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# Understanding Citizen Science: Insights from the 2024/2025 OpenSky Network User Survey

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**Abstract**

The OpenSky Network has grown into one of the largest community-driven air traffic surveillance infrastructures worldwide. While its data are widely used in research, comparatively little is known about the individuals who maintain the sensor network. In late 2024 to early 2025, we conducted the first large-scale user survey of OpenSky Network members to better understand the demographics, motivations, and barriers associated with participation. This paper presents key findings from more than 500 responses, highlighting who contributes to OpenSky and why, and what prevents others from becoming active feeders.

## 1. Introduction

A specific and underexplored form of scientific crowdsourcing is *stationary citizen sensing* (SCS), where individuals install and maintain fixed sensors that continuously transmit data to a central network for collection and analysis. Such networks generate global, high-resolution, real-time data and are particularly common in air quality, weather, radio spectrum, and air traffic monitoring. Beyond research [1], SCS data serve numerous applications, including policy development [2], investigative journalism [3], and even military intelligence [4]. Recent studies also highlight its value in detecting GPS spoofing and jamming incidents affecting civil aviation. [5]

Despite their growing importance, little is known about the social and behavioral mechanisms driving SCS participation. While the technical process of data collection is well understood, the human factors, i.e., who participates, why, and under what conditions, remain largely unexplored. Understanding these dynamics can improve network reliability, guide expansion strategies, and assess the feasibility of new projects.

The OpenSky Network (OSN) [6] is one such SCS initiative, focused on air traffic surveillance data, enabling over 750 academic publications with their data (as of November 2025), including the yearly OpenSky Reports ranging from current topics such as security to contrails [7, 8, 9, 10, 11, 12, 13, 14, 15, 16]. Understanding who contributes to OpenSky, and why, is vital for sustaining growth and ensuring balanced geographic coverage of the provided research data. We therefore launched a dedicated survey of OSN users in December 2024.

OSN is a global crowdsourced flight-tracking network where volunteers operate sensors that receive ADS-B and Mode S signals, and its open-science mission and accessible membership base make it a representative SCS case. Three aspects render OSN particularly suitable for investigation. First, unlike most citizen science projects, it has no single research objective; its data are available for diverse, initially unknown studies. This allows testing whether previously identified motivation patterns hold in a multi-purpose context. Second, OSN requires participants to purchase, set up, and

maintain dedicated sensors, implying higher entry costs than typical crowdsourcing models relying on smartphones or manual inputs. Third, the network is embedded in a pre-existing community of aviation enthusiasts—such as plane spotters [17, 18]. While not entirely unique in this area, this kind of synergy with hobbyist communities encourages participation. Specifically for SCS, the potential for synergy is quite significant due to interoperable receivers that enable data sharing across multiple platforms.

To discover who participates in such SCS and for what reasons, this project conducts a comprehensive survey of OSN members, examining demographic profiles, motivations for participation, and barriers to active involvement.

Our work deepens understanding of participation patterns in stationary citizen sensing projects and extends existing citizen science research to a novel technical and organizational setting.

## 2. Literature Review

Empirical research on citizen science and crowdsourcing consistently shows that participants do not accurately represent the general population. Studies report an overrepresentation of well-educated, above-median-income groups [19, 20, 21, 22]. Gender balance is uncommon: women are for example underrepresented in Volunteered Geographic Information (VGI) projects like OpenStreetMap [23, 24] or Wikipedia [25], while platforms such as Amazon MTurk show the opposite pattern [26]. Age patterns are mixed—participants often average around fifty years [27, 28], but projects with digital interfaces tend to attract younger groups [20, 29].

Motivational studies on participants are equally extensive and can be grouped by level of engagement, following Haklay's four-stage typology [30] of citizen science projects. At the low end, *crowdsourcing* involves providing data or computing power with minimal cognitive input, while *extreme citizen science* gives citizens full control of research design and execution. Most studied projects lie between these extremes, namely in the *distributed intelligence* category, where participants classify or actively collect data. Across such projects in the areas of astronomy, ecology, health, and VGI [31, 32, 33, 34], intrinsic motivations such as curiosity, learning, and contributing to science dominate.

Low-engagement projects - like distributed computing or citizen sensing - show only slightly different patterns. Participants in such initiatives emphasize altruistic motives and support for the respective underlying causes [35, 36, 37, 38]. Even when financial incentives are present, as it often is in classical crowdsourcing initiatives, intrinsic and reputational rewards remain strong motivators [39, 40, 41].

To enhance the comparability of research on participation motivations, Levontin et al. [42] proposed the *Citizen Science Motivation Scale* (CSMS), grounded in Schwartz's theory of basic human values [43, 44] and enriched by empirical results. Schwartz's model arranges twelve universal values along two bipolar axes—*openness to change vs. conservation* and *self-transcendence vs. self-enhancement*. A simplified version is shown in Fig. 1. The CSMS takes this as a point of departure and maps 280 empirically identified motivators onto it. Based on motivators that do not fit into Schwartz's framework it adds three values. These are "help with research" aligned with self-transcendence, "social expansion" aligned with openness to change, "routine" aligned with conservation, and "teaching" as a stand-alone category. This provides a comprehensive, theory-based framework for cross-project comparison.

