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Exploring Unidentified Aerospace Phenomena through Instrumented Field Studies: Historical Insights, Current Challenges, and Future Directions

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ABSTRACT

The study of Unidentified Aerospace Phenomena (UAP) requires a shift from a historical, narrative-based approach to a scientific and technology-based study. To conduct unbiased and agnostic research on UAPs, rigorous scientific study is necessary, including the collection of hard data to support credible explanations or scientifically prove the existence of unknown phenomena. Obtaining reliable and valid data requires instrumented observations, including multi-wavelength and multi-mode sensors (e.g., optical, radar, infrared). We present herein an overview of the benefits as well as the strategic and tactical considerations of instrumented field studies, highlighting common limitations and shortcomings with the objective of contributing to the development of future projects. We provide an overview of some past and current UAP military and civilian projects and analyze a timetable of instrumented projects spanning the years 1950-2023, encompassing contributions from both citizen science and professional/academic science. In conclusion, this paper reflects on how UAP field experiments might look going forward. Newer technologies like digital cameras, scientific instruments, computing, big data analytics, artificial intelligence, and satellite imagery are becoming more advanced and cost-effective. This is leading to the growth and progress of technical field studies, complementing local projects with global-scale investigations. Researchers can enhance their chances of success by adopting a more disciplined approach and exploring innovative avenues. Collaboration, transparency, and standardization in data collection and analysis are crucial, while also acknowledging the complex nature of the UAP phenomenon.

1. Introduction

Over several decades, UAP research has focused mainly on collecting eyewitness reports and supplementing them using various measurements, many of them retrospectively such as physical traces, radar scope data, photographs, film and video footage, physical effects, and medical records, when these are available. This approach has been necessary as UAP events are often brief and unpredictable, making it challenging to study the phenomenon in a rigorous and empirical manner. Researchers quickly recognized the need for a new methodology to advance our understanding of the UAP phenomenon, as existing data was insufficient. Instead of post-event analysis, a proactive investigative approach was necessary. This required trained observers with suitable instruments to be present and record UAP events, or the deployment of automatic stations for continuous monitoring of a large area during long periods.

Despite decades of stigma and negative perception towards UAP study, some civilians, organizations, and scientists have conducted instrumented field studies to detect and measure aerial anomalies. These efforts demonstrated that UAP can be studied scientifically, even before the recent renewed interest. Since 2017, the US government's perspective on the role of science in the study of UAP has shifted dramatically. The Office of the Director of National Intelligence's report (ODNI) to Congress in June 2021 (ODNI 2021) emphasized the scientific importance of UAP and recommended their continued study with improvements in data collection and analysis software, including the use of artificial intelligence. The Department of Defense (DoD) subsequently established the All-Domain Anomaly Resolution Office (AARO, website) to lead efforts to document, analyze, and resolve reports of UAP using a rigorous scientific framework and data-driven approach. The engagement of the US government has significantly enhanced the credibility of the topic, sparking heightened scientific interest within the field. As a result, there has been a notable surge in instrumented field studies concentrating on the lower atmosphere, as well as the increasingly important near-Earth space environment.

The paper is organized as follows: In section 2 we provide an overview of instrumented field research, discussing its benefits, purposes, and strategic as well as tactical aspects. Section 3 presents and discusses a comprehensive timetable of instrumented projects spanning the years 1947 to 2023. Section 4 offers an overview of noteworthy past UAP projects, spanning both military and civilian domains. We delve into the challenges these projects encountered, ranging from organizational hurdles to funding and data collection. Additionally, we emphasize the unique characteristics of civilian projects, distinguishing between citizen and academic science efforts, with the aim of refining future endeavors. Section 5 briefly highlights the common limitations and shortcomings observed in past instrumented projects, providing additional insights for improving future research. Section 6 showcases the novel citizen and academic scientific projects launched in recent years. We explore potential directions for future UAP field experiments in section 7, discussing important considerations and suggesting recommendations to enhance the rigor and effectiveness of this field research. The paper concludes with a summary of findings and key takeaways in section 8.

2. Instrumented field studies

2.1 Benefits

Deploying UAP instrumented projects offers advantages over human observers. First, instruments like infrared and magnetic sensors detect phenomena beyond human senses. Second, instruments eliminate subjective elements, being unbiased and objective in data collection. This facilitates analysis and comparison. Third, instruments enable consistent monitoring day or night, in all weather conditions, unlike human observers. Fourth, instruments can cover a wider geographical area, increasing chances of UAP detection. Finally, instrument-collected data can be recorded for future analysis of patterns and trends. Using various sensors across the electromagnetic spectrum offers significant advantages for studying UAP, as more metrics recorded in parallel can provide greater scientific insights into the chemistry, origin, and physics of these phenomena. However, optical sensors are the primary choice for initiating UAP field research due to their ability to capture images that closely resemble human perception, operating independently without any supporting data from other sensors, and providing useful context for the data collected by instruments. Still, human observers can also play a valuable role by providing visual observations and context for the data collected by instruments. In general, the adoption of a comprehensive methodology for gathering UAP data enhances the rigor of research and generates increased interest among mainstream academia and scientists.

2.2. Strategic-tactical considerations

Engaging in UAP instrumented field research involves thorough planning and execution, focusing on strategic and tactical aspects. The decision-making process requires considering long-term goals and short-term actions. By analyzing objectives, plans, and strategic considerations, we can identify key features of past and current projects in this field.

In general, the existing literature on UAP lacks comprehensive information regarding observable parameters, instrument trade-offs, and their selection. However, a few noteworthy exceptions stand out. One such exception is the Norwegian Project Hessdalen, which documented their implementation in a Field Technical report (Strand 1984). Additionally, in 2015, Dr Massimo Teodorani contributed to the UFODATA project by producing a document that outlines the physical parameters that can be derived using readily available measurement instruments. This resource aims to facilitate the determination of the nature of Unidentified Flying Objects (UFOs) and the extraction of relevant physics-related data (Teodorani 2015). Lastly, a recent significant development comes from the Project Galileo, which has published in 2023 crucial peer-reviewed papers (The Galileo Project, website). These papers not only offer a comprehensive roadmap for establishing UAP measurement requirements but also introduce a science traceability matrix. This matrix enables the connection between sought-after physical parameters and the corresponding observable and instrument requirements. This is the first time a dual-purpose, both civilian and professional, project has decided to build a dedicated instrumentation system and integrated software to conduct a multimodal census of aerial phenomena and recognize anomalies. Given this context, we provide below a list of key strategic and tactical points to consider for instrumented field studies.

2.2.1 Purpose

Clearly defining the primary goal of the project and its associated objectives is vital to drive its development forward. Are we primarily focused on collecting data on UAP sightings, identifying patterns, and gaining a deeper understanding of these phenomena? Or are we also exploring the potential for interaction and communication with the phenomenon? It is imperative to establish a clear vision and direction for the project to ensure a focused and effective approach.

2.2.2 Instrumentation

Developing a tactical plan involves carefully selecting the appropriate equipment for detecting and measuring UAPs. However, this selection involves making trade-offs between factors such as available resources, equipment complexity, completeness, portability, and sensitivity. To accurately document UAP events, researchers must measure multiple physical quantities simultaneously and synchronize all measurements and optical imagery to a single clock. This approach helps determine if changes in the visible characteristics of a UAP are correlated with significant changes in any measured quantities over time. Additionally, measuring the distance between the instrumentation and the UAP enables establishing spatial correlations and variations. However, due to the unknown nature of UAPs, determining which physical quantities should be measured, their required accuracy, and frequency of measurement is challenging. Some reports only describe unusual appearances or behaviors in visible light, while others mention electromagnetic, gravitational, and audible effects. Therefore, it is crucial to gather as many types of measurements as possible. The UFODATA project has outlined the scientific justification for measuring the type and intensity of radiation emitted by UAPs, including the use of spectroscopy and the valuable insights gained from analyzing a spectrum (UFODATA, website). When planning a research project, researchers need to decide whether to use off-the-shelf instrumentation already employed in field research or design a customized instrument. This choice depends on several factors, including the availability of resources, both in funding and qualified personnel, the project's objectives and strategies, and the motivations of the project leader(s).

Finally, it is of paramount importance to calibrate instruments to meet intended measurement objectives (e.g., accuracy, range of response), while considering both the level of effort required, the practicality of calibrating an instrument, and the precision required for measurement. Calibrating instruments not only underpins the reliability of data collected during UAP research but also facilitates meaningful comparisons across various studies. The Project Galileo requirements offer illustrative instances of both laboratory and on-site instrument calibration (Watters *et al.* 2023), while astrophysicist Teodorani emphasizes the critical role of wavelength calibration in the context of light spectra

(Teodorani 2004).

