MASTERARBEIT | MASTER'S THESIS

Titel | Title

Rhythms and Revolutions. A Time-sensitive Investigation into Skylab IV's Labor Conflicts.

verfasst von | submitted by

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angestrebter akademischer Grad | in partial fulfilment of the requirements for the degree of

Master of Arts (MA)

Wien | Vienna, 2026

Studienkennzahl lt. Studienblatt | Degree programme code as it appears on the student record sheet:	UA 066 906
Studienrichtung lt. Studienblatt | Degree programme as it appears on the student record sheet:	Masterstudium Science-Technology-Society
Betreut von | Supervisor:	Assoz. Prof. Mag. Dr. Nina Klimburg-Witjes MA

Acknowledgements

Wholeheartedly I want to thank the many people who supported me during the long journey of writing this master's thesis. First, I want to thank my partner and family for their continuous support. For providing safety, warmth, comfort, and advice during the last years. Second, I want to thank my friends and colleagues, who cheeringly encouraged me along the way in my studies and writing process. I would like to give special thanks to the people who feedbacked this thesis, including my supervisor Nina Klimburg-Witjes for her encouragement to write this thesis and continuous support. Further, I would like to thank Phillip Brooker for his time and insight into his research and knowledge about the case.

I could not have written this thesis without you.

Abstract (English)

A new space age, marked by the marketization of outer space and expansion of space infrastructure (Jeevendrampillai, Kozel and Gorbanenko, 2025), is already in full swing while policymakers and investors head into a new space race (Klimburg-Witjes, 2024). During this time, questions about how to live, research, and work in outer space resurface. To take a look at the history of collective, organized research of outer space, therefore, might be a worthwhile undertaking to learn from the past. In this thesis, I examine how and to what end time was constructed in the labor conflict aboard NASA's Skylab IV mission. I draw on archival transcripts, oral histories, and mission documentation to revisit the contested narrative of the alleged "strike" in space to explore how work, authority, and temporal structures were negotiated in low-earth orbit. I look into the temporal logics, practice, and moments in order to depict the mission's timescape and investigate how it co-construct Skylab's labor conflict. I argue that Skylab IV was governed by a quantitative approach to scientific data production and an economic-operational framework that would marginalize astronauts' agency and lower morale, shape research instruments and infrastructure design, create a timescape dominated by the imaginary of urgency with accompanying temporal experiences for astronauts, and co-shape scientific interpretation and data acquisition. Further, I aim to highlight that Skylab shares an unbroken line of history with today's euro-western astronautics, but also how the astronauts' endeavours protested and transformed the timescape.

Abstract (Deutsch)

Ein neues Weltraumzeitalter, geprägt von der Kommerzialisierung des Weltraums und dem Ausbau von Weltraum-Infrastruktur (Jeevendrampillai, Kozel und Gorbanenko, 2025) ist bereits in vollem Gange. Politische Entscheidungsträger und Investoren stürzen sich in einen neuen Wettlauf ins All (Klimburg-Witjes, 2024). In dieser Zeit kommen erneut Fragen über das Leben, Forschen und Arbeiten im Weltraum auf. Ein Blick in die Geschichte der kollektiven, organisierten Weltraumforschung könnte daher wertvolle Einsichten beinhalten, um von der Vergangenheit zu lernen. In dieser Arbeit untersuche ich, wie, und zu welchem Zweck, Zeit im Arbeitskonflikt an Bord der NASA-Mission Skylab IV konstruiert wurde. Ich stütze mich auf Archiv-Transkripte, Zeitzeugen-Interviews und Missions-Dokumente, um die umstrittene Erzählung des angeblichen „Streiks“ im Weltraum zu untersuchen, wie Arbeit, Autorität und zeitliche Strukturen hier ausgehandelt wurden. Ich untersuche die zeitlichen Logiken, Praktiken und Momente des “Streiks”, um den *Timescape* der Mission darzustellen und zu untersuchen, wie diese den Arbeitskonflikt auf Skylab mitgestaltet haben. Ich argumentiere, dass Skylab IV von einem quantitativen Ansatz zur Produktion wissenschaftlicher Daten und einem wirtschaftlich-operativen Rahmen bestimmt war, der die Handlungsfähigkeit und Arbeitsmoral der Astronauten an ihre Grenzen brachte, die Gestaltung der Forschungsinstrumente und der Infrastruktur mit prägte, sowie einen *Timescape* schuf, der von der von *Urgency* dominiert war und die wissenschaftliche Interpretation sowie die Datenerfassung mitbestimmte. Darüber hinaus möchte ich hervorheben, dass Skylab eine ununterbrochene historische Verbindung mit der heutigen euro-westlichen Raumfahrt teilt, aber auch, wie die Astronauten gegen diese Zeitlandschaft protestierten und sie veränderten.