A complementary approach by Budhathoki [33] identified twenty-four motivational categories for VGI contributors, derived empirically from volunteering, leisure, and knowledge-production literature. While less theory-driven, it captures domain-specific motivators for digital mapping and data-sharing communities underrepresented in the CSMS model. Both frameworks inform the analysis

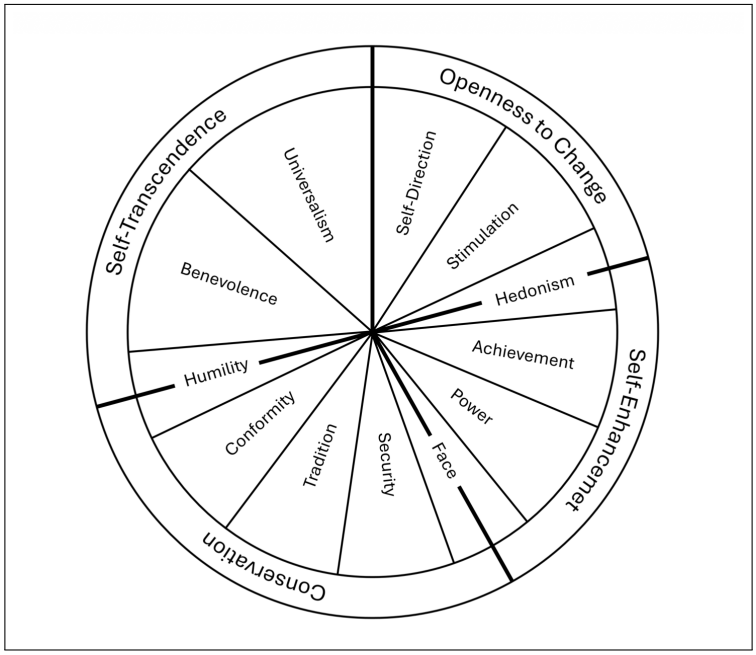


**Figure 1.** Simplified representation of Schwartz's value structure, showing twelve basic values arranged along two bipolar dimensions (adapted from [44]).

of motivations within the present study.

Research on non-participation remains scarce. Existing work [45, 46, 47] highlights the lack of time, physical ability, or skills as primary barriers.

Few studies have addressed networks comparable to OSN. Given OSN's unique combination of open data, hobbyist community, and upfront hardware investment, participation motives and deterrents may differ substantially from those found in other citizen science projects.

## 3. Theory and Hypothesis: Understanding OSN Members

Existing studies offer valuable insights into who participates in citizen science and crowdsourcing initiatives and why. This section contextualizes those findings within the OSN and formulates four hypotheses addressing demographic, motivational, and discouraging factors.

### 3.1 Demographic and Socioeconomic Factors

Empirical studies consistently show that participants in citizen science projects tend to be well-educated, above-average-income individuals from developed regions. Assuming that sensor location correlates with its owner's residence, the distribution of OSN sensors similarly indicates a dominance of contributors from Europe and North America. This can be derived more or less directly from OSN's coverage over time. [1]

Gender imbalance is also expected: men are likely to outnumber women, consistent with related hobbies such as plane spotting [17]. In addition, participants are expected to be younger than 50 years old, reflecting the technical competence required to install and maintain receivers. Because OSN participation (whether active or passive) demands little time, employment is not expected to be a factor driving up average age.

**H1:** Most OSN participants are well-educated, above-median-income males below the age of 50, living in the developed nations of the Global North.

### 3.2 Motivational and Discouraging Factors

Levontin et al. [42] present a comprehensive framework of possible motivations for citizen science participation. Applying their model to OSN, three factors stand out as particularly relevant, given the network's unique characteristics.

**Lack of a specific research goal.** Unlike most citizen science projects, OSN does not pursue a single defined research objective; its data serve diverse and independent research purposes. Prior studies suggest that clear project goals are powerful motivators. Consequently, OSN members are expected to place less emphasis on "helping with research" as a central reason for participation.

**H2:** Helping with research is not among the main factors motivating individuals to operate a sensor for OSN.

**Existing community engagement.** OSN benefits from a large, pre-existing community of aviation enthusiasts, i.e., plane spotters and users of other flight-tracking platforms, who often already possess compatible equipment. Because receivers can feed multiple networks, many OSN participants likely joined after already being active elsewhere. Routine, indicating pre-existing involvement in similar activities is thus expected to play a major role.

**H3:** Routine—being already engaged in a similar activity—is among the strongest motivators for operating a sensor for OSN.

**Financial barriers to active participation.** A further question concerns why many OSN members remain passive. Previous research highlights time and skill constraints as common deterrents. For SCS, however, an additional obstacle arises: the initial financial investment required for hardware setup. Unlike many citizen science projects that are not reliant on or supply participants with equipment, OSN depends on volunteers to purchase their own sensors. This cost barrier likely prevents some interested passive members from becoming active.

**H4:** The financial effort required to become an active member of OSN is among the most significant reasons individuals remain passive in the network.

## 4. Surveying OpenSky

We design an online survey of all OSN members to examine the community's demographic composition, motivations for maintaining an ADS-B receiver, and reasons for abstaining. Using surveys to study participation in citizen science is standard practice. [48] At the time of the survey, OSN comprised roughly 50,000 registered members, about 5,000 of whom operate(d) at least one sensor.

