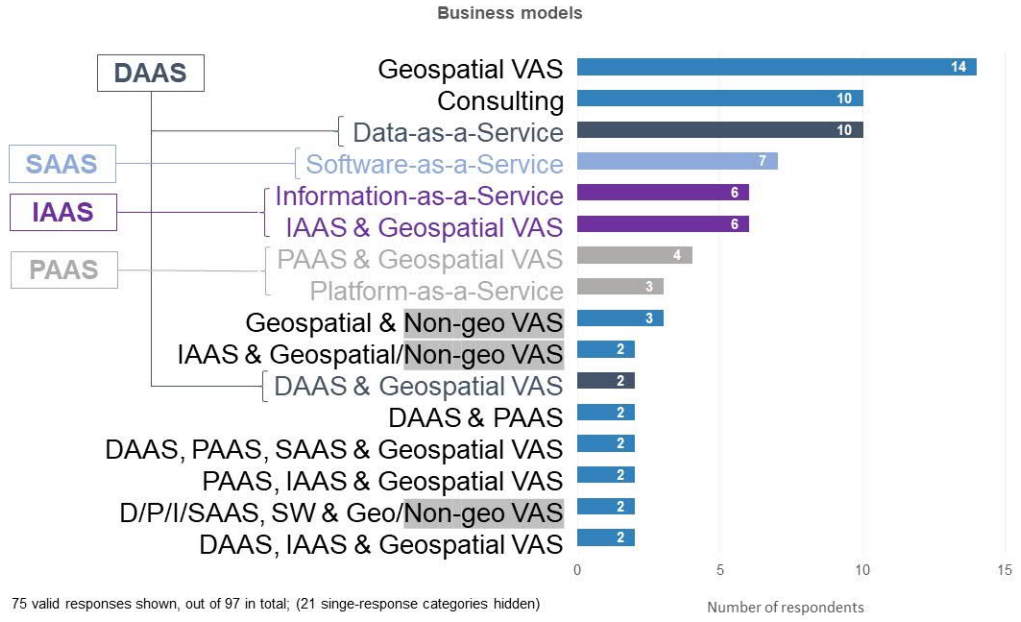

Figure 9: Business models (data recoded)

[5] It is perhaps worth mentioning that not all of these are actually combinations of responses; in some cases, the "original" unique options prevailed.

This allows consideration of the most prominent patterns across the sample. Geospatial VAS takes the top position – which is unremarkable, considering the nature of the industry. The concentration of Consulting activities (in joint second with Data-as-a-Service) is perhaps notable. Moving down the list, we find an arrangement of the as-a-Service business models, each on their own, and in combination with Geospatial VAS. Software-as-a-Service appears in third place, followed by Information-as-a-Service and then Platform-as-a-Service. The emergence of non-geospatial VAS (shaded in grey) within the top 10 is somewhat unexpected.

Splitting each business model combination by the legal status of the respondent (Figure 10), it becomes apparent that:

- the DAAS and Consulting categories contain the highest number of pre-commercial players, (5 each)
- the Geospatial VAS and SAAS categories contain the highest ratio of commercially active (start-ups and established companies) to pre-commercial participants.
- There is only one combination in which only a single type of entity appears: DAAS and Geospatial VAS, with two start-ups.

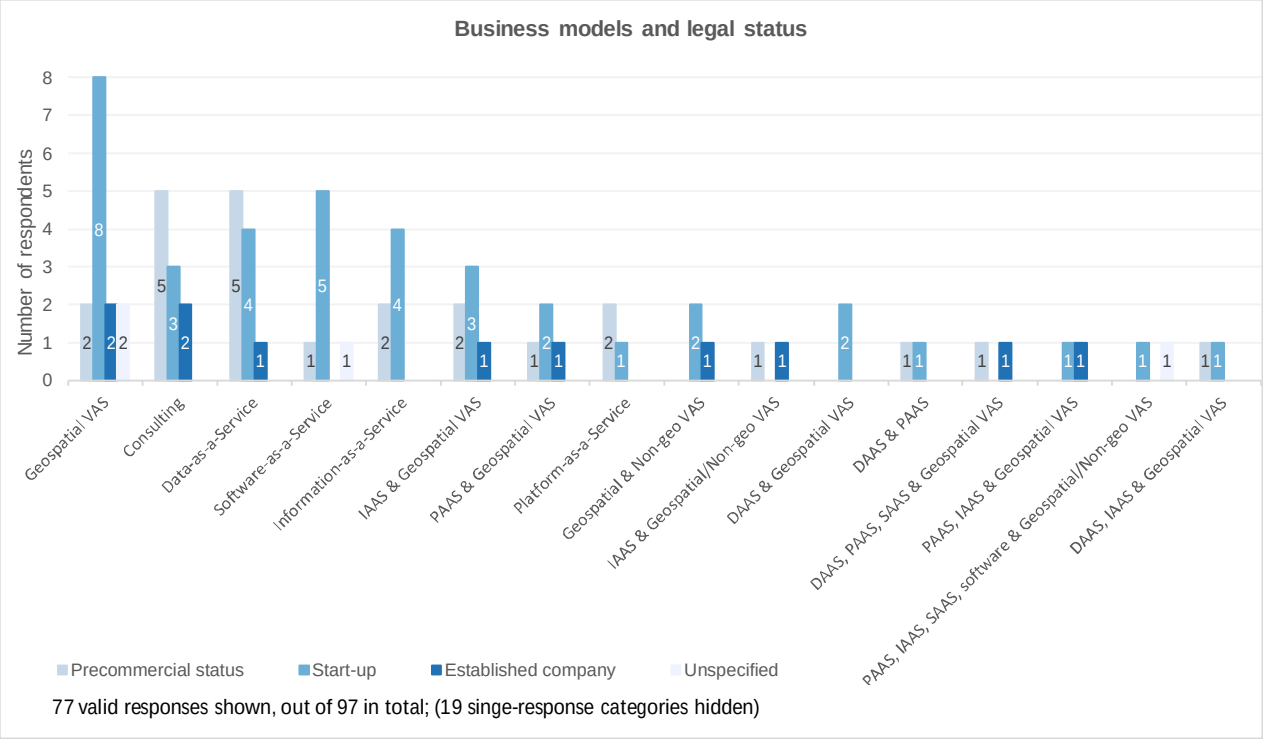

Figure 10: Business models and legal status (data recoded)

Q5. Which of the following best describes your core target customers?

The following responses were possible (multiple choice, multiple selection):

1. Business to Business (B2B)
2. Business to Consumer (B2C)

3. Business to Government (B2G)

1	2	3
Business to Business (B2B)	Business to Consumer (B2C)	Business to Government (B2G)
77%	19%	45%

Figure 11: Target customers - distribution of responses

The customer profile amongst respondents is overwhelmingly Business (B2B) or Government (B2G), including their combination (see Figure 12, below), with only a fifth of respondents indicating that they are targeting the consumer market.

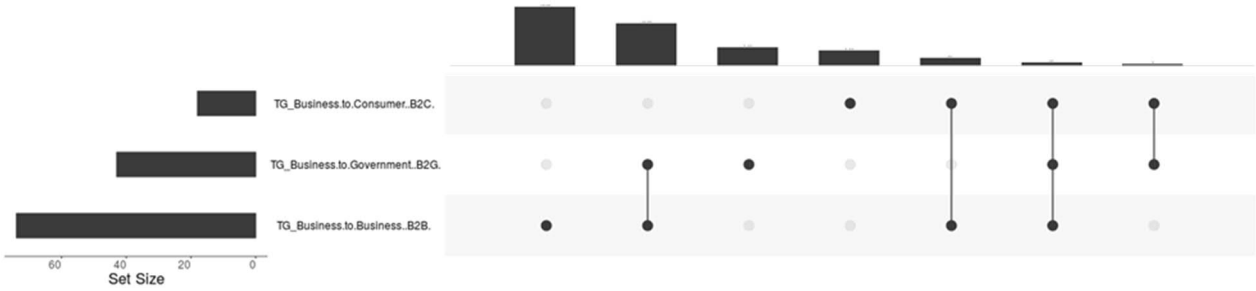

Figure 12: Target customers - intersection frequency (raw data)

The graph below shows how the re-coded combinations of target customers are distributed across the top 16 business model combinations.

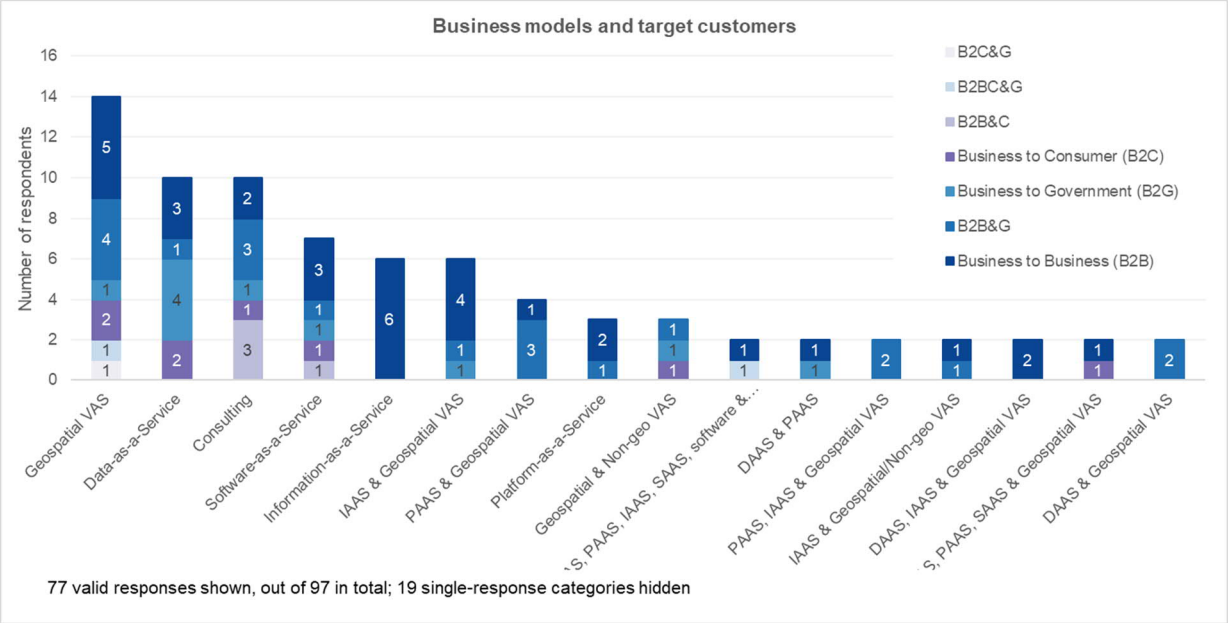

Figure 13: Business models and target customers

It seems that B2C companies are found mainly within the top four business models, whilst business models providing Information-as-a-Service are aimed purely at other businesses.