While instrument calibration is generally important and should be diligently carried out, the absence of perfectly calibrated instruments should not deter field work. For instance, initiatives like UFODAP (website) and UFODATA (website) represent initial efforts to gather evidence aimed at unequivocally demonstrating the existence of UAP through images and instrumented data. Notably, in their case, the precision of measurements may not be as critical due to the inherently gross nature of emissions from the intended UAP targets. The potential impact of UAPs on electromagnetic and gravitational fields could be so substantial that while absolute measurements remain important, UFODAP's equipment may be primarily focused on capturing the overarching impact rather than precise calibration. This valuable information could serve as a foundation for subsequent generations of instrumentation, driving precision improvements and generating support for further research due to their successful UAP detections in the field. In contrast, the Galileo Project, with its ample funding and high-caliber talent, exemplifies the highest level of instrument calibration, providing even more refined data and advancing our understanding from these early detections.

2.2.3 Strategies

These UAP instrumentation strategies encompass critical topics and actions for selecting an appropriate location based on factors like accessibility, visibility, and weather. The preference is for areas with higher UAP activity known as 'Hotspots' or 'Flap Areas'. This is because one persistent challenge has been the low probability of a UAP appearing where high-quality sensors are positioned. Deciding whether to establish a permanent or temporary location is also essential, with some projects like Project Hessdalen opting for permanence, while others like the Toppenish Field Survey remained mobile. Personnel with the necessary skills should be recruited, and resources such as employees, volunteers, equipment, and funding should be realistically assessed. Protocols should be established for data collection, analysis, and reporting, along with contingency plans for unforeseen circumstances. A plan for data management should also be developed, and partnerships with experts in relevant fields such as meteorologists or physicists could eventually be formed. Finally, clear communication channels should be established with stakeholders, including team members, partners, the UAP community, and the public.

3. Instrumented Field Research Timetable

A comprehensive list of fifty-two instrumented field studies spreading over the period 1947-2023 can be found in table 1. The table contains essential details such as the country where the research was conducted, the responsible organization or project leader(s), the duration of the study, and its operational status. This list contains all the studies that are widely recognized and regarded as significant contributions to the UAP research field. Most of these projects are based in North America (~46%) and Europe (~31%), with no information available for Asia, the largest continent in the world. The same lack of knowledge applies to Africa, the second largest continent, which is likely related to economic conditions. Highlighting the significance of UAP research, it is crucial to recognize that many of these investigations predate the public disclosure of the Pentagon's classified UFO program (AATIP) and the release of Navy videos. Moreover, it is worth noting that numerous endeavors have been made to study and quantify UAP through field experiments, although only a handful of them have entertained the hypothesis of extraterrestrial visitation. Most of these initiatives have primarily concentrated on the examination of 'nocturnal lights', revealing that this phenomenon appears to happen more frequently than the occurrence of 'unidentified structured aerial objects'. The timetable shows that field experiments peaked in the 1970s and early 1980s but virtually disappeared in the 1990s. The decline may be attributable to different factors, such as the closure of the American project 'Blue Book', a decrease in UAP sightings, a shift in focus to other topics in the US (e.g., Roswell, abductions), and a less supportive institutional and scientific climate for studying UAP. However, there has been an obvious increase in the number of initiatives around the world since the 2000s, mainly in Europe. Several long-term field projects continue into the new millennium, including Project Hessdalen in Norway, which has been running since 1984. Since the early 2010s, the increase in instrumented projects can be attributed to technological advancements such as high-resolution digital cameras, off-the-shelf scientific instrumentation, low-cost computing platforms, and progress in information technologies. This has also been further accelerated by the continuous reduction in the size and cost of equipment. In addition, the field has experienced since 2017 a resurgence in new actors such as the Galileo Project, UAPx, and the

Ref.	Research Project	Country	Project Leaders
1	First Civilian's UFO Detection station	USA	Los Alamos scientists
2	Project Twinkle	USA	U.S. Air Force
3	Project Magnet	Canada	W. B. Smith
4	Videon Cameras	USA	U.S. Air Force
5	Network of Magnetic Detectors	France	Lumieres Dans La Nuit
6	Harrisburg all-sky camera	USA	G. Rothberg (Project Blue Book)
7	Tully Monitor Stations	Australia	S. Seers, V. Mele
8	Projects "HAVE FEAR","LETHAL CHASER"	Viet Nam	U.S. Air Force & 4th Infantry Div.
9	RESUFO	France	M. Monnerie, Lumieres Dans La Nuit
10	The Exeter Experiment	USA	J. Oswald
11	Lockheed P-3 Orion aircraft	New Zeland	N.Z. Air Force
12	Project MADAR	USA	F. Ridge
13	Toppenish Field Studies	USA	D. Akers, B. Vogel
14	Project Identification	USA	H. Rutledge (Southeast Missouri State Univ.)
15	UFO Watch	USA	PMS
16	Project Starlight International	USA	R. Stanford
17	Operacao Prato	Brazil	Brazilian Air Force
18	Copper Medic	USA	J. Vallee
19	Programs " Setka-AN" & "Setka-MO"	USSR	IZMIRAN & NII 22
20	Filters Jobin-Yvon	France	GEPAN
21	MFI-6 Magnetic Detectors	Denmark	SUFOI
22	Team Note Field	Portugal	CEAFI
23	Project " Krug" ("Circle")	USSR	Soviet Ministry of Defense
24	Project Hessdalen	Norway	E. Strand & B. Hauge (Østfold Univ. College)
25	Identification OVNI & Tours Hertziennes	Belgium	SOBEPS, Belgium Air Force
26	Automatic Optical Station & SkyScan project	Germany	MUFON-CES
27	Brown Mountain Lights	USA	LEMUR; D. Caton & L. Hawkins
28	The Ambient Monitoring Project	USA	UFO Research Coalition
29	45°GRU	Italy	J. Ercolini
30	Marfa Lights Investigation	USA	J. Bunnell
31	Kingsland Observatory	Ireland	E. Ansbro
32	Mount Adams)	USA	D. Akers, M. H. Adams, E. Strand
33	UAP Missions	Various	M. Teodorani
34	UFO Camera Project	USA	W. Hollenbeck, C. O'Brien, A. Palfreyman
35	Smart Optical Sensor Observatory (SOSO)	Italy	M. Silvestri (CIPH)
36	Automatic Measurement Station	France	Les invisibles du Col de Vence
37	Institut Fur Technische UFO-Forschung	Poland, Norway	G. Gröschel
38	Project UAP-Italia	Italy	N. Tosi
39	Platform	USA	BAAS
40	UFODATA and UFODAP	USA	M. Rodeghier, A. Wendt (Ohio Univ.), R. Olch
41	VISION OVNI (ECOS)	Argentina	J. Perez
42	MF & MA (Physical & Aerospace Monitoring)	Ukraine	ZOND
43	UAP Tracker	France	P. Wright
44	UAPx & O.S.I.R.I.S	USA	G. Voorhis, K. Knuth & M. Szydagis (Albany Univ.), J. Mc Gowan
45	Skinwalker Ranch	USA	R. Bigelow, B. Fugal
46	Excursions	Brazil	Group Ufológico
47	(Ukraine)	Ukraine	B.E. Zhilyaev, V. N. Petukhov
48	Field work "Serra da Beleza"	Brazil	UAP Brazil (R. Vernet)
49	Sky360 (after SkyHub)	Austria	R. Hopf, O. Coutinho, C. Ambros
50	SkyCAM-5 camera system	Germany	H. Kayal (Würzburg Univ.)
51	Project Galileo	USA	A. Loeb (Harvard Univ.), W. Watters (Wellesley College)
52	EXOPROBE research program	TBD	B. Villarroel (Stockholm Univ.), G. Marcy

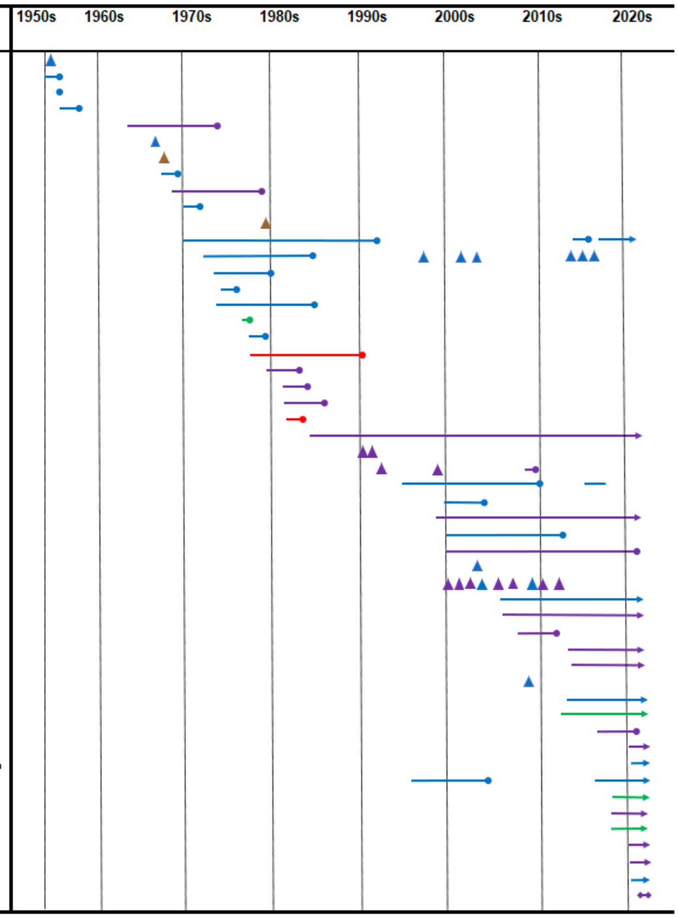

Table 1. Instrumented Field Research Timetable. *Note:* Color coding is used to represent different regions: North America and Canada are denoted in blue, South America in green, Russia in red, Europe in purple, and Australia/New Zealand in brown. Line end shapes represent project statuses: arrow = ongoing, round = stopped, lozenge = to start, none = status unknown, while a triangle indicates a short-term mission on the field.