Ethical approval was granted by the ETH Zurich Ethics Committee (Application No. ETHICS-403). The survey was hosted on *Qualtrics*, tested with nine pilot participants, and optimized for different devices. Recruitment occurred via the OSN newsletter and homepage as well as the OSN Discord group. To increase participation, an ADS-B receiver kit (Raspberry Pi + antenna) was raffled among respondents, an incentive expected to attract non-sensor owners in particular.

For representativeness, a 90% confidence level with a 5% margin of error required at least 258 active sensor owners and 270 passive, non-sensor-owning respondents, though all members were encour-

aged to participate. The questionnaire began with demographic questions and then branched into two paths: one for sensor owners (motivations) and one for non-owners (deterrents). Except for age, questions were non-mandatory. The complete survey instrument is provided in the Appendix.

### 4.1 Demographic and Socioeconomic Questions

To address **H1**, participants provided information on age, gender, residence, education, occupation, and income. Two additional questions asked about proximity to airports and employment in the aviation sector. Because OSN is international, income was measured subjectively by asking respondents to place themselves within national income quintiles, following the World Values Survey approach. [49] This relative measure avoids conversion barriers while capturing socioeconomic position. [50]

Education was classified using the 2011 International Standard Classification of Education (ISCED), condensed into eight levels from "no education" to "doctoral degree." Examples such as "years 1–6" or "licence / bachelor's degree" ensured clarity across countries. This structure facilitated consistent data collection across OSN's global membership.

### 4.2 Motivational Questions

The motivation module tested **H2** and **H3**. It combined elements from Levontin et al.'s Citizen Science Motivation Scale (CSMS) [51, 42] with items from Budhathoki [33], whose work on OpenStreetMap (OSM) mirrors OSN in some key asspects: no single research goal, global reach, absence of time constraint for contributions, and visibility of individual input on a map.

Where both frameworks overlapped, similar motivational categories were merged; where they diverged, alignment followed Schwartz's value definitions [44] and item examples. Notable adjustments included:

- *Instrumentality of local knowledge*: emphasizing the sense of indispensability of one's own contribution is mapped to the "achievement" value.
- *Unique ethos*: reflecting pro open data and anti-corporate attitudes is aligned with "social universalism".
- *Meeting self-needs*: where individuals participate out of need for the content resulting from the contribution (e.g., a map) is associated with "self-direction".
- *Fun*: captured under "hedonism," with added salience from the immediate visibility of one's contributions on a live map.
- *System trust*: excluded, as it represents a prerequisite rather than an intrinsic motivation for participation.

Six of Levontin et al.'s categories found no counterpart in Budhathoki's typology, likely due to the latter's empirical, rather than theoretical origin. Consequently, Levontin's CSMS, enriched with Budhathoki's compatible items, formed the basis for OSN's motivational survey.

After merging and refinement, 64 items across 18 categories were reduced to 37 items within 15 categories. Following Levontin et al.'s guidance, at least two items per category were retained. Redundant or overlapping items were merged, and the least relevant categories "tradition" and "stimulation–active" were removed. The live survey presented these statements as a randomized carousel with a five-point Likert scale (*not important – very important*) plus an "irrelevant" option and one attention check.

### 4.3 Deterrence Question

Respondents who indicated they did not operate a sensor were redirected to a multiple-choice question listing thirteen possible deterrents (select one to three). This section tested **H4**. The list combined literature-derived and context-specific factors, including concerns about data sharing and perceptions of local sensor saturation. An open-text "other" option captured additional reasons.

Beyond testing **H4**, this analysis helps identify low-effort strategies for converting passive members —OSN's "low-hanging fruit"—into active contributors. For example, if technical difficulty emerges as a common barrier, clearer setup documentation could effectively expand coverage.

### 4.4 Methods

Demographic data were analyzed descriptively and compared between active and passive members using Mann–Whitney, $\chi^2$, and, where necessary, Fisher's exact tests. Motivational constructs were validated via Confirmatory Factor Analysis (CFA) to assess model fit, reliability, and validity [52]. Composite reliability was measured with McDonald's $\omega$, with thresholds of 0.7 or higher considered acceptable [53]. Convergent validity was assessed through factor loadings ($\geq$ 0.5 acceptable, $\geq$ 0.7 ideal) and Average Variance Extracted (AVE $\geq$ 0.5). Discriminant validity was evaluated using a correlation threshold of 0.85 [54].

Responses failing the attention check were excluded. For each participant, category means were computed (excluding "irrelevant" responses), allowing comparison of the relative importance of 15 motivational factors. Category means $\leq$ 2.3 indicated low importance, 2.3–3.7 medium, and $\geq$ 3.7 high. Results were also compared between OSN and other networks' sensor operators to test **H2** and **H3**.

Finally, deterrence responses were summarized by frequency and region, and open-ended comments were analyzed qualitatively to identify emerging themes and actionable insights.