Q6. Which of the following best describes your revenue model?

The following responses were possible (multiple choice, multiple selection):

1. Sale of physical products
2. Rent/lease of physical products
3. Usage fee
4. Subscription fee
5. Advertising
6. None of the above / Other

1	2	3	4	5	6
Sale of physical products	Rent/lease of physical products	Usage fee	Subscription fee	Advertising	None of the above
29%	9%	35%	53%	8%	24%
Sale/Rent		Usage fee	Subscription fee	Advertising	None of the above

Figure 14: Revenue model - distribution of responses. Recoding logic is shown in the last row.

The main revenue model in use across the sample is subscription fees, with just over half the sample implementing this approach. Just over a third of the sample charges usage fees, and sale of physical products follows at 29%. A number of combinations are also witnessed (see Figure 15, below) involving Usage along with subscription fees and rent or sale of physical products.

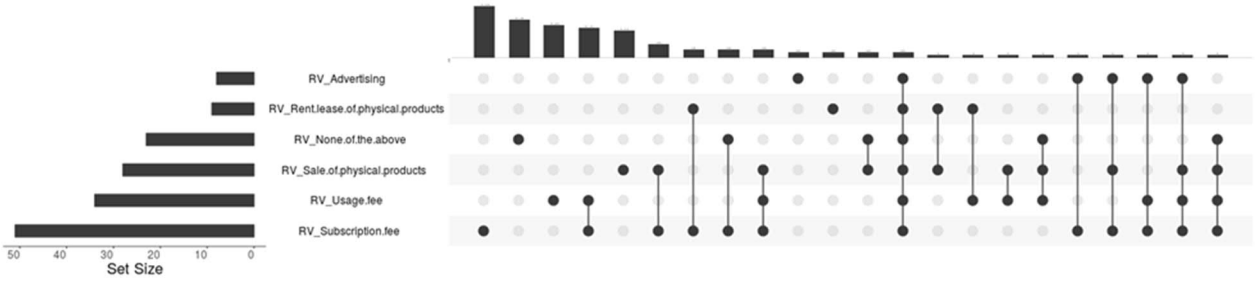

Figure 15: Revenue model - intersection frequency (raw data)

Since a quarter of respondents indicated the “none of the above” option, it is possible that additional options should have been included in the question. The following items were extracted from the comment fields, along with the approximate number of occurrences:

- “Consulting / sale of services” (11)
- “Funding from research projects” (6)
- “Data sales” (3)
- “Freemium (free product with optional paid features)” (1)
- “Metered subscription (pay-as-you-go)” (1)

It appears that consulting sales constitute perhaps a significant provider of income to the companies involved, and this is underscored by the high prevalence of consulting under the analysis of business models. Other income models not included in the answer list are research funding, data sales, freemium and pay-as-you-go.

The recoded option combinations are shown below. It is notable, that the usage fee revenue model is comprise almost exclusively of pre-commercial entities, and makes up by a fair margin the most popular

revenue model amongst pre-commercial entities. For start-ups, the most prevalent revenue model in the sample is subscription.

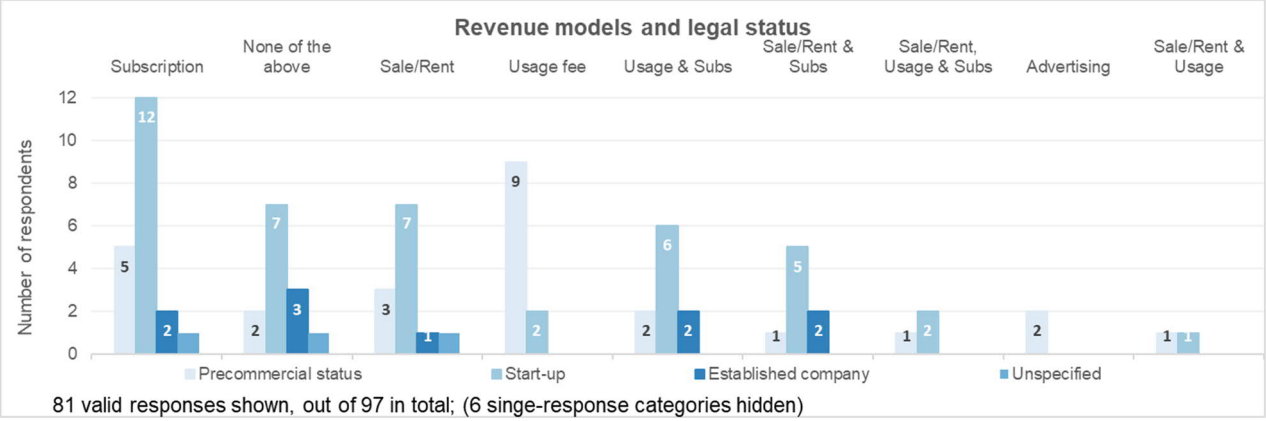

Figure 16: Revenue models and legal status.

4.1.4 Technological maturity

What levels of technological maturity are displayed by the products on offer by the companies and/or entities in the sample? This section examines the Technology Readiness Level of the products and services under consideration.

Q7. What is the current level of technological readiness (i.e. Technology Readiness Levels or TRL) of your product / service?

The following responses were possible (multiple choice):

1. Basic principles observed and reported (TRL 1)
2. Technology concept/application formulated (TRL 2)
3. Experimental proof of concept (TRL 3)
4. Technology validated in a laboratory environment (TRL 4)
5. Technology validated in a relevant environment (TRL 5)
6. Technology demonstrated in a relevant environment (TRL 6)
7. System prototype demonstration in operational environment (TRL 7)
8. System complete and qualified (TRL 8)
9. Actual system proven in operational environment (TRL 9)

1	2	3	4	5	6	7	8	9
TRL 1	TRL 2	TRL 3	TRL 4	TRL 5	TRL 6	TRL 7	TRL 8	TRL 9
4%	15%	18%	5%	6%	15%	13%	4%	17%

Figure 17: Technological readiness - distribution of responses

There is a fairly even distribution across TRL levels, with three groupings of 15-18% each: (i) TRL 2 and 3, (ii)TRL 6 and 7, and (iii) TRL 9. Since the options are mutually exclusive, intersection frequency is not shown.

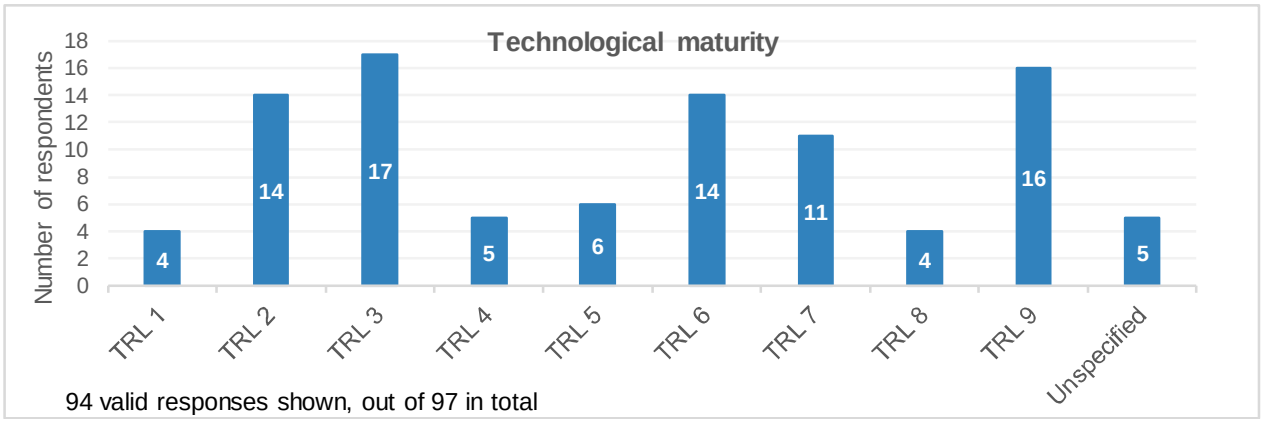

Figure 18: Technological maturity

In the graph below, the colours show TRL levels grouped into threes: 1-3 are shades of green, 4-6 shades of purple, and 7-9 shades of blue. The figure shows that the top four business model combinations are comprised of significant (30-60%) numbers of respondents with products at TRL between 1 and 3, and indeed, the majority of low- and mid-TRL products are found within these categories.