University of Würzburg, involving scientists, astronomers, and academia, due to increased government attention and more serious reporting from mainstream media. Furthermore, over the past two years, the legitimacy of studying UAP with instrumentation has been established from two different angles. On the defense side, the 2021 ODNI report acknowledged that many sightings represented physical objects and emphasized the need to collect consistent data on UAP. On the scientific side, NASA's unprecedented decision in June 2022 to establish an independent study to examine UAP from a scientific perspective has further bolstered the topic's legitimacy. These official governmental announcements have helped to reduce the stigma associated with the UAP topic, piqued greater curiosity, and sent an encouraging signal to the scientific community. Finally, the timetable shows that most field investigations were instigated by proactive individuals or civilian associations who astutely recognized the imperative to act. It appears that governments have been hesitant to support UAP research due to concerns about public ridicule, the possibility of wasting tax money, the belief that scientific discoveries will not be made, or national security implications. Therefore, civilians have taken the lead in pursuing UAP research, demonstrating their dedication to understanding this enigmatic phenomenon.

4. Projects review

To maintain a concise paper, we will limit our focus to a specific subset of UAP instrumented missions, including select historical and recent projects. Our examination will commence with a review of UAP-related military projects, followed by an analysis of relevant civilian research initiatives, categorized into citizen and academic science projects. Military and civilian projects differ in their objectives, funding, investigation methods, and transparency. Military-led projects aim to assess UAP's threat to national security or military operations and often involve classified information and advanced technologies. Civilian research projects are usually self-funded or rely on donations and focus on exploring the nature and origins of UAPs and their implications for humanity. Military projects tend to be less transparent, and this is evident from the lack of details provided in the ODNI year 2021 report on the 144 reported events, while civilian projects are more open with their findings and data made available to the public.

4.1 Military instrumented projects

Starting in 1948, inexplicable lights were seen in the southwestern US close to critical government research and military facilities such as Los Alamos and Sandia National Laboratory. Credible witnesses reported frequent sightings, prompting concern from security agencies (Elterman 1951). To gather data, the Air Force tasked the Geophysical Research Directorate, a group focused on atmospheric phenomena, to study the lights. Project Twinkle was launched in 1950, using instruments such as optical tracking with Askania photo theodolites, cameras, and electronic frequency equipment. Observation posts were established close to Holloman and Vaughn Air Force bases. Despite that the final report (Elterman1951) concluded that no conclusive opinion on the phenomena had been reached, it stated that some objects were photographed during some Bell aircraft missile and V-2 launchings, and several photos were also obtained in 1950. The report indicated also that the project suffered from issues such as delayed deployment and reduced activity at equipment locations (Elterman 1951). In retrospect, the project was not optimal from the beginning. The camera system was not located near the areas of reported incidents, and its deployment was delayed until after the incidents had decreased.

In the mid-1970s, Colares, an island off the coast of Pará in Northern Brazil, experienced a surge in UFO activity. The Brazilian Air Force's First Regional Air Command was alerted by a city mayor about alleged injuries caused by UFOs to fishermen and locals ("Óvnis no Brasil" 2017). The phenomena intensified from October to December 1977 and the first half of 1978, causing rising concern. The city mayor requested Air Force assistance and organized night vigils and used fireworks to deter the UFOs. In response, the Brazilian Air Force sent a small team led by a Captain of Aeronáutica, Uyrangê de Hollanda Lima, to investigate. The team consisted of approximately 10 unarmed soldiers and spent four months using various equipment, such as cameras and binoculars, a meteorological theodolite, and a Huey helicopter, to observe and record strange events reported by residents. Known as Operação Prato (Operation Saucer), the team conducted interviews, drew maps of events, used base camps at locations where sightings had regularly been reported and worked at night to increase their chances of observing a UFO. During the initial two months, no significant sightings were reported. However, in the latter part of the operation, Captain Hollanda's team documented numerous close-range observations of unknown phenomena on the outskirts of Belém ("Óvnis no Brasil" 2021). The team managed to capture hundreds of photos and several hours of super 8- and 16-mm films of these UFOs. Government documents declassified in 2009 contain details of the missions carried out by the team, including eyewitness sketches of the UFOs, pictures, and intelligence officers' reports (Portal Estudos do Brazil Republicano, website). After four months of relentless efforts, Captain Hollanda and his team successfully restored peace and tranquility among the local population. Despite their remarkable achievements, Operação Prato, unfortunately, ended abruptly as the Air Force decided to terminate the mission, leaving the public without any further updates or explanations. The Operação Prato, in hindsight, highlighted the inadequacy of the approach taken towards investigating UAPs. The absence of involvement from scientists or academics resulted in a lack of planning for data collection, and in understanding and dealing with unfamiliar phenomena.

Concerning other military files, it wasn't until 2016 that some US military records related to tracking UFOs during the Vietnam War came to light. According to these documents, in 1968, the US Air Force Weapons Laboratory established two special projects to observe UFOs from Con Thien, the highest hill in the eastern demilitarized area (Dean 2016). The first project, called 'HAVE FEAR' utilized laser range finders and night observation devices to identify the sightings. This project's personnel saw red lights and captured video blips. The UFOs typically traveled at speeds ranging from 30 to 80 mph at altitudes of 1,200 to 1,600 feet. After several days of tracking, the red blinking lights would disappear when under 'HAVE FEAR' surveillance. The project ran from August 4-12 and resumed from August 18-31 in 1968. The second project, called 'LETHAL CHASER', utilized manpack radar and joined forces with 'HAVE FEAR' in mid-August. From August 18 to September 3, 1968, the observation systems conducted a joint, integrated search that also employed another radar further north at Dong Ha, known as 'Waterboy' which covered the southern areas of North

Vietnam. This joint exercise produced 67 valid tracks, but no conclusive identifications. The two projects were stopped by late August due to lack of results.

In a completely distinct strategic context, given the ongoing challenges faced by the US Government when assessing UAP within or in proximity to DoD training areas and installations, it becomes compelling to delve into an alleged experiment undertaken by the Russian military in the early 1980s. This experiment aimed to summon UFOs. It's worth noting that this experiment coincided with the existence of a state program for UFO research called 'Setka' in the Soviet Union, which included both civilian and military components and had been operational since 1977 (Gershtein 2015, 22-28). The objective of the 'Setka-MO' ('Ministry of Defense Network') was to conduct a military investigation into anomalous atmospheric and space phenomena and their impact on the performance of military equipment and personnel well-being. During the early 1980s, a significant number of UFO sightings were reported in the vicinity of a military range near Akhtubinsk, located within the Kapustin Yar military training ground in the Astrakhan region. According to retired Federal Security Service (FSB) Air Force Major General V. Eremenko, it became apparent that UFOs were consistently appearing in areas where military equipment and weapons were extensively tested. In response to this phenomenon, a project known as 'Krug' (translated as 'Circle' in English) was set-up. This six-months project involved a substantial increase in military aircraft flights and military equipment movement, accompanied by the installation of sensitive equipment to monitor UFO activity (Kruglyakova 2016, 72-77). Having been engaged in the experiment, Eremenko firmly stated that through the escalation of military operations, the regularity of UFO sightings increased, frequently manifesting as luminous spheres. This experiment, which effectively garnered significant scientific data such as photographs and radar detections of the phenomenon, ultimately contributed to an understanding of how to potentially summon a UFO. During this experiment, Eremenko also stated that the soldiers on the proving ground began to experiment with interacting with the UAP, the soldier in question made arm movements that were remarkably mirrored by the UFO, creating a mysterious connection between them (Kruglyakova 2016, 72-77). Nevertheless, despite the dedicated efforts of the military and scientists engaged in the endeavor, a conclusive explanation for these phenomena remained elusive (Kruglyakova 2016, 72-77).