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Table of Abbreviations

ATM	Apollo Telescopic Mount
ASP	Activities Scheduling Program
CC	Capsule Commander
CMR	Commander
CMG	Control Moment Gyroscope
EREP	Earth Research and Exploration Package
JSC	Johnson Space Center
JOP	Joint Operation Procedures (or Program)
LEO	Low Earth Orbit
MER	Mars Exploration Rover
MCC	Monitoring Capsule Commander
MOPS	Mission Operation Planning Software
NASA	National Aeronautics and Space Administration
SPT	Science Pilot
PH	Personal Hygiene
PI	Principal Investigator
PLT	Pilot
PT	Physical Training
RT	Real Time

1. Introduction

The Space Race is back! With the corporalization of outer space infrastructures and an ever-increasing entanglement between public institutions, the military-industrial complex, and corporations, private investors claim the low-earth orbit (LEO) as a new domain for economic enterprises. Elon Musk shoots for Mars as a new space to inhabit, with SpaceX making multiple-use rocketry for ever-cheaper space travel and Jeff Bezos performing low-earth orbit tourism for the millionaire class. While in Europe, states try to gain more agency by establishing their own space megastructures far from the influence of other global actors such as the U.S., other, smaller companies find their share in the production of satellites or technologies to clean the debris outer space infrastructures leave behind. Yet other states still entertain manned space stations like China's Tiangong Space Station. In all that, the National Aeronautics and Space Administration (NASA) is still an agency in the forefront of space exploration in the global northwestern sphere, with research teams in Europe, the U.S., and regions still bound to the nation through imperial or colonial policy. With the retirement of the ISS in 2030, an abundance of ideas to establish life in low-earth orbit emerged, from commercial space stations from the private sector to new projects by state-affiliated players like the ROS from Russia or NASA's lunar gateway, partnering with the CSA, ESA, JAXA, and MBRSC, both anticipated to be launched in 2027. This 'deep space home' will share a history with the earliest attempts to make living and working in outer space a possibility.

With scientific endeavors and attempts at living in outer space not likely to decrease anytime soon, a look at the predecessors of the ISS and other manned space stations may produce unique insights into the social life of space stations in the past, the present, and even the future. But histories are not a mere look into the past; they can be the foundation and/or blueprint for the next generations to come. Is it not fitting that the earliest attempts at spacefaring and research for a prolonged period of time were from the aftermath of the space race? Enter, Skylab. NASA's first endeavor to research living in outer space. Against this background of new ambitions at conquering outer space, it becomes crucial to examine earlier attempts at sustaining human life and labor beyond Earth. Historical cases not only illuminate technological challenges but also reveal how social organization, work expectations, and institutional pressures shaped life in LEO. One such case, both pioneering and contested, is NASA's Skylab program and, in particular, its final mission. To understand why this mission may be best suited for a time-sensitive investigation into labor relations in outer space, we must first situate Skylab IV within the broader context of the Skylab program itself.