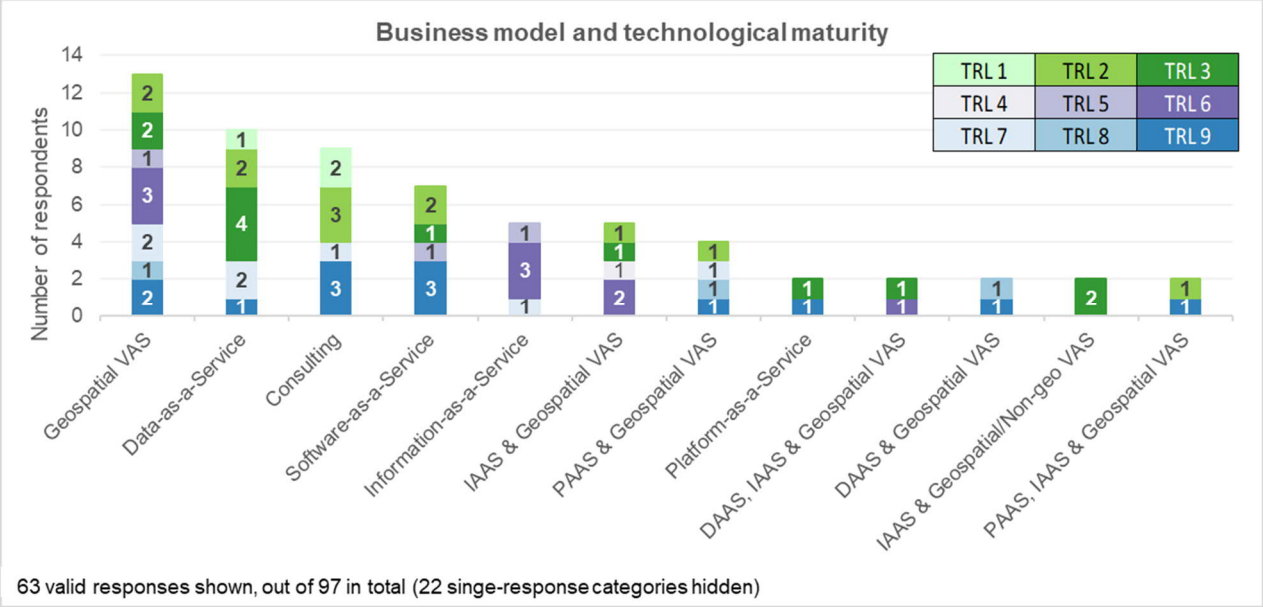

Figure 19: Business model and technological maturity

The Data-as-a-Service category contains more products with TRL below 4 than it does other levels of technological maturity, whilst the Information-as-a-Service category is one of only two categories with no products under TRL 4.

4.1.5 Entrepreneurial maturity

Entrepreneurial maturity is examined by looking at three topics: commercial readiness of products, number of paying customers and start date.

Q8. What is the current level of commercial readiness of your product/service?

The following responses were possible (multiple choice, multiple selection):

1. Product not commercially available
2. Product in pre-commercial piloting (funded under research framework)
3. Product in pre-commercial piloting (funded privately)
4. Product commercially available on a demo/trial basis
5. Product commercially available to customers
6. None of the above / Other

1	2	3	4	5	6
Not commercially available	Pre-commercial piloting (research framework)	Pre-commercial piloting (funded privately)	Commercially available (demo/trial)	Commercially available	None of the above / Other
27%	14%	15%	10%	25%	5%
Not commercially available	Pre-commercially available		Commercially available		None of the above / Other

Figure 20: Entrepreneurial maturity - distribution of responses. Re-coding logic shown in the last row.

Although most respondents (27%) indicated that their product was not commercially available, a quarter stated that their products are commercially available and a further 10% noted that their product is available commercially in demo/trial mode. A total of 29% of respondents indicated that their products are available pre-commercially. Intersection frequency is not shown here, since responses were assigned to a single option only in each case, despite the selection of multiple options being permitted.

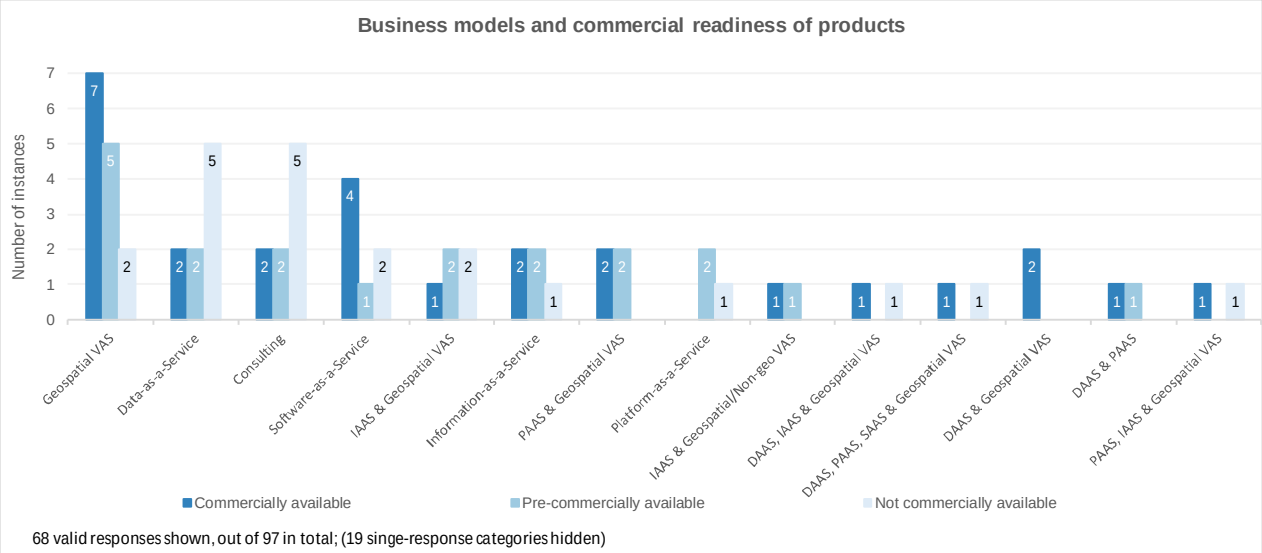

Figure 21: Business models and commercial readiness

Q9. For commercially available products - how many paying customers has your product or service generated?

This question involved a single choice per respondent, therefore no further grouping or coding was necessary. The results, shown in Figure 22, below, indicates that the majority of respondents (33 out of 58) fall into the 1-10 customer bracket, whilst a further 9 have from 11 to 100 customers. The upper

brackets contain only two companies each – one of which is featured as a success story in the final chapter.

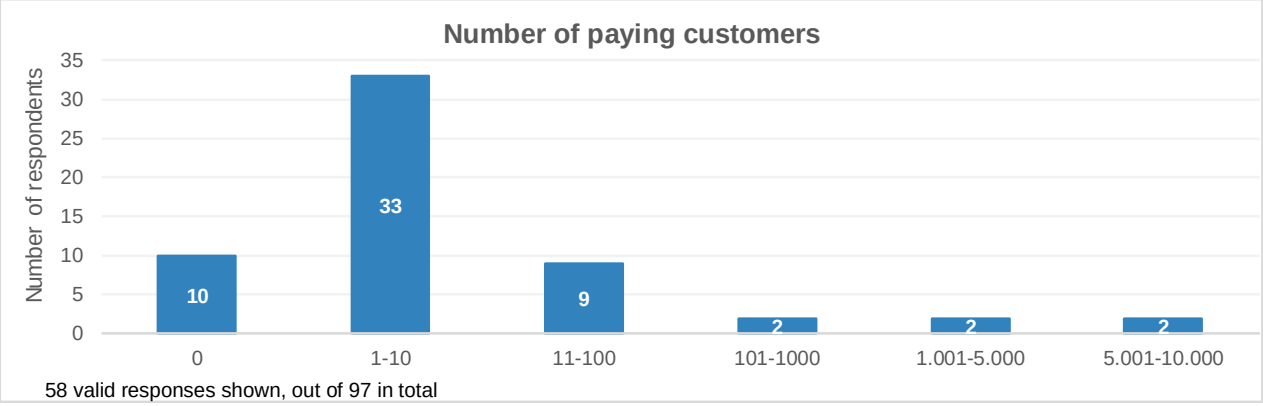

Figure 22: Number of paying customers

It is notable that two start-ups which launched in 2018 already succeeded in breaking into the two upper brackets.

4.1.6 Use of Sentinel data

This section examines which Sentinel datasets are used and the patterns of use of Sentinel data across the companies surveyed.

Q10. Which Sentinel dataset(s) do you use in your product/service?

The following responses were possible (multiple choice, multiple selection):

1. Sentinel-1: C-Band SAR
2. Sentinel-2: MSI
3. Sentinel-3: SLSTR
4. Sentinel-3: OLCI
5. Sentinel-3: SRAL
6. Sentinel-3: MWR
7. Sentinel-5p: TROPOMI
8. If you would like to elaborate further on your use of Copernicus Sentinel data (or of the Copernicus Services), or any other datasets, please do so here.

1	2	3	4	5	6	7	8
S-1: C-Band SAR	S-2: MSI	S-3: SLSTR	S-3: OLCI	S-3: SRAL	S-3: MWR	S-5p: TROPOMI	Other
60%	72%	22%	18%	15%	7%	13%	17%
S-1	S-2	S-3 (Opt.)		S-3 (Top.)		S-5p	Other

Figure 23: Sentinel data - distribution of responses. Re-coding logic shown in the last row.

Sentinel-2 is used by the majority (72%) of the respondents, with Sentinel-1 following (60%). Sentinel-3 usage is split between the optical (40%) and topographic (22%) packages. 13% of the sample surveyed indicated that they use Sentinel 5-p.