To round out the list of military projects, it's also worth mentioning two airborne actions taken outside the USA in response to UAP sightings. On the nights of December 20th and 21st, as well as the 30th and 31st in 1978, there were numerous sightings of UAP above the Kaikoura Mountain ranges in New Zealand. The Wellington Air Traffic Control radar and the crews of a SAFE Argosy aircraft witnessed these sightings both visually and on radar ("Kaikoura Lights," n.d.). On December 30th, a television crew from Australia captured footage of these UAP during their flight to Christchurch. After the second sightings, a Royal New Zealand Air force Lockheed P-3 Orion reconnaissance aircraft was sent on a reconnaissance mission to Kaikoura in January 1979 in an official attempt to accurately observe and report on unusual visual, electronic, or meteorological phenomena. The military plane was equipped with radar, cameras and a host of other sophisticated tracking and monitoring equipment. The search returned a negative result (Siegert 1979). Declassified files reveal that an administrative error prevented the launch of the Orion aircraft during the second UAP sightings (Siegert 1979). The January mission was in fact a response to negative media coverage and accusations of the defense ministry acting irresponsibly. Certainly, the unpredictability and elusive nature of the UAP indicate the need for better preparedness and quicker reactions to maximize the chances of collecting scientific data.

Between late 1989 and mid-1991, a wave of anomalous sightings occurred in Belgium, with UAP observations reported almost daily (COBEPS, website). Witnesses included civilians, military personnel, and police officers. The UAP reported were typically triangular, over 15 meters in size, and equipped with large 'headlights' that projected intense beams of light. They were also capable of tight changes of course and lightning accelerations. The continuous flow of UAP reports prompted the involvement of the country's authorities, including the Ministry of National Defense, the Air Force, and the Gendarmerie. In April 1990, a joint operation with a civilian UFO association (Société Belge d'Etude des Phénomènes Spatiaux) was organized to collect data and determine the nature of the phenomena. The Operation Identification involved a network of observers and resources provided by the Belgium armed forces, including the Liege's town airport (Bierset) as headquarters, two military planes, with one equipped with infrared thermal cameras and night vision equipment, several optical cameras, and military pilots and technicians. However, the operation was unsuccessful in detecting or observing any UAP during the 4-day long campaign. Despite this, the collaboration between civilians and the military marked the first time in Europe that joint efforts were made to seek answers to the UAP phenomenon. One of the most important lessons learned from this operation was to avoid media coverage as it can create unrealistic expectations and hype, leading to disappointment when reality doesn't meet the portrayed image. These remarkable UAP events also led to a resolution being proposed by Belgian deputy Elio Di Rupo to the European Parliament in 1991 to develop UAP research at a European level (European Parliament 1990). This proposal, which received substantial ridicule in the media, was ultimately rejected in early 1994.

Is there a trove of UFO instrumented projects related information hidden in US military archives? This question gains importance with the recent U.S. Fiscal Year 2023 National Defense Authorization Act (NDAA), H.R. 7776, which mandates the Director of the Office of the Assistant Secretary of Defense for Intelligence and Security to provide a comprehensive report on the U.S. government's engagement with UAPs from January 1, 1945, onward (Johnson 2022, 9-10). Anticipating the future publication of the AARO Historical Record Reports, the first volume, currently in preparation for delivery to Congress and the public in January 2024, holds the potential to reveal previously unknown insights into military UAP projects, enriching researchers' understanding of this historical requirement (Kirkpatrick 2024).

4.2 Civilian instrumented projects

Within this section, we delve into the realm of civilian research. The related projects encompass a wide spectrum of endeavors, with a particular focus on the involvement of both non-professional and academic or scientists. Citizen science, or the participation of non-professional scientists in a scientific project, has a long history and often characterizes efforts driven by enthusiastic individuals from various backgrounds (Mordechai (Muki) Haklay, Mazumdar & Wardlaw 2018). Conversely, academic, or professional science projects represent the domain of experts and scholars within the scientific community. These initiatives are characterized by the application of rigorous methodologies, adherence to established scientific standards, and the use of specialized equipment and resources.

Categorizing projects as either citizen or academic science can be nuanced. The criteria, multifaceted in nature, primarily depend on the level of involvement, methodology, and project objectives. Regarding projects labeled as 'academic science' in this paper, it's important to clarify the role of university professors. The criteria aren't solely based on their affiliation or time commitment but rather on research goals, methodologies, and adherence to academic standards. If a project meets these criteria, it falls under academic science, irrespective of professorial involvement or affiliation.

4.2.1 Academic or professional science projects

The notion that UAP might represent a physical phenomenon with quantifiable attributes that could be studied through instrumentation dates to the early 1950s. Edward Ruppelt's book details one notable instance of early scientific interest and the first professional scientific field research effort in this direction during his time as the head of Project Blue Book from 1951 to 1953 (Ruppelt 1956, 203-209). Ruppelt recounts an experiment conducted by scientists to test whether UAP activity could be correlated with radiation increases, based on a case where observers reported a simultaneous visual sighting of UFOs and a sharp rise in radiation levels in an area near the Mount Palomar Observatory. The experiment began in the summer of 1950, when some physicists working for the Atomic Energy Commission at Los Alamos, New Mexico, met on weekends at a shack atop a low mountain near the installation where they set up a UFO detection station. The detection device they devised consisted of rows of Geiger tubes arranged to measure radiation levels continuously, with a tape recorder attached to document any fluctuations. Meanwhile, they monitored local news reports to check for any UFO sightings in the Los Alamos region. In early 1951, the equipment registered three abnormal radiation spikes coinciding with reports of visual UAP sightings, one of which was also picked up by radar. The team kept the equipment running until June 1951, but did not detect any further correlations between UAP sightings and radiation anomalies. Despite expert consultations, no satisfactory explanation for the UAP-radiation correlations was found (Ruppelt 1956, 205).

In the mid-1970s, a pioneering academic UAP project arose in response to numerous sightings near Piedmont, Missouri. Led by the Chairman of the Physics Department at Southeast Missouri State University, this seven-year 'Project Identification' aimed to measure the physical properties of observed lights and objects in the sky and identify their origins

(Rutledge 1981). Dr. Rutledge and his team, comprising university staff, qualified students, and scientists, employed advanced scientific instruments, established 158 viewing stations in key geographic areas, and engaged over 600 observers, amassing 427 hours of sky observation. The project documented 157 sightings, including 34 class A sightings with unusual properties defying conventional explanations.[1] However, no Class A sightings were captured in the 700 project photographs claimed by Dr. Rutledge. Unfortunately, these photographs were limited to nighttime exposures, lacking broad daylight images or anomalous light spectra. According to Dr. Rutledge, his research not only confirmed the UAP phenomenon's existence but also revealed a unique connection between observers and the phenomenon, as he claimed that on at least 32 recorded occasions, the lights' movements synchronized with the actions of the observers (Rutledge 1981).

In a parallel historical context during the mid-1970s, a little-known but significant UFO chapter unfolded in Gorredijk, the Netherlands. This recent revelation (Smedes, 2024) has brought to life the pioneering initiative of a high school teacher named Geert Meijer. Motivated by his personal sighting, Meijer aimed for a scientific approach, setting up observation posts with 10-25 participants, including students and adults, not only in Gorredijk but also in five neighboring villages. What sets this case apart is the concentrated and numerous UFO observations confined to a limited geographic area only during February 1974.

The observed phenomena encompassed predominantly dynamic lights, often in motion but occasionally stationary, displaying a spectrum of colors. Additionally, formations of lights emerged, some with accompanying flashing lights. Intriguingly, serving as precursors to subsequent decades, witnesses reported sightings of a sizable 'boomerang'-shaped object and a triangular craft. Enhancing the fascination, Gorredijk witnessed both solitary sightings and occurrences where multiple individuals concurrently reported observing the same UFO. To validate these sightings, Meijer introduced innovative methods like cross-referencing and a 'game of right and wrong',[2,3] Equipping participants, who were both students and adults, only with binoculars and cameras, Meijer orchestrated simultaneous sightings across different observation posts, enhancing the credibility of the observations. This approach resulted in some remarkable instances where multiple student and adult observers reported the same UFO. Furthermore, a few photographs were taken during these observations, adding a visual dimension to the documented sightings.

As February ended, the sightings and reports of UFOs above Gorredijk abruptly ceased, almost overnight, marking the swift conclusion of this UFO wave. The enigmatic phenomenon concluded without yielding any definitive answers regarding its causes. Similar to Dr. Rutledge's Project Identification in the United States, Meijer's initiatives marked a noteworthy early endeavor in European UFO studies, contributing valuable optical data to document the presence of unexplained aerial phenomena.

Nowadays, one particularly well-known academic science initiative is the Norwegian Hessdalen project which is internationally known as the 'UAP Laboratory'. Led by professors from the Department of Engineering and the Faculty of Computer Science at Østfold University College since 1984, this project continues to attract additional resources and the interest of the scientific community, serving as a prime example of success (Hauge 2005 and 2007; Teodorani and Nobili 2002; Teodorani 2023). This is evidenced by the organization of science camps, procurement of new equipment and implementation of innovative strategies, as well as the forging of collaborations with international experts across various scientific disciplines (Hauge 2010). Certainly, investigating mysterious light phenomena in the concentrated area of the Hessdalen valley in central Norway is viewed as a safer pursuit compared to chasing most UAP cases. These lights, confined to this specific region, exhibit intriguing geophysical aspects such as piezoelectricity, tectonic strain, and gaseous emanations linked to the rare mineral Scandium, making them more scientifically credible (Hauge 2007).