1.1. The Case: What is Skylab IV?

Times were changing for NASA in the 1970s. As parts of the U.S.-American public were discontent with the ongoing Vietnam War and the U.S. war machine, to which NASA was counted by some, the organization found itself entangled in the critique voiced against its government. After Apollo 13, the strained geopolitical situation led to the U.S. government under the leadership of President Nixon reducing funds (e.g., Hutchinson, 2000; Gibson, 2000).

From its very beginning, NASA was run by military or military-affiliated personnel. The engineering of rockets tied the organization to the military-industrial complex of its nation. Astronauts were mostly drafted from fighter pilots, while scientists were rare to encounter, let alone researchers from outside the organization, within its walls. The Skylab program introduced scientists into the fray, introducing researchers and academic institutions to the forefront of space exploration and allowing scientists to be in direct contact or even become astronauts. Further, Skylab was designed to achieve a large degree of transparency with the U.S. American public, with transcripts of all conversations that were held on the communication channels made accessible during a press conference each day. Skylab achieved a milestone in the history of the U.S. American astronautics program with the first manned research station in outer space, specifically LEO. NASA introduced the program as part of the Apollo Applications Program in order to repurpose and improve the designs, personnel, and devices from the previous Apollo missions. Skylab IV was the longest mission up to this point (1973), with astronauts occupying the space for 84 consecutive days (see, Hitt, Garriott, and Kerwin, 2008). The Skylab program included four missions. The first explored Skylab's potential as an unmanned station controlled from earth, while the following three missions sent a team of three astronauts to the space station to engage in the production of scientific data through numerous observations and experiments. The centerpiece of the station was the Apollo Telescope Mount (ATM), a huge camera-device running on film that would allow the crew to record various phenomena on Earth and the Sun. The Skylab program went off to a troublesome start, as parts of the foiling were ripped apart during the launch, so the first manned team (Skylab II) worked primarily on repairing the foil that would shield the crew from radiation and heat. The second crew (Skylab III), trying to catch up with the schedule, outperformed all expectations of how much scientific work could be accomplished, earning them the nickname '150% crew.' The third crew (Skylab IV), Edward Gibson, William Pogue, and Gerald Carr, on the other hand, struggled with the scheduled workload as soon as they arrived on the space station, leading to what is today infamously known as the first "mutiny" in space (Uri, 2020).

1.1.1. A Mutiny in Space? A debated history.

This master's thesis follows to some extent the contested story of the Skylab IV mission's labor dispute, more famously known as the "Strike" in Space (e.g. Uri, 2020, Burns and Gibson, 2021), in which three novice astronauts allegedly refused to work under their current labor conditions aboard the Skylab space station to conduct a number of scientific experiments in service of NASA research. As Edward Gibson, one of the astronauts of Skylab 4, states in an interview with the BBC (Burns and Gibson, 2021), the mission started with one of his co-researchers, William R. Pogue, being sick. Falling behind on schedule, the astronauts were confronted with rigid micromanagement by mission control in order to improve the performance of the researchers. As told by Gibson, they experienced ground control as bossy and competitive, the reason being that the Skylab III mission surpassed expectations in performance and raised the bar for their successors (Burns and Gibson, 2021).

In 2020, John Uri of the Johnson Space Center published an article on the NASA website called "The Real Story of the Skylab 4 'Strike' in Space," in which he declares the strike an urban legend and discredits a number of publications such as the journalist Henry S.F. Cooper's book titled "Life in a Space Station," in which he claims that a mutiny happened during the Skylab IV mission. From Uri's perspective (2020), publications, such as a Harvard Business School case study called "Strike in Space," reinforced this belief. He attributes the story to the realm of myth-making and claims that "after a thorough review of the available evidence, it is clear no strike or mutiny took place during the Skylab 4 mission." (Uri, 2020). One year before (2019), ethnomethodologist Phillip Brooker started a conversational analysis of the transcripts of Skylab 4 around the five-day period of the alleged strike, discussing his ethnomethodological process in a podcast format where he also constructed a narrative account of what happened during that time frame. Brooker, in contrast to Uri, is more interested in how different interpretations of the event are possible, given the existence of publicly available transcripts. What Brooker's analysis suggests are a number of labor-condition-related conflicts between the crew as well as mission control. He further states that the astronauts were using different strategies, including the weaponization of the specificities of the communication system's timings, in order to improve living and working conditions at Skylab. Their efforts ultimately led to something that is similar to union table discussions (Brooker, 2019-2020).