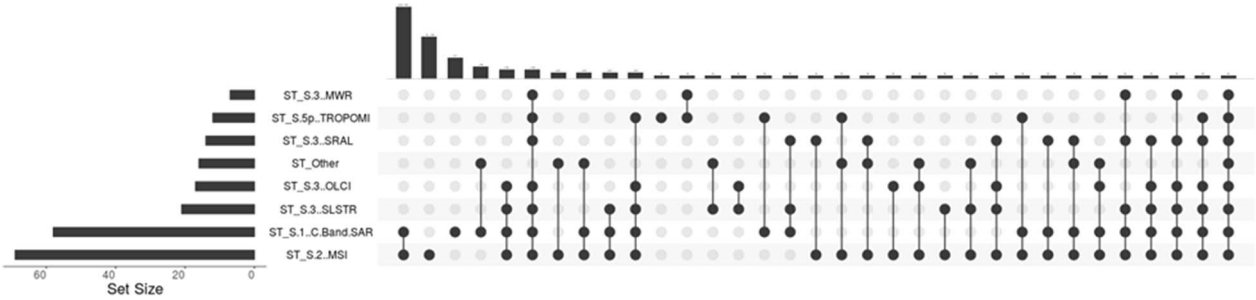

Figure 24: Sentinel data - intersection frequency (raw data)

Although there is a significant number of combinations of the various Sentinel datasets, Sentinels-1 and -2 clearly dominate as far as the choice of datasets is concerned. Between them, and including their combined use (together and with other unspecified data), they comprise 60% of the responses to this question. Sentinel-3's optical package enters into the mix after a rather steep drop, and Sentinel-5p appears next in combination with all the aforementioned. Sentinel-3 (optical) and Sentinel-5p are only used alone (i.e. without other combinations) by 2 and 1 respondents, respectively.

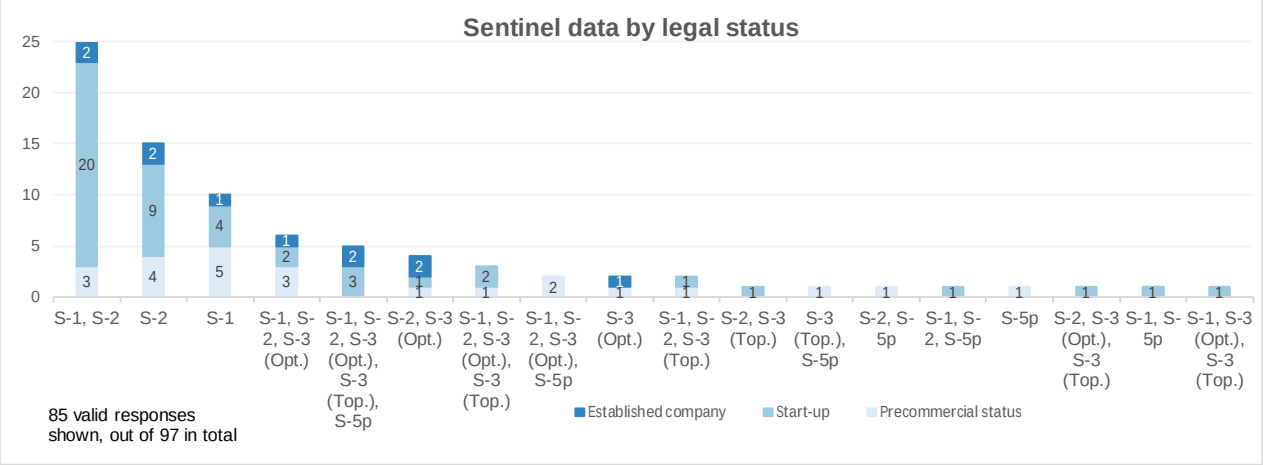

Figure 25: Sentinel data (recoded) by legal status

Q11. Which of the following best describe(s) your product/service's use of Copernicus Sentinel data?

1. Processing: Transforming data into a form suitable for analysis, including operations such as atmospheric correction, cloud detection and radiometric calibration[6].
2. Analytics - Descriptive: Providing analytical results which describe the present situation (e.g. derivation of NDVI - Sinergise's Sentinel Hub)
3. Analytics - Predictive: Providing analytical (modelling) results which predict the future situation (e.g. air pollution forecasts – AirText)
4. Analytics - Prescriptive: Providing analytical results which provide a guide to action (e.g. construction sites leading to sales opportunities - BuildingRadar)
5. Aggregation: Combining the satellite data with other information sources.

[6] [6] (Note: * "Processing" here refers only to data preparation (L0-L2), not to information extraction, which is captured by the other activities in this answer).

6. Visualisation: Creating visual representations of the data (e.g. Mapalupa, Descartes Labs)
7. Distribution: Providing access to data, via direct download, application programming interfaces (API) or web services (e.g. Sinergise's Sentinel Hub)
8. None of the above is an appropriate description / Other.

1	2	3	4	5	6	7	8
Processing	Analytics - Descriptive	Analytics - Predictive	Analytics - Prescriptive	Aggregation	Visualisation	Distribution	None of the above
40%	49%	26%	30%	46%	36%	15%	3%
Processing	Analytics			Aggregation	Visualisation	Distribution	None of the above

Figure 26: Use of data - distribution of responses. Re-coding logic shown in the last row.

Analytics – Descriptive attracted the most individual responses overall (half of the sample), closely followed by Aggregation (46%). Processing follows at 40% of responses, with the other Analytics categories and Visualisation making up a bottom tier between 26 and 36%. Only 15% of respondents indicated activity in the area of Distribution.

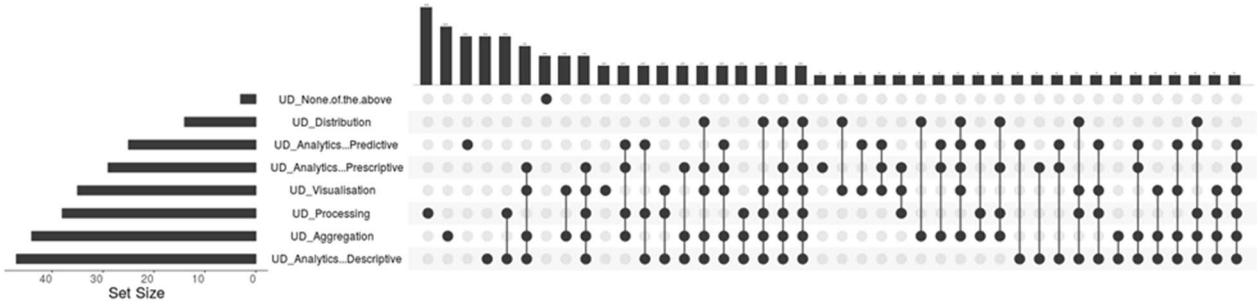

Figure 27: Use of data - intersection frequency (raw data)

However, looking at the intersection graph in Figure 27, it is clear that in practice, the answers to this question were comprised of a large number of combinations, gradually decreasing in frequency. Amongst these, Processing and Aggregation and Analytics – Predictive make up the top three positions, followed by Analytics – Descriptive. Thereafter, a long tail of low-frequency categories, involving numerous permutations of these and other categories unfolds.

With the categories re-coded[7] and somewhat simplified, a top combination emerged: Analytics, followed by Analytics, Aggregation and Visualisation.

[7] This involved merging the three Analytics categories into one, following Hartman et al., 2016.

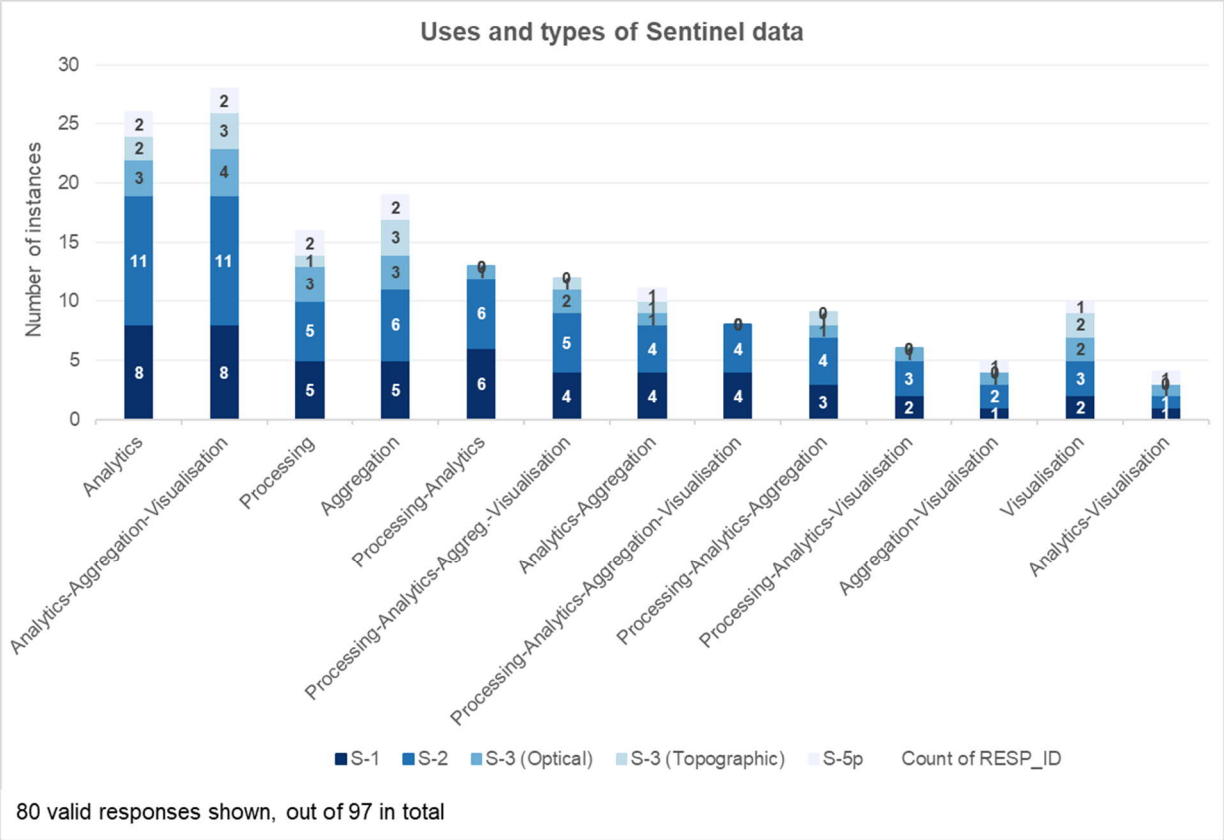

Figure 28: Use and types of Sentinel data

4.1.7 Impact of Sentinel data

This section examines how the use of Sentinel data has influenced the businesses in the survey.