A different approach to UAP research has been undertaken by the Ukrainian Scientific Research Center for Analysis of Anomalies (SRCAA) 'Zond'. Established in 2004 within the Aircraft and Space Systems department of Kyiv

1 Dr. Rutledge, drawing from direct field experience, categorized UFO sightings into two classes: A and B. Class A encompassed sightings of extraordinary phenomena, involving lights and/or objects exhibiting peculiar behavioral and/or physical properties that defied conventional explanations. On the other hand, Class B UFOs, more commonly observed than Class A, referred to lights and/or objects that remained unidentified by available instruments. However, these sightings, in the observer's judgment, lacked the unusual behavioral or physical properties that would challenge rational explanation.

2 The term 'cross-referencing' here refers to the practice of comparing and verifying UFO sightings from different locations to validate the observations.

3 In the context of Meijer's UFO studies, the 'game of right and wrong' involved participants intentionally making claims about observed UFOs. If someone made a deliberately incorrect claim about a stationary UFO, corrections from others were sought to validate the collective sightings.

Polytechnic University, this organization is at the forefront of studying anomalous phenomena in Ukraine. 'Zond' initiated the deployment of hidden ground-based monitoring systems, known as MF-2, between 2016 and 2019 (Kovalenko, Bilyk, and Kyrychenk 2020). These systems were strategically placed in areas where alleged UAP landings occurred or where frequent sightings were reported. MF-2 devices were equipped with various sensors, automatically gathering environmental data such as temperature, air pressure, magnetic fields, gravitational fields, and geoelectric statuses, all of which could potentially indicate the presence of aerial anomalies. This approach has allegedly proven effective in the field, with notable instances of recorded abnormal changes in the magnetic field as documented by 'Zond' (Kovalenko, Bilyk, and Kyrychenk 2020). Unfortunately, due to the ongoing war situation, the vital fieldwork of the SRCAA 'Zond' has been suspended. The team remains committed to resuming their research as soon as circumstances permit, continuing their valuable contributions to the study of anomalous phenomena in Ukraine.

4.2.2 Citizen science projects

Since 1947, significant evidence has emerged concerning the physical effects that accompany UAP sightings. These effects often involve peculiar magnetic disturbances (Akers 2001), such as interfering with airplane compasses, creating residual magnetic effects on cars, rocks, and soil at landing sites (Maccabee 1994), and disrupting electronic equipment (Rodeghier and Longden 1981). Hypothesizing that UAPs generate, rely on, or can manipulate magnetic fields, civilian researchers worldwide began using instruments to detect magnetic changes as early as 1952. These devices were later integrated into early detection projects as UAP early-warning alarms. To increase the chances of UAP detection, some researchers deployed several of such devices across a wider geographic region. Table 2 shows the principal projects undertaken. Although there have been instances of detector alarms and claims of potential correlations with certain UAP sightings, the systematic and dependable detection of UAPs by such instruments remains unverified.

	Period	Location	Project Leaders
Project Magnet	1952-1954	Canada	W. B. Smith
Saucer Seeker Detector	~1967	USA	Aerial Phenomenon Research Organization
Network of Magnetic Detectors	1963-1974	France	Lumières Dans La Nuit
Tully Monitor Station	~1968	Australia	S. Seers, V. Mele
UFO McCarthy Detector Network	1968-1970	UK	D. Lloyd
The Exeter Experiment	1970-1973	USA	J. Oswald, D. Webb
The MADAR Project	1970-today	USA	F. Ridge
The Toppenish Field Studies	1972-2002	USA	D. W. Akers
Project Starlight International	1972-1985	USA	R. Stanford
Precision Monitoring Systems	1974-1976	USA	J. Herr, H. Boylan, G. Wolter
MFI-6 Magnetic Detectors	1981-1984	Denmark	Scandinavian UFO Information

Table 2. Principal Magnetic-based UAP Detection Projects

Furthermore, it is evident that most past detector alarms were false positives, resulting from technical deficiencies in the detectors (over-sensitivity) and other sources of magnetic interference such as thunderstorms, lightning, nearby passing cars, and active televisions (UFO-Nyt 1983, 43-47). Despite the extensive efforts made, the potential relationship between UAP and magnetic fields continues to be a topic of great interest. To gain a better understanding of this potential connection, all current UAP detection projects systematically incorporate magnetometers (e.g., fluxgate magnetometers). One notable ongoing project is the MADAR project which aims to develop and deploy sensors for detecting electromagnetic disturbances possibly associated with UAPs. Additionally, it seeks to correlate citizen reports with instrumented data (MADAR, website).

More recently, the secret UFO study, Project Condign, conducted by the British Government's Defence Intelligence Staff from 1997 to 2000, explored magnetic field effects in a dedicated working paper (The National Archives 2006). This report emphasized the importance of purely magnetic effects in relation to UAP, as they influence human brain responses and resemble UAP reports.

Regarding civilian instrumented research, it is also important to acknowledge Robert C. Beck, an American engineer and inventor, as a true pioneer in advocating and practicing such studies. Beck advocated for a variety of possible instrumentation and emphasized the need for detailed records, including photographs of the sky and weather conditions. He was a fair-minded and objective skeptic and had his own mobile UAP laboratory before anyone else had even taken any realistic action about such possibilities. While others only talked about ideas for instrumented studies, Beck was actively conducting some in the 1950s, as evidenced by Max B. Miller's 'Saucers' publication (Beck 1960).

As a response to the ongoing reports of the UAP phenomenon and technological advancements, researchers in the mid-1970s began integrating revolutionary sensors, leading to increased levels of sophistication and affordability. Speculation arose due to the sensors' ability to detect various segments of the electromagnetic spectrum, suggesting that UAPs could potentially emit radiation across a range of wavelengths. Instrumented research was focused on convenient locations such as Project Starlight International (Stanford 1976, 177-190) and Kingsland observatory (Ansbro 2013) or areas where 'nocturnal lights' were frequently seen, such as Toppenish field studies (Akers 2007) and Marfa lights investigation (Bunnell 2009). In addition to the location considerations, some researchers have also adopted an 'on the go' strategy, moving their experts and instruments to areas where UAP activity was recently observed (e.g., the Toppenesh field studies, Project Starlight International (Meessen 2012), Operação Prato).

Various innovative approaches have also been developed to capture the elusive UAP, including disguising automatic cameras as rocks to provide long-term photographic surveillance of UFO sites. In 1978, Dr. Vallée obtained clearance from the state of California to install equipment on public land, including an automatic camera with a 25mm lens, an intervalometer timing circuit, and a battery unit for power. The device, named 'Sleeping Beauty', was discreetly placed in the hills around Redding. It captured one picture every six minutes for six hours daily, from 6 a.m. to noon, and then remained dormant for 18 hours. This experiment ran for one year, from August 1978 to July 1979, resulting in 1,800 exposures in a single month. However, no UAP were observed in the exposures, leading to the project's termination (Vallée 1990, 231-247).

In the face of complex phenomena potentially under intelligent control, employing multiple strategies becomes relevant, as these occurrences may not be easily captured or understood through conventional photography alone. For instance, a Brazilian researcher documented an elusive UAP encounter during a nighttime observation, with the UAP abruptly vanishing and reappearing (Do Carmo, email, July 3, 2014). In another case during fieldwork, a different researcher experienced interference with photography and data acquisition, suggesting an interaction (Akers, personal email, October 20, 2023).

The Ambient Monitoring Project, a lesser-known initiative, was begun in 1998 and focused on gathering data about the physical phenomena associated with purported 'alien abductions', a subject popularly intertwined with the UAP phenomenon. The project involved designing a sensor system to continuously record 11 environmental variables (e.g., temperature, pressure, gravity, electric and magnetic fields) and placing it in the home of a repeat abduction experiencer for 4 to 8 months (Deuley 2008, 3-7). While 13 individual research cases were completed between 2000 and 2003, yielding large amounts of physical data that may or may not correspond to the abduction phenomena, the statistical data analysis is today still pending analysis and publication.

In summary of this section on military and civilian efforts, although several projects have gathered preliminary data in the past decades (Meessen 2012), the data remains inconclusive. This emphasizes the need for continued and enhanced field work. A crucial observation that has come to light is that the instrumentation projects that have yielded the highest success rates thus far are the ones where researchers could physically be present on-site with the necessary equipment. This enabled them to both initiate and visually confirm the accuracy of the UAP instrumented observations and ensure successful operation of the equipment.

5. Limitations and implications for further research

The analysis of historical instrumentation projects reveals common issues and shortcomings that have practical implications for future initiatives. These findings provide valuable insights that can serve as a checklist for addressing critical challenges before embarking on new projects. Throughout this section, we will reference specific projects from Table 1, e.g., [1, 2, 3] to illustrate these issues and their impact, while acknowledging that this list is not exhaustive.