## 5. Results

**Table 1.** Age distribution of OpenSky Network survey participants by sensor ownership.

| Age group | No Sensor (n) | % | Sensor (n) | % |
|---|---|---|---|---|
| <18 | 0 | 0.00 | 0 | 0.00 |
| 18–24 | 13 | 5.53 | 10 | 3.15 |
| 25–34 | 27 | 11.49 | 39 | 12.30 |
| 35–44 | 52 | 22.13 | 72 | 22.71 |
| 45–54 | 42 | 17.87 | 86 | 27.13 |
| 55–64 | 56 | 23.83 | 67 | 21.14 |
| 65–74 | 39 | 16.60 | 36 | 11.36 |
| >75 | 6 | 2.55 | 7 | 2.21 |
| **Mean age** | 49.20 (SD = 14.90, 95% CI: [48.00, 50.40]) | | | |
| **By group** | **Mean** | **SD** | **Lower 95% CI** | **Upper 95% CI** |
| No Sensor | 49.90 | 15.27 | 47.29 | 51.11 |
| Sensor | 48.90 | 13.80 | 47.56 | 50.84 |

The survey was open for ten weeks, starting on December 22, 2024. In total, 858 individuals clicked the link, and 596 provided at least partial answers. Nearly 95% of responses were collected via newsletter invitations, with the remainder recruited through the OpenSky website and Discord channel. Of these, 552 completed the demographic questions, including 317 sensor owners. Given the

network's size at the time, active participants were overrepresented, an expected outcome given their high engagement level. While this slightly limits generalizability for passive members, the overall sample remains informative.

## 5.1 Demographic Factors

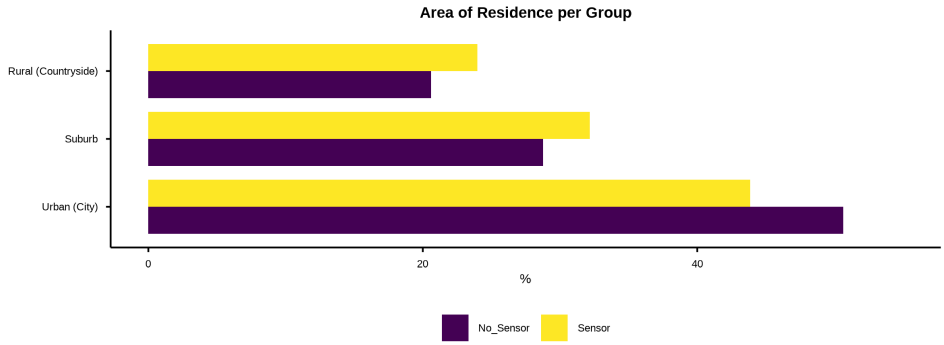


**Figure 2.** Participants' area of living.

Most respondents were male, residing in Europe or North America. 56.9% of respondents lived in Europe, 29.2% in North America, and 9.9% in East Asia and the Pacific; the remaining participants were distributed across Latin America (1.9%), South Asia (1.4%), and MENA or Sub-Saharan Africa (0.7%) (see Fig. 3). Only 22.5% reported living in rural areas (see Fig. 2). Most were employed in the private sector (55.1%), with 30.2% working in aviation-related fields. Over half (51.9%) said their daily lives were at least somewhat affected by airport activity.

Active and passive members were broadly similar across demographic variables except for gender (Fisher's exact test), primary occupation ($\chi^2$ test), and income (Mann–Whitney). Only two female respondents operated a sensor. While most respondents were full-time employees (62.8%), active members were more likely to be employed full-time or unemployed, whereas passive members were more often students, retired, or part-time employees. Active members' average income was 0.3 quintiles higher than that of passive members (3.6 vs. 3.3).

The findings largely support **H1**: most OpenSky members are well-educated, above-median-income males under 50 living in developed nations. Approximately 76% hold at least a bachelor's degree, while none reported only primary education. Overall, 94% identified as male, 2.8% as female, and 3.2% preferred not to say. Respondents came from 56 countries, with 25.6% from the United States. The U.S., Germany, the U.K., and France accounted for more than half (53.6%) of all responses. Only 4.4% of participants came from major emerging economies, and just 0.4% from least developed countries. The average age was 49.2 years, with an upper 95% confidence bound of 50.4—suggesting members are around, but not clearly below, 50. Table 1 shows the full distribution.

## 5.2 Motivational Factors

As shown in Table 2, a total of 317 respondents reported operating a sensor, though 71 did so for other networks. Of these, 285 answered more than half the motivational items, and 277 valid responses remained after excluding nine who failed the attention check.

Confirmatory Factor Analysis (CFA) indicated a moderate model fit ($p(\chi^2) < 0.05$, CFI = 0.91, RMSEA = 0.04, SRMR = 0.07). Reliability and validity tests show that categories such as *face*, *social expansion*, *security*, *benevolence*, *universalism*, *help research*, and *teaching* demonstrated satisfactory composite