Q12. Which of the following describe the impact of free and open Sentinel data on your business?

The following responses were possible (multiple choice, multiple selection):

1. Sentinel data has provided the basis for my company's competitive advantage
2. My business model would not be possible without Sentinel data
3. My business model would be possible without Sentinel data, but less efficient
4. My business model would be possible without Sentinel data, but less profitable
5. None of the above fully or accurately describes the impact of Sentinel data on my business

1	2	3	4	5
Competitive advantage	Business model not possible without	Possible, less efficient	Possible, less profitable	None of the above
33%	23%	39%	24%	8%

Figure 29: Free and open data impact - distribution of responses.

Intersection frequency across categories is not shown in detail, although some overlaps were present. Recoding the data resulted in the distribution shown in Figure 31. Most of the respondents indicated that their business models could continue, less efficiently, without Sentinel data. However, some 30

start-ups indicated that Sentinel data provided the basis for their competitive advantage or that their business models would not be possible without Sentinel data.

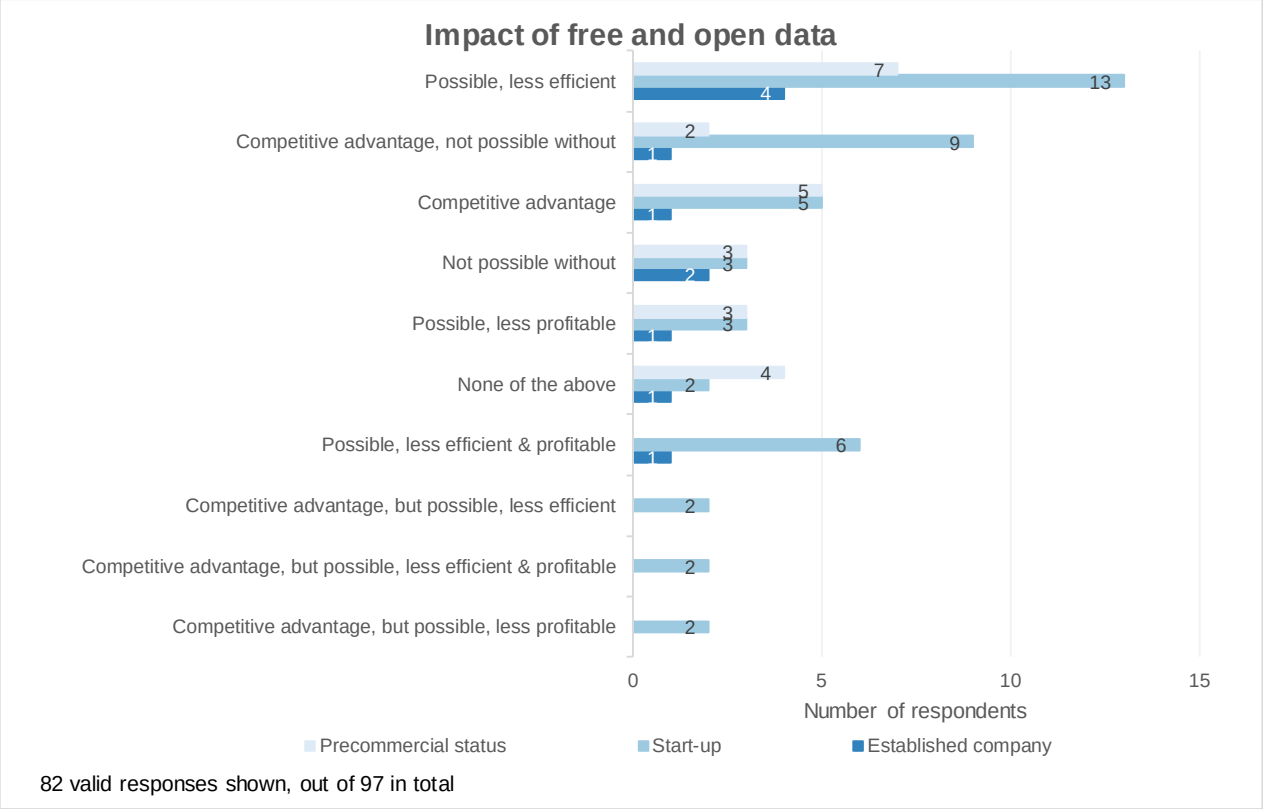

Figure 30: Impact of free and open data

4.1.8 Obstacles and challenges

This section examines the obstacles encountered and the degree of difficulty faced by start-ups.

Q13. Please rate the degree of difficulty which you have encountered for each of the areas below on the development of your concept/start-up

The following responses were possible (multiple choice, multiple selection):

1. Access to sectoral/market knowledge
2. Access to legal support or advice
3. Access to partnership opportunities
4. Access to finance or investment
5. Access to EO expertise
6. Access to Sentinel data
7. Access to infrastructure/data processing capacity
8. Other (please specify)

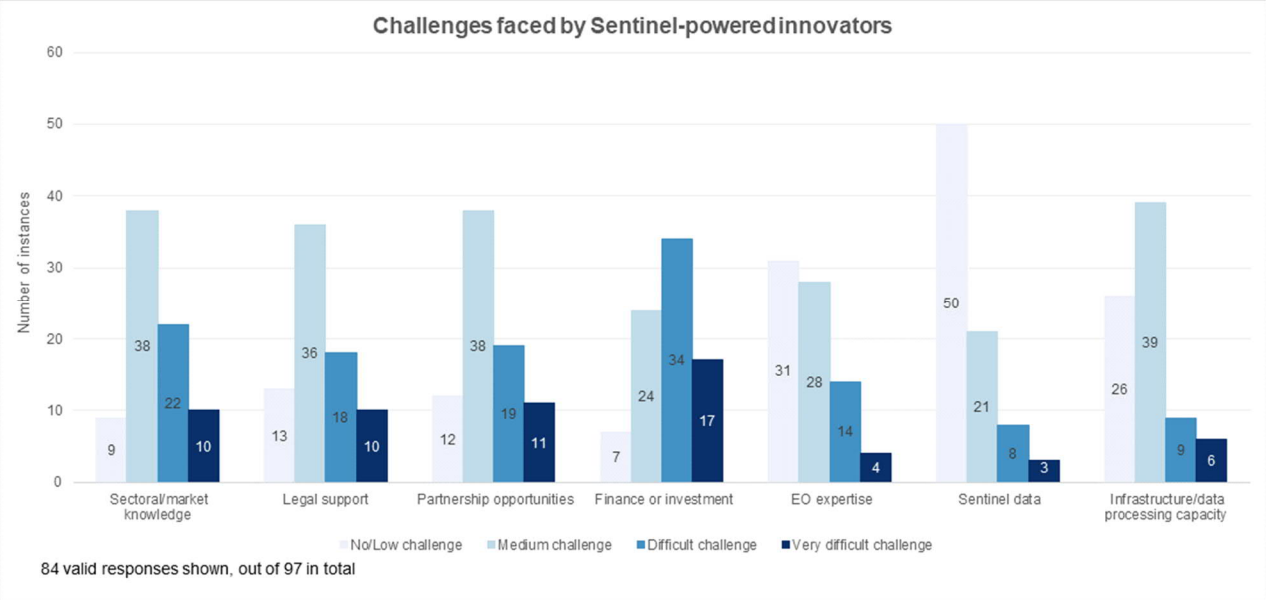

Figure 31: Challenges and obstacles

4.1.9 Success factors and incentives

This section examines incentive schemes which have supported founders, and how turnover, headcount and profit were affected by participation, as well as asking which factors contributed most strongly to their success.

How would you describe the impact of incentive schemes or programmes on the evolution of your concept/ start-up?

Scheme / Programme	Turnover			Headcount			Profit		
	HIGH	MEDIUM	LOW	HIGH	MEDIUM	LOW	HIGH	MEDIUM	LOW
Copernicus Masters	11%	9%	6%	13%	9%	6%	4%	19%	8%
Copernicus Incubator		11%		2%	11%			11%	2%
Copernicus Accelerator	6%	9%	2%	4%	9%	2%	6%	11%	4%
H2020 SME Instrument		2%			2%				2%
H2020 FTI									
H2020 IA	2%				2%			2%	
H2020 RIA	2%	2%			2%	2%	2%		2%
Other H2020			4%	2%		2%			6%
Eurostars			2%		2%				2%
ESA BIC	11%	8%	9%	8%	8%	8%	8%	8%	6%
ESA ARTES IAP / KickStart	9%	8%	4%	8%	8%	4%	4%	6%	8%
ESA Space App Camp	2%	2%		2%	2%		2%		
Other ESA	2%	9%	4%	2%	9%	4%	2%	6%	6%
Other app camp or hackathon (please specify	2%	2%			2%		2%		
Other competition (please specify)	2%		2%	2%			2%		
Other incubation scheme (please specify)		2%			4%	2%	2%	2%	
None of the above / Other									

53 valid responses shown, out of 97 in total

Percentage of respondents

Figure 32: Incentive schemes and programmes

Here, the impact of the Copernicus Masters is most evident, with 19% of respondents indicating its "medium" contribution to profit, and "high" contribution to headcount (13%) and turnover (11%). The Copernicus Incubator programme scores 11% for "medium" contribution across the three areas. ESA BIC is also notable for attracting 11% of responses in support of a "high" contribution to turnover.

4.2 Discussion

Overall, the sample is relatively small, at n=97 total respondents (of which 96 were used in the analysis). This low n was not entirely unexpected, as the European Earth Observation industry as a whole is itself relatively small (> 600 companies according to EARSC, 2017). A large sample was not a requirement for the achievement of this study's objectives, as outlined in Chapter 2. However small, the sample has generated a diverse dataset, from which a set of observations can be extracted related to the core research questions: to what extent have the Copernicus Sentinels enabled entrepreneurship and innovation, what kinds of business models are emerging as prominent, and what factors played into the success of these enterprises?