- <u>Inadequate Financial Resources:</u>
  A recurring challenge in all the projects is the insufficient financial resources to cover the costs of equipment, software algorithm development, and overall manpower, which hampers their effectiveness and progress [16, 22, 36, 40, 44, 50].
- <u>Organizational and Logistics Challenges:</u>
  Project organization and logistics capabilities often

presented significant hurdles to successful implementation [2, 7, 11, 13, 24, 30, 42].

- Insufficient Availability of Competent Technical Personnel:
  The lack of consistently available, competent technical personnel in the field has been a recurring issue, impacting project performance [5, 17].
- Limited Familiarity with Instruments:
  Inadequate familiarity with the specialized instruments used in these projects has affected their efficiency and outcomes [5, 21].
- Maintenance Difficulties:
  Difficulty in promptly maintaining hardware or software during failures has presented an ongoing challenge, affecting the continuity of functioning [1, 4, 24, 36].
- High Suggestibility of Researchers:
  Researchers and participating members of field surveys, particularly in novel observation situations, have shown high levels of suggestibility, which could potentially lead to erroneous conclusions [5, 25, 47].
- Unprepared Governmental Teams:
  When faced with the challenges of studying a novel phenomenon like UAP in the field, government teams frequently found themselves ill-equipped and unprepared to meet their assigned tasks and responsibilities [2, 17].
- Limited Publication of Results:
  Results from UAP field experiments were not consistently published, even when they were negative, limiting knowledge-sharing [12, 16, 19, 22, 34, 36, 39].
- Lack of Knowledge-Sharing and Collaboration:
  Until recently, there has been a general notable lack of cooperation and knowledge exchange among researchers, resulting in duplicated efforts and imposing a significant global financial burden.
- Challenges in Maintaining Long-Term Motivation:
  Sustaining long-term motivation among project development teams proved to be a significant challenge [9, 27, 36, 40].
- Careful Instrument Calibration:
  It is uncertain whether projects have consistently paid sufficient attention to instrument calibration in laboratories and on-site. It is important to emphasize that this factor is widely recognized as crucial for accurate data collection and analysis (see page 7).

6. Recent developments

In recent years, several novel citizen and academic scientific projects have come to light, as listed in Table 3. Each of these projects adopts a distinctive approach to studying these phenomena, presenting its own array of obstacles in terms of coordination, financing and data gathering.

6.1 Academic or professional science projects

UFODATA, which was launched in 2015, aims to establish an extensive network of automated surveillance stations equipped with advanced sensors to ensure continuous monitoring of the skies for any anomalous activities (UFODATA, website). However, due to limited funding and a lack of volunteers, the project has experienced slow progress in developing a viable station design and building a prototype. To expedite progress, a decision was made in 2020 to partner with another project called UFODAP which already had functioning versions of automated stations in various configurations, including a camera and tracking system (UFODAP, website). As of February 2023, UFODAP had already provided 54 sensor systems to various clients.

Project	Science Lead: Citizen (C) or Academic (A)	Year created	Project Leaders	Objective
UFODATA	A	2015	Dr. M. Rodeghier, Dr. A. Wendt (Ohio Univ.)	Building a large network of automated surveillance stations with sophisticated sensors that will monitor the skies 24/7 looking for aerial anomalies.
UFODAP	C	2016	R. Olch, C. O' Brien	Enabling UAP/UFO research by deployment of advanced data collection technology.
MADAR	C	2018	F. Ridge	Attempting to correlate citizen UFO reports with the instrumented data (magnetic anomalies) collected through a wide network of devices.
Field Work "Serra da Beleza"	C	2018	R. Vernet	Instrumented research around Serra da Beleza, Rio de Janeiro.
UAPx	A	2019	G. Voorhis, Dr. K. Knuth (Albany Univ.), Dr M. Szydagis (Albany Univ.)	Collecting, Analyzing, Studying, and Publishing Actionable Data on the UFO/UAP Phenomena.
SKY360	C	2021	R.G. Hopf, C. Ambros	Facilitating a citizen science project to observe the skies and all their phenomena around the globe, 24/7 and provide harmonized high-quality results and analysis - available to everybody.
UAP Tracker	C	2021	P. Wright	Observing and documenting potential UAP events using consumer-grade equipment, and featuring a live dashboard streamed on YouTube.
Galileo	A	2021	Dr. A. Loeb (Harvard Univ.), Dr W. Watters (Wellesley College)	To determine whether there are scientific anomalies in Earth's atmosphere, by conducting an aerial census.
SKYCAM-5	A	2021	Dr. H. Kayal (Würzburg Univ.)	Detection of unidentified aerial phenomena using artificial intelligence methods.
Exoprobe	A	2024 (TBC)	Dr. B. Villarroel (Stockholm Univ.), G. Marcy	Searching for probes from extraterrestrial civilizations in orbit around the Earth and in the solar system.

Table 3. Current Civilian Projects.

However, the main UFODATA challenge remains the lack of a centralized network and data collection point to gather potential information on interesting detections for scientific analysis. Consequently, the primary focus of the UFODATA team is nowadays to develop the necessary software infrastructure to support the uploading, storage, and sharing of data collected using UFODAP's technology (UFODATA, 2023).

Another organization called UAP eXpeditions (UAPx, website) has also recognized the advantages of utilizing UFODAP's equipment. UAPx aims to be mobile and deploy the equipment into the field, targeting hotspots to collect their own high-quality data. In July 2021, UAPx conducted a five-day research expedition to a suspected UAP hotspot in the Catalina Channel off the coast of Los Angeles in July 2021. Collaborating with physicists from UAlbany SUNY, the expedition detected unusual atmospheric anomalies and energetic particles. The preprint report submitted in December 2023 (Szydagis *et al.* 2023) clarified ambiguous observations, with none definitively classified as true anomalies. Key successes included stress-testing equipment, developing versatile software, and extracting valuable lessons for future fieldwork. Recommendations include using at least two sensors of each type, employing two distinct sensor types, and establishing quantitative rigor in defining ambiguities vs. anomalies. Future excursions, which will include visits to Catalina and other locations, will incorporate improvements to equipment and methods, building on past work.

The main challenge of fieldwork is that, regardless of the sophistication of the instrumentation, the likelihood of detecting highly conclusive evidence during relatively short expeditions appears to be quite low. Additionally, short-term field studies face the challenge of not comprehensively grasping the 'background', which includes rare events that may appear unusual but are, in fact, typical for a given area due to a limited understanding of the local environment.

In recent years, the academic sphere has also made notable progress in the field of UAP research. While independent scholars have been contributing to the study of UFOs across various disciplines for decades (Appelle 2000), there is now a significant emphasis on instrumented research within the academic community. This shift is particularly noteworthy because it involves two major universities, one in Europe and the other in the US, each hosting a UAP project.

Historically, one prominent example of academia's involvement was the University of Colorado UFO Project, which received funding from the United States Air Force Project Blue Book from 1966 to 1968. Led by Edward U. Condon, an esteemed professor of physics and astrophysics, this project sought to conduct a comprehensive investigation into UFOs. A noteworthy, instrumented reference relates to the summer of 1967 when concerted efforts were made to enhance the objectivity of data collection during a localized surge in UFO sightings within a specific geographical region. The project conducted a field investigation in Harrisburg (Pennsylvania) to study the ongoing UFO sightings (Case 27, Condon 1968). The investigator used various tools such as cameras, infrared sensors, and a Geiger counter. They stayed in contact with a telephone answering service to record sighting reports. Additionally, an all-sky camera on a hospital roof captured thousands of exposures over 17 nights. Despite receiving multiple reports, the investigator found nothing noteworthy. The project's conclusion in the Condon report was highly negative, stating that the likelihood of placing a trained and equipped investigator at the scene of a UFO sighting was virtually nil (Case 27, Condon 1968). However, this discouraging outcome did not stop future researchers and projects from exploring different approaches in subsequent decades, leading to some valid observations and valuable preliminary data.

In 2022, the Julius-Maximilians-Universität of Würzburg (JMU) in Germany made history as the first high-profile Western university to recognize UAP as a legitimate subject of academic research. The university's Interdisciplinary Research Center for Extraterrestrial Science (IFEX) expanded its goals to include UAP research, alongside space exploration, celestial objects, and signs of extraterrestrial life. This approval by the university's senate marks a paradigm shift in how these phenomena are approached academically, both in Germany and worldwide. IFEX aims to collaborate with relevant institutions and authorities, such as the Max Planck Society, the German Aerospace Center, and the Federal Aviation Office, to advance UAP research. The chairman of IFEX, Dr Hakan Kayal, focuses on addressing the lack of rigorous data in UAP research. He is developing intelligent sensor systems, such as the SkyCAM-5 camera system, which has been undergoing outdoor tests since December 2021 on a university building's roof (Universität Würzburg 2021). This system employs artificial intelligence (AI) methods to detect unknown celestial phenomena. However, significant funding is needed to expand the UAP detection system, add different sensor types in various spectral ranges, and deploy multiple systems in Germany, Europe, or worldwide. Despite the growing interest and improved accessibility of advanced and affordable scientific sensors, the lack of public funding remains a major obstacle to UAP research. Researchers advocating for financial support should highlight the undeniable link between substantial funding and significant progress in complex scientific problems. History has demonstrated that almost every scientific breakthrough is inseparable from adequate financial resources.