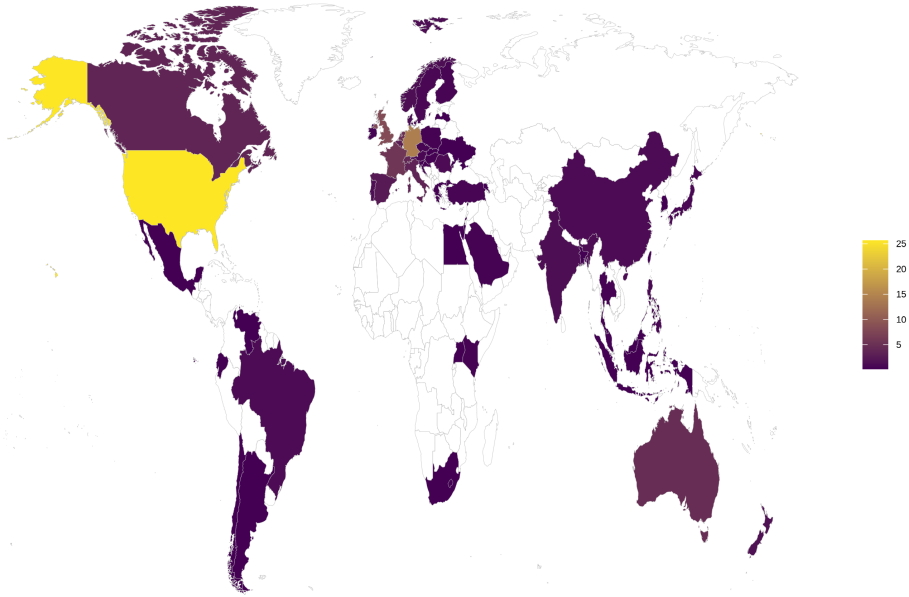


**Figure 3.** Participants country of residence.

reliability and convergent validity. *Conformity* and *self-direction* were acceptable but weaker, while *routine* performed poorly, lacking both internal consistency and convergent validity.

**Table 2.** Sensor ownership among OpenSky Network survey participants.

| Sensor ownership | Frequency | % |
|---|---|---|
| I operate a sensor, but it does not contribute to OpenSky | 71 | 12.86 |
| No sensor | 235 | 42.57 |
| Yes, I operate an OpenSky sensor | 246 | 44.57 |

Descriptive results revealed that "help research" ranked among the most important motivators ($p = 0.95$ for $H_0$: true mean $\geq 3.7$), whereas "routine" showed only moderate importance ($p < 0.001$). Relative thresholds, however, suggest that "routine," along with several other factors, still ranks among the key motivators. Neither **H2**: Helping with research is not among the main factors motivating individuals to operate a sensor for OSN, nor **H3**: Routine—being already engaged in a similar activity—is among the strongest motivators for operating a sensor for OSN find support in the data at hand.

When separating OpenSky contributors from those operating sensors for other networks, notable differences emerged, especially in the *face* and *power resources* categories. Mann–Whitney tests ($p < 0.05$) and OLS regressions controlling for demographics confirmed these as significant. OpenSky participants appear less motivated by social recognition and personal gain than participants in other flight-tracking networks. Even with the grouped data, neither **H2** nor **H3** is supported.

Item-level analysis showed that "I am interested in aviation" and "I want to contribute to independent, open-access data initiatives" were the strongest motivators (means of 4.25), while "I want to

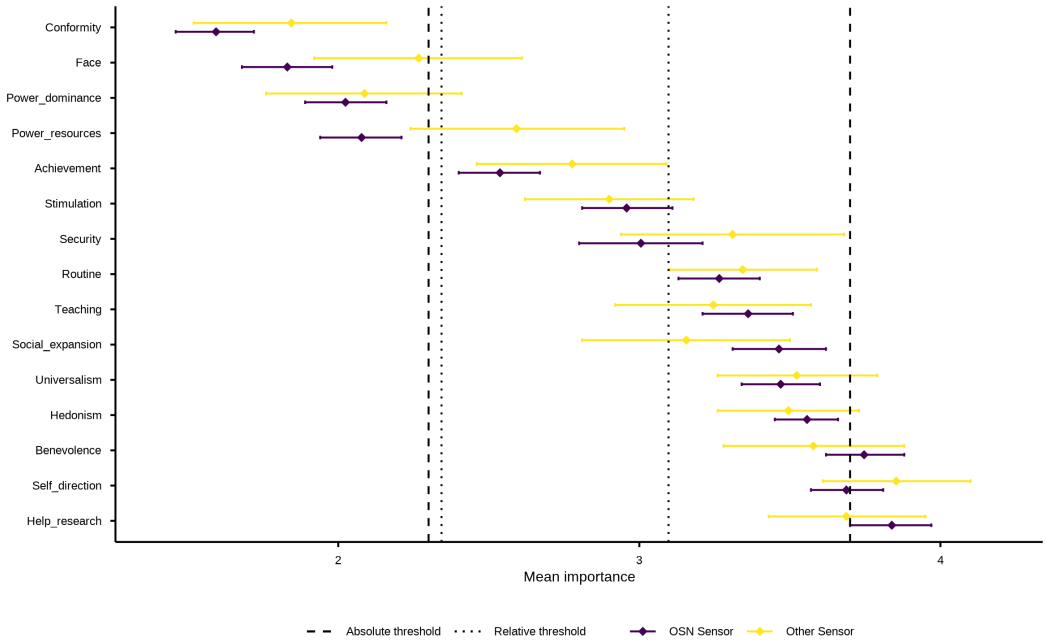


**Figure 4.** Mean and confidence intervals of motivational factors, grouped by people who contribute to OS and people who contribute to other networks.

gain financially" was the least (2.24). The two items most often rated "irrelevant" were "I was requested to participate by somebody" and "I am required to take part in such a project," both reflecting minimal conformity motivation.

### 5.3 Deterrent Factors

Among 235 respondents without a sensor, financial cost emerged as the leading deterrent (see Fig. 5), supporting **H4**. Cost concerns dominated across all regions but were particularly pronounced outside Europe and North America. In the North America, lack of interest was most cited, while in the Pacific region, respondents noted limited personal benefit. European respondents most often referenced resource conservation or environmental considerations. Obstacles identified as relevant in the literature, like insufficient skills and time constraints, are not pivotal for OSN.

Open-ended "other" responses were few and did not deliver additional insights: several participants intended to set up a receiver but had not yet done so, while others cited broken or unreplaced hardware. These comments broadly echoed predefined categories.