To this end, this chapter will examine the emerging observations from two main standpoints: that of the pre-commercial respondents, and that of the start-ups.

4.2.1 Pre-commercial entities

Pre-commercial participants, who did not have a legal entity in place in support of their concept or idea, made up a total of 33% of the survey respondents. Of these, most declared themselves as being affiliated with research institutes. The next most popular category is the informal group.

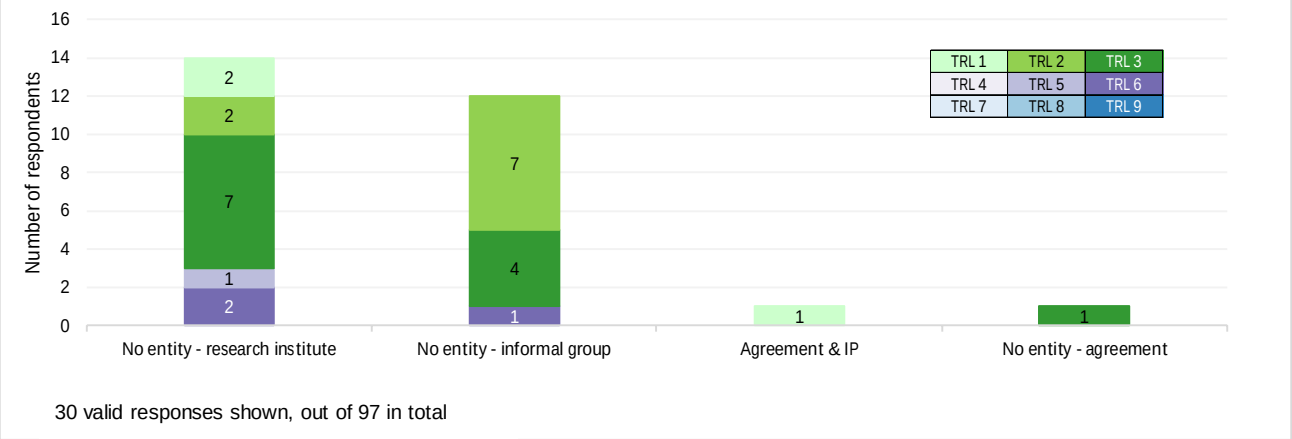

Figure 33: Distribution of pre-commercial entities, with TRL

Together, these two categories account for 90% of the precommercial entities in the survey, and the remainder of the discussion centres on the difference between these two subsets (RI for research institute-affiliated and IG for informal group). Understandably, both categories are comprised of low-TRL products, with RI holding a very slight majority (2) of products between TRL 4 and 6.

Examining the business models proposed by these pre-commercial players, Consulting and Data-as-a-Service are the most prevalent among the group, with 5 respondents each - explaining the contribution to Figure 19.

Information-as-a-Service and Geospatial VAS are next, with 2 respondents each. Following this, a "long tail" of individual responses to category combinations begins.

Amongst IG respondents, only two business models have more than 1 response each: Data-as-a-Service and Information-as-a-Service. Only RI respondents indicated Geospatial VAS as a business model, whilst only IG respondents indicated Information-as-a-Service. Beyond the top four business models, responses from both groups are thinly spread over the remaining 13 combinations. It could be suggested that the IG respondents are more uniformly distributed, whilst the RI have a clear majority within the first two options.

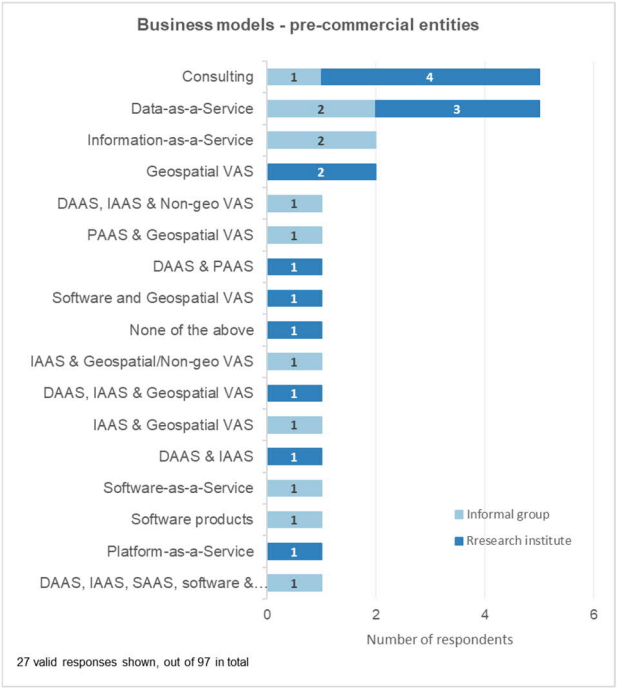

Figure 34: Business models - Pre-commercial entities

The question of challenges and obstacles is perhaps particularly relevant to the pre-commercial participants, who may find deciding whether to invest in taking a path towards full commercialisation. Examining the difference ratings provided by IG vs RI respondents, the following conclusions can be extracted:

- Access to sectoral/market knowledge is considered a medium or difficult challenge for all RI respondents, and just over half of IG respondents;
- Access to legal support or advice is considered a more challenging issue for RI than for IG respondents;
- Access to partnership opportunities is considered to be a medium challenge by both groups, with more amongst IG participants viewing it as difficult;
- Access to finance or investment is considered to be more difficult amongst IG participants, although the margin is small, and both groups seek support in this area;
- Access to EO expertise is considered a difficult challenge by more IG respondents;
- Access to Sentinel data is considered not to be a challenge by more RI respondents, whilst scores rating it difficult or very difficult are comparable across the groups;
- Access to infrastructure/data processing capacity seems to be more of a challenge for IG respondents.

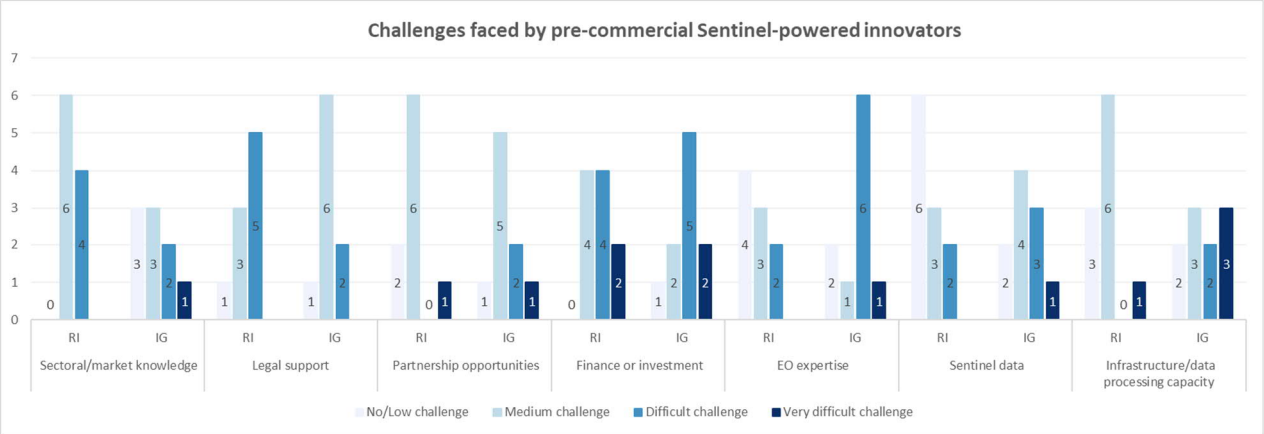

Figure 35: Challenges and obstacles - pre-commercial entities

Clear signals emerge from the respondents concerning providing market knowledge and infrastructure support to research institutes, whilst finance and partnerships are strongly sought by both sides. Perhaps most surprising is the difficulty amongst informal groups of accessing EO expertise; this may prove to be a signal of broader participation in Sentinel-powered entrepreneurship from outside the EO sector. Validated over a larger sample, these conclusions could support more targeted efforts to support entrepreneurship.

4.2.2 Start-ups

Start-ups made up about half of the sample, and are the core focus of this study.

Examining the combinations of business models, it is notable that there are some small differences with respect to Figure 9 (although clearly, start-ups made the largest contribution to the overall distribution of that graph). The entire set of responses amongst start-ups is shown in Figure 37, with 17 single-response combinations making up the long tail of the distribution[8].

Geospatial VAS remains the primary business model (8 respondents), but in this case, Software-as-a-Service follows, with Data-as-a-Service and Information-as-a-Service jointly in third position. IAAS combined with Geospatial VAS is tied (at 3 respondents) with Consulting. Finally, DAAS and PAAS are both found in combination with Geospatial VAS, and Geospatial VAS combined with non-geographic VAS, each with two start-ups embodying these business models.

Thereafter, we have 19 individual responses against a unique combination of business model elements. This may suggest vertical integration across the four tiers (or at the very least, the ambition of such integration, if the start-ups succeed in their endeavours). Figure 37 also maps the Technology Readiness Level of the start-up in the sample.

[8] There is one less response shown here than the number of start-ups (48), since this respondent skipped the question on TRL.

Around half the sample (52%) have products with a TRL between 7 and 9, whilst 35% are between 4 and 6. The remaining 12,5% are between 1 and 3, and represent six respondents amongst the top six business models. In descending order, TRL 9 (13 respondents), 6 (11) and 7 (8) are the most frequent, together making up two-thirds of this sub-set of the data.

Although the absolute numbers are small, the appearance of low- and mid-TRL products within the most common business models amongst start-ups signals the introduction of new products onto the market and hints at an innovative ecosystem, willing to test the market and commit to iterative product development.

The pattern of Sentinel data choices amongst start-ups strongly mirrors that of the general sample, as per Figure 25 – with a majority of start-ups exploiting Sentinel-1 and Sentinel-2.