However, the Galileo project, launched in July 2021 by Harvard University astrophysicist Avi Loeb, stands today as a remarkable exception. This project focuses on obtaining high-resolution images of UAPs, studying interstellar objects like 'Oumuamua', and searching for potential extraterrestrial satellites exploring Earth. In line with the 'Matthew Effect' in the sociology of science, the Galileo Project has already amassed millions of dollars in private donations and secured a notable roster of researchers from various institutions worldwide because of the reputation of Loeb[4]. This support has contributed to rapid progress, exemplified by the construction of a state-of-the-art UAP observatory on the roof of the Harvard College Observatory in 2022. Equipped with advanced instruments such as infrared, optical, radio, audio, magnetic, energetic particles, and weather sensors, such observatory is designed to monitor the entire sky at all times from one location, collecting high-quality data, which is then analyzed using AI algorithms. In the coming years, the project plans to replicate the observatory design and deploy them in ten different locations across the United States for up to five years (Watters *et al.* 2023, p. 32).

The project's recent release of several open-access UAP peer-reviewed scientific papers signifies a significant step toward mainstream acceptance. The Galileo Project is developing three classes of instruments to tackle the UAP investigation challenge. Firstly, observatory systems based on the original telescope at Harvard University. Secondly, portable systems for rapid deployment and continuous operation in favorable conditions. Lastly, low maintenance 'Mesh' systems optimized for cost and scalability (Watters *et al.* 2023). In retrospect of several decades of UAP research, this remarkable work and the technological advancements achieved highlight the stark contrast in resources available to large teams of scientists and technicians with sufficient funding, as opposed to previous or current under-funded UAP research endeavors.

Space provides a distinctive vantage point for real-time Earth data collection, a capability that is becoming increasingly indispensable for scientific research. Acknowledging the superiority of space-based data collection over extensive ground sensor deployment, the Galileo Project has also prioritized a groundbreaking method for UAP detection. This innovative approach utilizes satellite imagery from Earth Observation (EO) satellites (Keto and Watters 2023). Enabled by extensive EO datasets, this global strategy represents a noteworthy departure from previous decades' localized UAP studies. By harnessing the advantages provided by satellites, including their wide-area coverage, frequent and systematic image acquisition of the Earth's surface and atmosphere, the project strives to create software that employs pattern-recognition techniques for the automatic identification of moving objects in commercial satellite images provided by company Planet Labs. The primary objective is to identify objects exhibiting velocities, accelerations, sizes, or shapes that deviate from those expected of natural phenomena, common vehicles, or projectiles. Of particular importance would be satellite data capturing objects entering Earth's atmosphere that do not follow ballistic orbits like meteors or rockets. Undoubtedly, this undertaking poses significant complexity and challenges. The task of analyzing an extensive volume of Earth observation data is time-consuming, and retrieving satellite data coinciding precisely with a UAP event has a low probability.

Regarding new professional actors collecting observational scientific data, noteworthy articles by Ukrainian astronomers (Zhilyaev, Petukhov, and Reshetnyk 2022) have emerged on arXiv, a free scientific preprint publication archive. The Main Astronomical Observatory of the National Academy of Sciences of Ukraine independently investigated UAPs using two meteor stations in Kiev with a specialized observation technique. However, these reports were discredited by the National Academy of Sciences of Ukraine due to scientific rigor issues and errors in determining distances to observed objects. Some scientists suggest that certain UAPs in the report may be related to foreign surveillance or military technologies, given the ongoing Russian invasion of Ukraine since February 2022. While previous UAP field experiments have faced limited publication options, this case involves a reputable

4 The 'Matthew Effect,' originating from the biblical verse 'For to everyone who has, more will be given, and he will have abundance; but from him who does not have, even what he has will be taken away' (Matthew 25:29), is a sociological concept in the realm of science. This phenomenon suggests that established individuals in a field tend to accumulate more recognition and resources, while those who are less established may struggle to gain recognition. In the context of the Galileo Project, the 'Matthew Effect' has contributed to the project's ability to amass significant financial support and attract esteemed researchers, who are drawn by the reputation of Professor Loeb and the Harvard University.

astronomical institution's publication, albeit lacking peer review and scrutiny. Such unverified claims should be avoided to maintain the integrity of UAP research.

6.2 Citizen science projects

UFODAP is not the sole citizen-led UFO research initiative with affordable observation stations monitoring the skies 24/7 for UAPs. In October 2021, a European group of astronomers, software developers, and hardware engineers founded Sky360, a non-profit non-governmental organization (NGO) registered in Austria (Sky360, website). The Sky360 stations are comprised of inexpensive off-the-shelf components, aiming to find the most effective combinations at the lowest cost. Detailed schematics, blueprints, and suggested equipment are available on their website. Currently, 20 stations are operational worldwide, spanning from the USA and Canada to remote regions like the Azores in the Atlantic. However, the challenge lies in motivating enough people to acquire these systems, thereby increasing the chances of success for these citizen-led networks of UAP monitoring stations.

In addition to technological advancements, smaller sensor sizes, and reduced costs, it can be argued that the rise of popular social media platforms has also contributed to the increase in detection projects since the 2000s. Researchers have recognized the value of utilizing platforms like 'YouTube' and 'Twitter' to share UAP optical information recorded in the field, such as videos and pictures. These online tools allow for widespread dissemination of research activities and intriguing detections, reaching a global audience, and engaging viewers. Furthermore, this offers opportunities for projects to generate income and support further research. For instance, UAP Tracker, a prominent UAP research platform, has noticed substantial growth in its viewership, with an average of 2.7k monthly viewers, since they began live streaming a few years ago (UAP Tracker, email communication). Similar engagement is observed in projects like UAP Brazil, where their videos have gained significant attention (Vernet 2021). Watching UAP videos on 'YouTube' has become a convenient alternative for those seeking a UAP experience, providing a sense of witnessing something genuinely unidentified and extraordinary. However, it is important to note that legitimizing serious UAP research and maintaining data credibility can be challenging on popular free media platforms, where hoaxes and fake videos can rapidly spread.

7. Future directions

Due to the increase of instrumented projects and as time progresses, there might be instances where different projects studying UAP share similar objectives or collect comparable data. While this may lead to some overlap, it is crucial to view this as an opportunity rather than a drawback. Having multiple research groups independently investigating the same phenomenon allows for cross-validation of findings, verification of results, and the discovery of complementary insights. The nature of scientific exploration often thrives on collaboration, as it encourages diverse perspectives, methodologies, and approaches to problem-solving. With UAP research, the significance of collaboration becomes even more pronounced, considering the intricate and enigmatic nature of the phenomena under investigation. Our current understanding of what precisely we should be pursuing is lacking, and we may encounter substantial obstacles in exploring a subject that potentially possesses awareness, actively eludes, or distorts our observations, and might even have an interest in studying us. By having various groups examining UAPs from different angles, we increase the chances of gaining a more comprehensive understanding of these anomalous events.

Based on the research conducted for this paper, the enhancement of rigor and effectiveness in instrumented UAP field studies should prioritize two key areas:

Firstly, building a more disciplined approach to such studies is essential. This can be achieved by establishing closer collaboration between interested parties to share ideas, methods, and findings. Regular meetings and workshops should be organized to facilitate this process. Table 1 clearly illustrates that the current stage has brought together a substantial number of dedicated researchers, enabling the establishment of more frequent communication channels for the exchange of ideas. The UFO research community should moreover capitalize on the fact that several reputable organizations have now integrated instrumented research into their agendas. For example, the American Institute of Aeronautics and Astronautics (AIAA) established the Unidentified Anomalous Phenomena Integration & Outreach Committee (AIAA UAP, website) and has been organizing technical sessions on UAP since 2021 (Aviation Forum, website). The Scientific Coalition for UAP Studies has conducted annual conferences for the past four years (SCU, website), while the newly formed Society for UAP Studies

(SUAPS, website) aims to serve as a unifying platform for strategic planning and collaborative research. SUAPS also hosted its inaugural symposium in 2023.

To complete this picture of newly created organizations, it's worth noting the Sol Foundation, which officially launched in August 2023 (The Sol Foundation, n.d.). Led by Dr. Nolan, Professor in the Department of Pathology at Stanford University School of Medicine, and sociocultural anthropologist Dr. Skafish, the Sol Foundation is a pioneering think tank dedicated to researching the philosophical, policy, and scientific implications of UAP. Beyond academic research, the Foundation aims to be a leading source of UAP-related research and to provide informed policy recommendations to governments. Noteworthy for its commitment to government transparency and scientific rigor, the Foundation stands out in its objective to offer advisory and policy recommendations to the public sector.