### 5.4 Discussion

With the exception of age, demographic findings fully supported **H1**. OpenSky participants are, on average, around 50 years old—slightly older than participants in many other technology-based citizen science projects. The significant gender imbalance was anticipated. As data is collected by sensors this doesn't impact data quality. The limited participation of individuals from the Global South is more consequential, as it affects network coverage and representativeness.

The motivational results did not support **H2** or **H3**. "Helping research" was confirmed as a strong motivator, while "routine"—though conceptually plausible—lacked empirical validity. The CFA re-

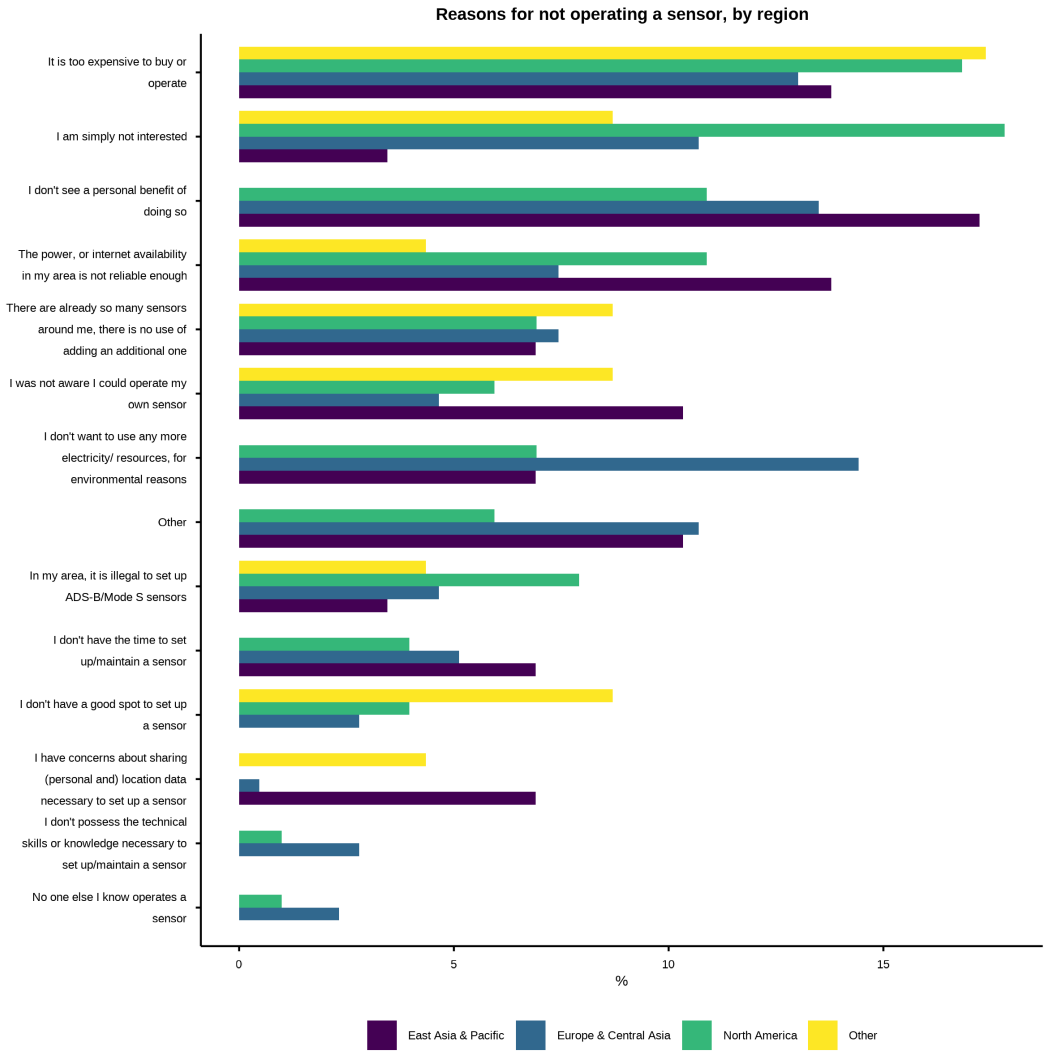


**Figure 5.** Reasons for not operating a sensor by region.

sults suggest that respondents may group motivational items differently from the predefined structure, indicating a need for theoretical refinement in future work. High inter-category correlations were also observed, consistent with Schwartz's (2012) notion of fluid value boundaries.

Finally, deterrence results clearly supported **H4**: the financial cost of equipment remains the main obstacle to active participation. Motivation alone is insufficient for engagement—practical and economic barriers also matter. Addressing these could involve distributing free or subsidized sensors or emphasizing exclusive benefits for contributors (e.g., personal dashboards or data visualizations).

Interestingly, while "too many sensors nearby" was a relevant deterrent, "poor coverage in my area" was only a moderate motivator, suggesting that awareness of network needs does not directly drive participation. Future recruitment strategies should therefore target both motivation and material accessibility.

## 6. Limitations

One limitation of the type of survey that was conducted is, that participants self-selected for the survey. This introduces certain bias in the data, which is almost inescapable with the given online setup [55]. The fact that helping research is identified as the most important motivational factor might have been influenced by such a self-selection bias. Specifically, it could be assumed that the general predisposition toward responding to surveys is higher among people interested in research than those not. The raffle that was intended to motivate more people to participate might have helped balance out the rate between active and passive members a bit, but in the end, the response rate among the active members was still higher.