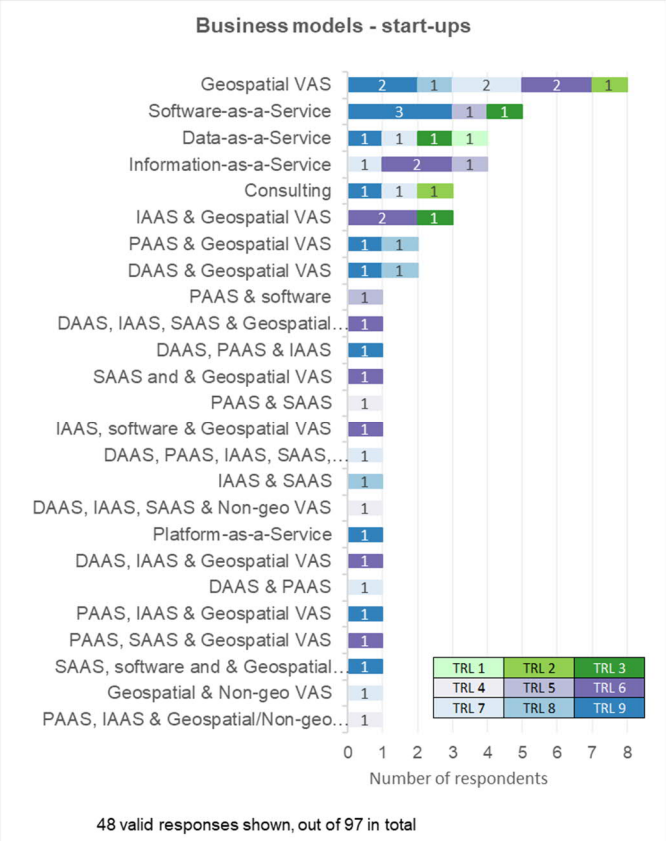

Figure 36: Business models - start-ups

Uses of data within the various business models differs somewhat, however, from the general trends identified within Figure 28. Shown in Figure 38 below are the uses of data amongst start-ups. Whilst a great variety of combined options are presented, there is a narrow majority (6) performing Analytics, Aggregation and Visualisation activities, closely followed by Aggregation (5) alone. Processing joins the three former activities in combination, alongside Analytics in its own right, both with 4 respondents.

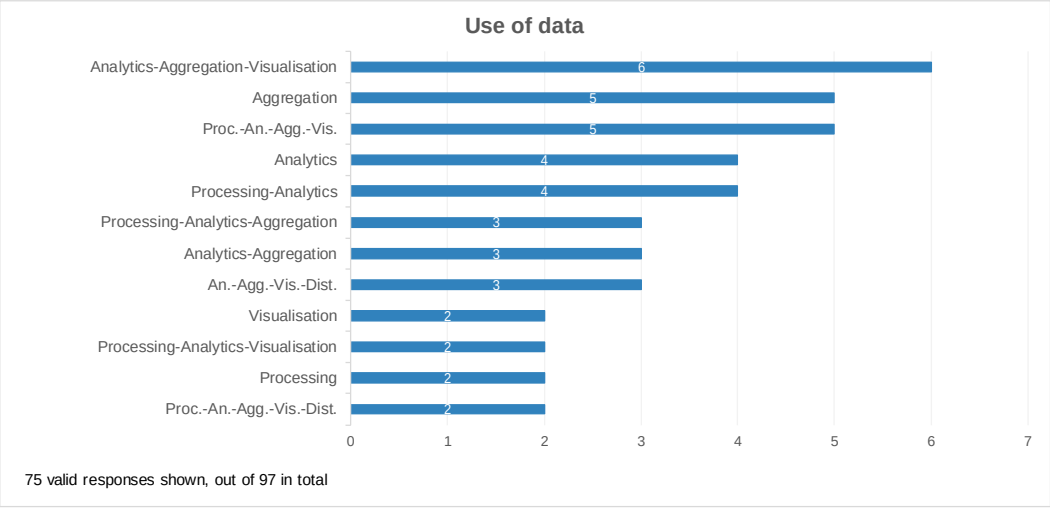

Figure 37: Uses of data – start-ups

Turning to the challenges faced by start-ups, there are three clear messages emerging from the focused query on the dataset:

- Sectoral knowledge, legal support, partnership opportunities and infrastructure are mostly regarded as medium-scale challenges, with very strong agreement in response levels.
- Access to Sentinel data is not regarded as a challenge by the majority of respondents;
- Access to finance is considered to be the most difficult challenge, in both categories of difficulty.

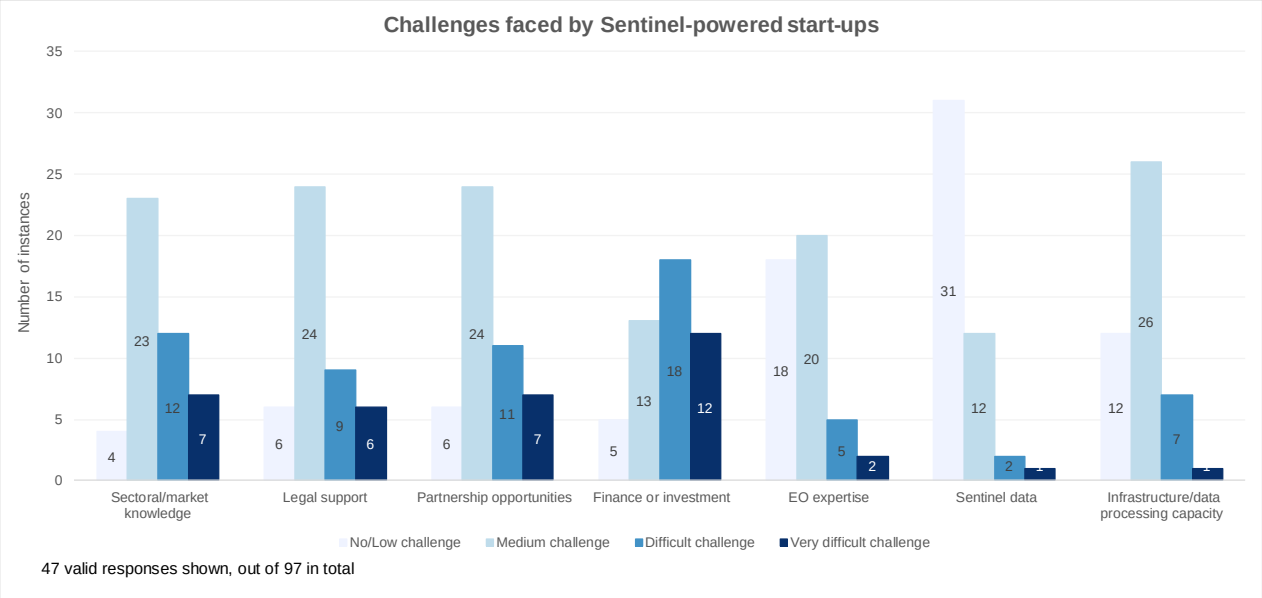

Figure 38: Challenges and obstacles – Start-ups

4.3 Success stories

This section presents selected success stories based on interview data and open sources.

4.3.1 FarmAR – Create4D

Profile

FarmAR is amongst only two other start-ups in the sample to report paying customers in the range 5.001-10.000. A summary profile of the responses provided to the questionnaire is shown below.

Legal Entity							Based	Launched
No entity - informal group	No entity - agreement	No entity - IP registered	No entity - research institute	**Start-up**	Established company	None of the above	**Netherlands**	**09/09/2014**

Business model								
Data-as-a-Service	Platform-as-a-Service	Information-as-a-Service	**Software-as-a-Service**	Software products	Geospatial VAS	Non-geo VAS	Consulting	None of the above

Target Customers			Revenue Model					
Business to Business (B2B)	**Business to Consumer (B2C)**	Business to Government (B2G)	Sale of physical products	Rent/lease of physical products	Usage fee	Subscription fee	Advertising	None of the above

Technological Readiness								
TRL 1	TRL 2	TRL 3	TRL 4	TRL 5	TRL 6	TRL 7	TRL 8	**TRL 9**

Customers	Commercial Readiness					
5.001-10.000	Not commercially available	Pre-commercial piloting (research framework)	Pre-commercial piloting (funded privately)	Commercially available (demo/trial)	**Commercially available**	None of the above / Other

Sentinel Data							
S-1: C-Band SAR	**S-2: MSI**	S-3: SLSTR	S-3: OLCI	S-3: SRAL	S-3: MWR	S-5p: TROPOMI	Other

Use of Data							
Processing	**Analytics - Descriptive**	**Analytics - Predictive**	Analytics - Prescriptive	Aggregation	**Visualisation**	Distribution	None of the above

Impact of Sentinel Data				
Competitive advantage	Business model not possible without	Possible, less efficient	**Possible, less profitable**	None of the above

Concerning the revenue model of FarmAR, a comment was provided: the product is offered for free, but with some paid extra features.

Background

Beril Sirmacek founded Create4D in 2014.The company's most successful product – the first one to rely on Sentinel data, the FarmAR App – was selected as a B2B finalist in the 2017 edition of Copernicus Masters. The product is fully automated and does not require background support on behalf of Create4D. FarmAR has been available for iOS since July 2018, and already provides worldwide service to more than 10,000 users, registering over 3,000 data requests every day. The app enables users to track vegetation density and irrigation needs, up close and for free, as well as to create their own AR content. Furthermore, it offers access to additional services such as yield prediction and disease type recognition.

To further their success, Create4D has been running user testing throughout the past six months, and the feedback is soon to be implemented into the long-awaited Android app – a response to the multitude of requests addressed daily to the company. This will allow, among else, for a service more adapt to the needs of the Indian and African markets.