In the past, numerous instrumented projects operated in isolation, lacking mutual awareness, and failing to draw from the collective knowledge gained by others. However, in the digital age, with the advent of modern communication channels like the internet, email, and social media, collaboration and information-sharing have become more accessible. Given the complexity of addressing the UAP enigma, no single organization can tackle it effectively. Consequently, researchers must collaborate on field work efforts to lower costs, avoid duplication, and pool resources.

A unified research plan could also be established to ensure that studies are conducted consistently and with a common goal in mind. As suggested by Dr. Rodeghier in a personal email on October 2nd, 2022, the astronomical community conducts a decadal survey every ten years to prioritize research, including the construction of new telescopes, space missions, and other projects. Considering this, it raises the question of why the UAP community shouldn't adopt a similar approach for instrumented field investigations.

In terms of dissemination results, ensuring that the findings reach a wide range of stakeholders and contribute to future research is equally crucial. This can be achieved through conferences and research publications.

Secondly, it is important to explore new potential and innovative avenues for increasing the chances of success. By leveraging established calibrated automated monitoring stations like UFODAP or SKY360 and integrating them into a future network such as UFODATA, we can enhance the effectiveness of data collection and analysis. In terms of software, machine learning techniques can also be implemented to aid in analyzing large volumes of data and uncovering patterns and insights that may have been missed through manual analysis. Finally, expanding the instrumented field research to include the atmosphere, low Earth orbit, bodies of water like lakes and oceans, or deserts, can provide valuable information and insights into phenomena that are not easily observable from the ground.

While field research in the maritime domain presents increased complexity and cost, it should be regarded as a viable avenue. UAP sightings are not confined to land; they have been observed by both military and civilian mariners in oceans and seas, as well as by pilots from the sky. It's worth noting that the 2023 AARO report emphasizes its commitment to advancing the integration of the maritime domain (AARO report 2023). For civilian projects, a feasible initial step could involve continuous water-facing instruments placed along the coast, such as Catalina Island or Florida beaches, with similar technical challenges as inland UFO detection systems. Subsequently, floating instrument platforms could be deployed in areas with higher UAP sightings. Additionally, satellite data covering coastal proximity could complement this research. American oceanographer and retired Rear Admiral Gallaudet has recently proposed several actions, including a survey by the Naval Studies Board of universities with ocean datasets to investigate anomalous phenomena (Gallaudet and Mellon 2023).

When it comes to mining civilian satellite imagery data for UAPs and considering the initial approaches taken by the Galileo Project, there is room for improvement by adopting a more practical approach that involves reversing the workflow. In this alternative approach, researchers interested in studying UAPs could start by leveraging well-established databases of significant UAP events. These databases can help identify high-quality reports that serve as reliable starting points. Subsequently, researchers can narrow down their focus and target specific areas or timeframes for satellite imagery data collection, optimizing the resources and efforts involved in the search for anomalies.

Significant progress is underway in Defense and military initiatives, and these efforts are expected to yield positive outcomes in the near future. Recognizing the limited scientific data available on UAP, the US DoD has adopted a proactive approach, moving beyond passive evaluation of past military sightings and associated data. At the recent public meeting of NASA's UAP Independent Study Team (UAP, NASA UAP-IST) on May 31st, 2023, Dr. Kirkpatrick, the director of

AARO, unveiled the development of new sensors specifically designed to enhance detection, tracking, and characterization of typical UAP objects. Dr. Kirkpatrick's presentation also highlighted the deployment of such purpose-built surveillance systems in high-activity areas for extended periods, enabling 'Pattern of Life' analysis (NASA Unidentified Anomalous Phenomena Independent Study Team, May 31, 2023). This analysis aims to prioritize locations for data collection, potentially offering valuable insights. Additionally, AARO has initiated collaboration with the 'Five Eyes' alliance, comprising the United States' allies, to establish processes for sharing UAP data and calibrating assets, thus improving investigations.[5]

In terms of recommendations, AARO suggested that NASA explore techniques to integrate 'Tip and Cue' collection capabilities throughout the scientific architecture, both overhead and ground based. This innovative approach holds significant potential for UAP research. 'Tip and cue' refer to the practice of monitoring an area or object of interest using one sensor and requesting another complementary sensor platform to capture images. Typically, this process starts with a cost-effective, wide field-of-view sensor to identify an object or location, followed by a higher-resolution sensor for further investigation and analysis, which may be more expensive. It is worth noting that civilian UAP projects had already envisioned such an approach, similar in essence to the original UFODATA concept of employing an all-sky camera for UAP detection, with higher-resolution cameras zooming in to capture photos and videos, albeit on a much larger and more capable scale.

In relation to the latest developments involving NASA and AARO, there are several important suggestions that warrant attention. Firstly, it is crucial for these organizations to recognize the potential benefits of studying the valuable work conducted by civilian groups, which can provide valuable insights for their own plans. This entails conducting a thorough examination of field studies and the most compelling evidence from UFO cases, regardless of their origin. It is noteworthy that during the NASA public meeting, the UAPIST conveyed a limited awareness of the range of UAP reports and deferred to the AARO characterization of sightings as small objects at high altitudes (UAP, NASA 2023). Acknowledging the full breadth of UAP reports is essential in determining the scope of study and the appropriate strategies to employ. Secondly, it is highly advisable for NASA and AARO to explore the possibility of collaborating with external experts such as the Scientific Coalition for UAP Studies, UFODATA, UFODAP, UAPx, and similar organizations. By engaging these experts as consultants for planned studies, NASA and AARO can leverage their extensive expertise, which has been developed over time. These external experts can provide valuable guidance and contribute their specialized knowledge to enhance the effectiveness and thoroughness of the research conducted. Finally, it is worth noting that incorporating past research and leveraging the knowledge of established experts are fundamental practices in the pursuit of scientific progress, and, therefore, treating the UFO field no differently from any other field of science is crucial in this regard.

Without a doubt, the widely held belief that advanced extraterrestrial civilizations are visiting or observing Earth, referred to as the extraterrestrial hypothesis, will continue to inspire new instrumental projects for studying UAPs. This is partially attributed to the extensive promotion of the Galileo Project and the unprecedented decision made by NASA in 2022 to establish a study team to investigate UAP. In the foreseeable future, we can therefore expect the emergence of innovative projects with a specific focus on the space surrounding Earth, aiming to detect probes within Earth's orbit, such as the 'EXOPROBE' project (Villarroel & Marcy 2023). This research naturally complements the recent interest within the SETI (the Search for Extraterrestrial Intelligence) community to search for 'Technosignatures', defined as observational evidence for the existence of industry or technology in the universe. However, these endeavors will encounter a significant challenge in assuming the existence of such probes and differentiating them from human-made objects using their intended instruments. Nonetheless, it is important to recognize that the extraterrestrial hypothesis is just one of numerous explanations for UAP occurrences, and we should remain open to other possibilities.

As a final consideration, venturing into uncharted territory in UAP research involves exploring the high strangeness aspects of these phenomena. In the study of the UAP literature, it's becoming more apparent that these occurrences can exhibit complexity beyond conventional explanation. Some researchers advocate critically examining the more unusual facets of UAP events and considering them for field experiments. As mentioned on pages 7, 9, and 11, the instances of UAPs apparently interacting, vanishing, or

5 The NASA-IST released their final report on 14 September 2023. It can be found on the UAP section of NASA's website (https://science.nasa.gov/uap).

interfering with data acquisition during observations raise questions about the potential influence of the observers. These cases suggest that observers may impact UAP behavior, akin to quantum mechanics principles where measurement choices affect subsequent particle behavior. In contemplating future UAP research and despite the added layer of uncertainty in data collection and interpretation, it appears important to investigate the potential role of human presence in UAP behavior. While designing field experiments to test observers influence may be challenging, researchers must remain mindful of this phenomenon and its implications for data quality. Collaboration with experts in various fields, including physics, psychology, anthropology, behavioral sciences, and neuroscience, can provide valuable insights and ensure rigorous methodology. As we delve deeper into UAP studies, these high-strangeness aspects serve as reminders of the mysteries challenging our understanding.

Through the implementation of the key steps outlined in this section, it is the central premise of this thesis that we can enhance the quality and reliability of UAP research, thereby advancing our understanding of this captivating phenomenon.

8. Conclusions

Instrumented field research has played a crucial role in establishing the scientific study of UAP, providing much-needed legitimacy to the field. Despite being more common in some areas, UAPs still appear intermittently, making long-term funding essential for sustained research efforts. Placing instrumentation at sites where UAPs are frequently seen has proven more successful than relying on convenience alone. While UAP photographs, and some instrumental data, have provided clear evidence of their existence, the lack of scientific measurements has hindered our understanding of the phenomenon. Developing reliable methods for measuring UAP characteristics remains the major challenge and opportunity in the field, and recent technological advancements and improved software tools offer new and more effective options for detection and analysis. With the recent surge of interest in UAP and the involvement of more qualified professionals and research organizations such as NASA, AIAA and the US Department of Defense, the efforts to detect, track and measure the UAP phenomenon in real time has recently entered a new phase. We can cautiously expect that continued and expanded efforts as described in this paper will lead to increased scientific understanding of the characteristics of the UAP phenomenon.

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