## 7. Conclusion

The survey conducted among OpenSky Network members offered valuable insight into who participates in sensor-based citizen science projects and why. The results confirm that OSN's active community largely consists of well-educated, above-median-income males from Western countries. Despite OSN's digital nature, the average participant age was around 50, contrary to expectations that technology-driven citizen science attracts younger individuals.

Motivational analysis revealed that *helping research* was the most important factor driving participation. This finding is striking, as OSN contributors are not aware of any single, clearly defined research goal; instead, their data are made openly available for scientific use across domains. This is further supported by the item level results, which underscores the appeal of contributing to open, independent research. Routine engagement, such as maintaining existing aviation-related hobbies, was also relevant but measured less reliably, suggesting that the underlying construct may require further refinement.

The deterrence analysis identified *financial cost* as the strongest barrier preventing individuals from operating a sensor. This confirms **H4** and aligns with broader findings on material constraints in citizen science participation. Importantly, this barrier was most acute in regions with limited network coverage, suggesting that financial support programs, such as distributing or subsidizing sensors, could meaningfully expand OSN's global footprint. In contrast, in wealthier regions such as Europe and North America, disinterest and environmental considerations were cited more frequently as reasons for non-participation.

The survey also highlighted regional disparities in participation: while the network's presence remains concentrated in Europe and North America, engagement is very limited in the Global South. This pattern reflects both economic and infrastructural inequalities. Addressing these gaps will require targeted strategies, combining awareness campaigns with practical support, to enhance inclusivity and coverage.

Finally, results from both motivational and deterrent analyses point to a broader lesson for SCS and specifically OSN: while interest in the topic and financial aspects matter, maintaining the network's *open-access, independent character* is a central motivational driver for contributors. The most highly rated individual motivation - "I want to contribute to independent, open-access data initiatives" - emphasizes that participants value openness and trust as much as technological innovation. Strengthening this message, while exploring low-cost ways to support new contributors, could help OSN and the researchers, who use its data, sustain growth and broaden participation in the long term.

## Author contributions

- First Author: Data Curation, Formal Analysis, Investigation, Methodology, Software, Supervision, Validation, Visualization, Writing (Original Thesis)
- Second Author: Conceptualization, Supervision, Survey Planning, Writing - Second Draft
- Third Author: Conceptualization, Supervision, Writing - Second Draft
- Forth Author: Conceptualization, Supervision, Project Administration, Resources, Survey Planning, Visualization, Writing - First Draft

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## Open data statement

We make available the full R notebook for data analysis of the survey data. For reasons of individual anonymity data privacy and ethics requirements, we cannot make available the individual survey responses.

## Reproducibility statement

We make available the full R notebook for data analysis of the survey data. For reasons of individual anonymity data privacy and ethics requirements, we cannot make available the individual survey responses.

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# Appendix 1. Questionnaire

### Informed Consent Form

Welcome to the OpenSky Survey!

This survey is conducted as a part of a master's thesis project at ETH Zurich and the Cyber-Defence Campus. The goal is to understand the makeup of the OpenSky Network (OSN) and the reasons why members of the network choose to participate actively as sensor operators or remain passive members. Gaining these insights can help enhance engagement and data coverage within OSN and similar networks, supporting broader public access to aviation and other data. Participation is voluntary, and you may withdraw at any time. To participate, you must have an OSN user account and be at least 18 years old. At the end of the survey, you may choose to leave your e-mail address to participate in a price draw for a new ADS-B/Mode S sensor. The survey takes around 5-10 minutes to complete. The survey will ask for your OSN username. This is simply to confirm your membership and, if you operate a sensor, link your responses to sensor activity data. This helps us better understand the network's patterns. Please note that this does not involve accessing or analyzing your personal activity on the OSN in any way. In accordance with the ethical guidelines of ETH Zurich, your information will be treated strictly confidentially, and the identifying information will be removed before data analysis. No conclusions will be drawn about your person at any time. Please read the information above carefully. By clicking "Next" you consent to participate in the survey. We thank you in advance for taking your time to participate! If you have any questions about the study, please contact jinauen@student.ethz.ch anytime. This study was reviewed and approved by the ETH Zurich Ethics Committee under application number 24 ETHICS-403. The secretariat of the ETH Zurich Ethics Committee is available to help you with complaints in connection with your participation in the study. Contact: ethics@sl.ethz.ch or 0041 44 632 85 72.

### Q1

What is your OpenSky username? Please make sure the spelling is correct.

### Q2

How old are you?

- younger than 18 (1)
- 18-24 (2)
- 25-34 (3)
- 35-44 (4)
- 45-54 (5)
- 55-64 (6)
- 65-74 (7)
- older than 75 (8)

### Q3

What is your gender?

- Male (1)
- Female (2)
- Non-binary / third gender (3)

- Prefer not to say (4)

Q4

What country do you live in? Please enter and select the country's English name below.

Q5

What type of area do you live in?

- Rural (Countryside) (1)
- Urban (City) (2)
- Suburb (3)

Q6

How much is the area where you live influenced by the presence of an airport (e.g., through noise, visual presence, ...)?

- Very much (1)
- Somewhat (2)
- Not much (3)
- Not at all (7)

Q7

What is your highest completed level of education?