Rationale or motivation behind the decision to start up

According to Ms. Sirmacek, FarmAR aims at making the free and open Sentinel data easily accessible to farmers, by improving its use in terms of both simplicity and mobility. In order to get the project running, and gain a deeper comprehension of the needs of the agricultural community, Mrs. Sirmacek spent weekends driving to farms and meeting the potential users in person. Hence, the final product adapted to users with diverse level of technical expertise in order to avoid imposing an unnecessarily tedious learning curve.

Extent to which the cost or capabilities of the Sentinels factored into the decision
FarmAR offers a feasible solution for covering the often missing link in the value chain, between the free and open data provided by Copernicus on one hand, and the end users on the other, who may benefit from a service which is easy to use and tailored to their needs. Driving factors to the decision to start up were the free availability of Sentinel data, the ease of validation, the frequency of revisit and the ease to set up API calls.

Extent to which products and services offered depend on Sentinel data

It is precisely through API calls to Sentinel Hub that FarmAR obtains the data needed (i.e. Sentinel 2 data for vegetation cover, further combined with weather forecast and other sources for soil moisture calculation). All this set up in in a simple and automatic machine-to-machine configuration that does not require additional interfaces. Ms. Sirmacek herself is not aware of alternative data sources that could have guaranteed similar ease of use and quality of the final service, such as the one provided by the Sentinels.

4.3.2 Collective Crunch

Profile

No entity - informal group	No entity - agreement	No entity - IP registered	No entity - research institute	**Start-up**	Established company	None of the above	**Finland**	**04/26/2016**

Business model								
Data-as-a-Service	Platform-as-a-Service	Information-as-a-Service	**Software-as-a-Service**	Software products	Geospatial VAS	Non-geo VAS	Consulting	None of the above

Target Customers			**Revenue Model**					
Business to Business (B2B)	Business to Consumer (B2C)	Business to Government (B2G)	Sale of physical products	Rent/lease of physical products	Usage fee	**Subscription fee**	Advertising	None of the above

Technological Readiness								
TRL 1	TRL 2	TRL 3	TRL 4	**TRL 5**	TRL 6	TRL 7	TRL 8	TRL 9

Customers
1-10

Commercial Readiness					
Not commercially available	Pre-commercial piloting (research framework)	Pre-commercial piloting (funded privately)	**Commercially available (demo/trial)**	Commercially available	None of the above / Other

Sentinel Data							
S-1: C-Band SAR	**S-2: MSI**	S-3: SLSTR	S-3: OLCI	S-3: SRAL	S-3: MWR	S-5p: TROPOMI	Other

Use of Data							
Processing	Analytics - Descriptive	**Analytics - Predictive**	Analytics - Prescriptive	Aggregation	Visualisation	Distribution	None of the above

Impact of Sentinel Data				
Competitive advantage	Business model not possible without	**Possible, less efficient**	**Possible, less profitable**	None of the above

Background

CollectiveCrunch was a Copernicus Masters finalist in 2018 for Land Monitoring. The three co-founders, are Rolf Schmitz (CEO), Jarkko Lipponen (CPO) and Christof Danzl (CTO), from Germany, Finland and Austria. They are supported by a management board and advisors. The company was listed as being in the top 15 AI Companies in Finland in 2018.

Their flagship product is Linda Forest, a SaaS-based product that predicts wood inventories for the forestry supply chain. It is capable of running on any public or private cloud infrastructure. The product predicts wood mass, wood species and wood quality more accurately than existing and conventional methods, which are generally inaccurate by 20-50% in calculating wood mass. Traditional solutions also require an operator to drive out into the woods to make manual measurements.

CollectiveCrunch solves this problem by giving the industry better prediction accuracy and reducing the time spent on manual inspection. Target customers include buyers and sellers of wood-based raw materials (logs) who wish to know the quantity and quality of wood coming into the mills on a daily basis.

Extent to which products and services offered depend on Sentinel data

Linda Forest makes use of a wide array of space data sets, optical and other, as well as Lidar and process data to accurately predict wood quality and quantity. Sentinel-2 is a contributor to the stock of data from which the market intelligence is derived. Whilst the business model could operate without Sentinel data, it would be less profitable and less efficient.

5 Conclusions

This exploratory study has examined entrepreneurship and innovation based on the use of Sentinel data, primarily amongst young start-ups and pre-commercial ventures. From a survey of 97 individuals conducted during October 2018-April 2019, the study has examined the characteristics of Sentinel-based start-ups, their business and revenue models, and entrepreneurial and technological maturity, as well as

the challenges standing in the way of Sentinel-based entrepreneurship. The main conclusions from this study are summarised as follows:

The survey attracted 48 start-up respondents from 17 countries, of which the majority were founded within the last two years. The main business models in use by start-ups are Geospatial VAS, Software-as-a-Service, followed by Data-as-a-Service and Information-as-a-Service. For pre-commercial entities, Consulting and Data-as-a-Service are the most prevalent. Sentinels-1 and -2 clearly dominate as far as the choice of datasets is concerned.

The top four business model combinations are comprised of significant (30-60%) numbers of respondents with products at TRL between 1 and 3. The high degree of business model permutation amongst respondents may suggest vertical integration across the four tiers.

Companies aiming at B2C are found mainly within the top four business models, whilst business models providing Information-as-a-Service are aimed purely at other businesses. Analytics, Aggregation and Visualisation activities are most common amongst start-ups, closely followed by Aggregation.

The main revenue model in use across the sample is subscription fees; the usage fee model is almost exclusively applied by pre-commercial entities. Extrapolating from text comments, consulting sales may also constitute a significant contributor to revenue.

A quarter of respondents stated that their products are commercially available, slightly more indicated their products are not on the market. The majority of respondents with paying customers (33 out of 58) have between 1 and 10 customers.

Most of the respondents indicated that their business models could continue, less efficiently, without Sentinel data. However, some 30 start-ups indicated that Sentinel data provided the basis for a competitive advantage and/or that their business models would not be possible without Sentinel data.

For start-ups, the main challenges are sectoral knowledge, legal support, partnership opportunities and infrastructure, and although access to Sentinel data is not regarded as a challenge by the majority of respondents, access to finance is considered to be the most difficult challenge. Amongst pre-commercial entities the main challenges are accessing market knowledge and infrastructure support (for research-based enterprises), whilst finance and partnerships are strongly sought. Amongst informal groups, the main difficulty is accessing EO expertise, which may be a sign of widening participation in Sentinel-powered entrepreneurship from outside the EO sector.

6 References

EARSC, 2007. EO Industry Survey, September 2017. Available at http://earsc.org/news/results-eo-industry-survey-september-2017. Accessed May 2019.

HARTMAN P.M., ZAKI, M., FELDMANN, N., NEELY, A. et al., 2014., Big Data for Big Business? A taxonomy of data-driven business models used by start-up firms, Working Paper, Cambridge Service Alliance.

PASSARO, R., RIPPA, P., QUINTO, I., THOMAS, A. 2016. The start-up lifecycle: an interpretative framework proposal. XVII Annual Scientific Meeting of the Italian Association of Management Engineering (AiIG), - Higher Education and Socioeconomic Development, October 13-14, 2016, At Bergamo, Italy

PWC 2019. Copernicus Market Report (2019). Available at: https://www.copernicus.eu/sites/default/files/2019-02/PwC_Copernicus_Market_Report_2019_PDF_version.pdf Accessed: May 2019.

7 Annexes

7.1 Annex 1 – Cross-tabulations

The table below provides a cross-tabulation of legal status against the eight other main variables.

		Legal Status			
		Pre-commercial status	Start-up	Established company	Unspecified
Business model	Data-as-a-Service	11	13	3	1
	Platform-as-a-Service	5	12	3	1
	Information-as-a-Service	9	17	5	1
	Software-as-a-Service	3	14	2	2
	Software products	3	5	1	1
	Geospatial VAS	10	27	10	3
	Non-geo VAS	3	6	3	1
	Consulting	13	25	8	
	None of the above	3	3	1	
Target	Business to Business (B2B)	17	44	12	2
	Business to Consumer (B2C)	8	6	1	3
	Business to Government (B2G)	13	21	7	2
Revenue model	Sale of physical products	5	18	4	1
	Rent/lease of physical products	3	5	1	
	Usage fee	15	16	2	1
	Subscription fee	12	31	8	1
	Advertising	4	3	1	
	None of the above / Other:	4	12	6	1
Technological Readiness	TRL 1	3	1		
	TRL 2	9	2	1	2
	TRL 3	12	3	2	
	TRL 4		3	2	
	TRL 5	1	3	1	1
	TRL 6	3	11		

	TRL 7		9	3	
	TRL 8		4		
	TRL 9		13	3	

Commercial	Not commercially available	18	4	3	1
	Pre-commercial piloting (research framework)	3	7	3	
	Pre-commercial piloting (funded privately)	5	7	2	
	Commercially available (demo/trial)	2	7		1
	Commercially available		20	3	1
	None of the above / Other		4	1	

Sentinel Data	Sentinel-1: C-Band SAR	15	35	6	2
	Sentinel-2: MSI	16	42	9	2
	Sentinel-3: SLSTR	7	10	4	
	Sentinel-3: OLCI	3	8	6	
	Sentinel-3: SRAL	2	10	2	
	Sentinel-3: MWR	2	3	2	
	Sentinel-5p: TROPOMI	5	5	2	
	Other	9	4	2	1

Use of Data	Processing	13	20	4	1
	Analytics - Descriptive	12	29	5	1
	Analytics - Predictive	7	15	1	2
	Analytics - Prescriptive	4	21	3	1
	Aggregation	6	30	5	3
	Visualisation	6	21	6	2
	Distribution	4	6	4	
	None of the above / Other		3		

FODP Impact	Basis for company's competitive advantage	7	21	2	2
	Business model not possible without Sentinel data	5	12	3	2
	Business model possible, but less efficient	8	24	5	
	Business model possible, but less profitable	4	16	2	1
	None of the above	4	3	1	

Figure 39: Cross-tab: Legal status vs other variables