- No education (1)
- Primary education or less (e.g., years 1-6, ...) (3)
- Lower secondary education (e.g., years 7-9, middle school, ...) (4)
- Higher secondary education (e.g., high school, basic vocational training, ...) (5)
- Short tertiary education (e.g., extended professional training, ...) (6)
- Bachelor's degree or equivalent (e.g., undergraduate, licence, ...) (7)
- Master's degree or equivalent (8)
- Doctoral degree or equivalent (9)

Q8

What is your current primary occupation?

- Unemployed (1)
- Student (2)
- Self-employed (4)
- Part-time employed (5)
- Full-time employed (6)
- Retired (7)
- Other (8)

Q9

What sector are you primarily occupied in?

- Private business or industry (1)
- Academia (2)
- Other public or government insitution (3)
- Private non-profit organization (4)
- Other (5)

Q10

Is your occupation in any way related to aviation?

- Yes (1)
- No (2)

Q11

What is your income group?

Below you see a scale from 1 to 5. On this scale, 1 represents households in the lowest 20% of income in your country, while 5 represents those in the highest 20%. Please indicate what group you think your household belongs to by adjusting the slider. Consider all wages, salaries, pensions and other kinds of income of your household when doing this.

Slider with levels 1-5

Q12

Do you own and operate a ADS-B/Mode S Sensor that contributes to OpenSky?

- Yes (1)
- No (2)
- I operate a sensor, but it doesn't contribute to OpenSky (3)

Q13.1

What are the main reasons you do not own a sensor? Select up to 3 responses. (List randomized for respondents)

- It is too expensive to buy or operate (1)
- I don't have the time to set up/maintain a sensor (2)
- I don't possess the technical skills or knowledge necessary to set up/maintain a sensor (3)
- I have concerns about sharing (personal and) location data necessary to set up a sensor (4)
- I was not aware I could operate my own sensor (5)
- There are already so many sensors around me, there is no use of adding an additional one (6)
- I don't see a personal benefit of doing so (7)
- The power, or internet availability in my area is not reliable enough (8)
- I don't have a good spot to set up a sensor (9)

- I am simply not interested (10)
- I don't want to use any more electricity/resources, for environmental reasons (11)
- In my area, it is illegal to set up ADS-B/Mode S sensors (12)
- No one else I know operates a sensor (13)
- Other (please indicate the reason) (14)

Q13.2

Motivations for operating a Sensor.

This part of the survey explores your motivation for maintaining a sensor and participating in the OpenSky or a similar Network. Using a scale from 1 (not important) to 5 (very important), please rate how important each of the following reasons is for your participation. We encourage you to use the full range of the scale when answering. If a statement doesn't apply to you, feel free to select "irrelevant."

Options provided to users shown in Table 3.

Q14

If there is anything you would like to add to your responses, feel free to leave a comment below.

**Table 3.** Motivational items and their corresponding categories.

| Category | Item Nr | Description |
|---|---|---|
| Self-direction | 1 | I want to learn about aviation, airspace security, or similar. |
| | 2 | I am interested in aviation. |
| | 3 | I contribute because it gives me access to information that I need. |
| Stimulation | 4 | I want to do something new. |
| | 5 | I want to break away from my routine. |
| Routine | 6 | Maintaining an ADS-B/MODE-S sensor is related to another hobby I have (e.g., plane spotting). |
| | 7 | I was maintaining an ADS-B/MODE-S sensor anyway (e.g., as part of my job/studies). |
| | 8 | I'm a regular participant in citizen science, crowdsourcing, or similar projects. |
| Hedonism | 9 | I enjoy maintaining an ADS-B/MODE-S sensor. |
| | 10 | I enjoy seeing my own contributions appear on the map and/or my personal dashboard. |
| | 11 | I am passionate about the OpenSky Network. |
| Achievement | 12 | I want to advance my career. |
| | 13 | It's an opportunity to perform better than others. |
| | 14 | I want to provide sensor coverage in an area that is otherwise badly/not covered. |
| Power resources | 15 | I want to gain financially. |
| | 16 | I expect something in return (e.g., general data access, newsletter, personal dashboard, ...). |
| Attention test | 17 | If you are actively reading this, please select five. |
| Power dominance | 18 | I want to gain recognition and status. |
| | 19 | Providing OpenSky with data makes me feel important. |
| Face | 20 | I want to enhance my reputation. |
| | 21 | Other people think positively about my contribution to OpenSky. |
| Social expansion | 22 | I want to be part of this volunteer community. |
| | 23 | I want to feel part of something worthwhile. |
| Security | 24 | I want to keep myself secure and healthy. |
| | 25 | I want to live in secure surroundings. |
| Conformity | 26 | I am required to take part in such a project. |
| | 27 | I was requested to participate by somebody. |
| | 28 | Other people I know are participating. |
| Benevolence | 29 | It is a good thing to do. |
| | 30 | I want to contribute to my community. |
| Universalism social | 31 | I want to improve our society. |
| | 32 | I want to contribute to independent, open-access data initiatives. |
| | 33 | I want to raise public awareness about aviation. |
| | 34 | I want to protect the environment. |
| Help with research | 35 | I want to contribute to the knowledge about aviation. |
| | 36 | I want to contribute to scientific research. |
| Teaching | 37 | I want to provide learning opportunities to others. |
| | 38 | I want to share my knowledge and experience. |