In a previous essay of my studies (unpublished, 2024), I discussed that Uri's primary concern was debunking the myth of a strike or mutiny during the Skylab 4 mission. Due to his close link to NASA's Johnson Space Center, in combination with his rhetoric strategy, he shows an implicit interest in the legacy of the Skylab program. Employing a "work-as-usual" argument, Uri details the crew's activities without an investigation of labor relations between the crew and mission control. Contrasting Uri's narrative with Brooker's analysis reveals discrepancies in their interpretations of the Skylab 4 mission. While Uri portrays a seamless operation devoid of labor unrest, Brooker's analysis acknowledges the complexities of communication and decision-making in outer space, offering a more nuanced understanding of the situation, astronautics, and the issues astronauts struggled with during the mission. One of Brooker’s key discussion points is that although data exists on the conflicts and issues of the team due to NASA’s strict transparency policy and documenting protocols, little to nothing is found on the labor issues in the scientific output of the mission. Studies like the “H151 time and motion study” (Kubis and McLaughlin, 1975) were more concerned with producing ‘hard’ evidence on how to live and work in space, measuring and quantifying, for example, nutrition intake, time to exercise, etc., while qualitative data was largely dismissed or not taken into consideration (Brooker, 2019-20).

1.1.2. Skylab as a Documented Phenomenon

Skylab, as a space station, does not exist anymore. 46 years ago it plummeted back into the earth's atmosphere, its debris scattered across the Indian Ocean and Australia (Uri, 2024). What we do have are replicas in exhibitions and documents that passed the test of time. Because of NASA’s transparency policy during the Skylab program, a number of documents are available from the mission, including multiple transcripts, the air-to-ground and on-board communication, and conferences. Moreover, Skylab material published and/or archived by NASA includes press kits, design manuals, video recordings, schedules, and numerous scientific publications. Further, in the 2000s, the Johnson Space Center introduced its oral history program, interviewing countless NASA employees and associates on their biographies and involvement in various missions. With the International Space Station (ISS) in NASA’s future, interest in these interviews sometimes focuses on Skylab as the predecessor of the ISS. Skylab lives on in the accounts and countless pages and recordings dedicated to the intricacies of the station. It is a ‘documented phenomenon,’ a description utilized also by Brooker (2019-20), that summarizes the unique features and difficulties of Skylab as a case study for research. For one, all documentations (visual, auditive, and descriptive) can never depict the reality of what happened aboard Skylab; they are actively shaping our understanding of what may have happened, invoking and incorporating specific practices such as specific ways of writing, and existing in a context by which a document may relate to or frame different actors in specific ways (Asdal and Reinertsen, 2022). All in all, a document may for all intents and purposes be understood as an actor. The transcripts are full of errors, not matching up to who is speaking when in fast discussions, combining different information, and so on. Further, these transcripts are all released in a short time frame to the public, and NASA would use this time frame, for example, to censor specific words (Brooker, 2019–20). In addition, everyone using these communication channels was aware of the fact their words were made available to the public. Therefore, a historic case study such as this master's thesis must not only see documents as incomplete and prone to error but also as a multifaceted enactment of possible realities serving a multitude of purposes. The documents of Skylab not only enact transparency, but they also marginalize conversation as astronauts and communicators are now representatives of NASA.

For researchers, Skylab can only be experienced through accounts of others and Skylab's remnants, but there lies also the potential. Skylab, as a case, is well-documented and can therefore be accessed by researchers in order to repurpose the already existing data. One of the explicit goals of the program and a reason for the prolonged stay in space during Skylab IV was to understand how humans can live and work in space. NASA and researchers at the time focused on the quantitative data produced, resulting in studies such as the "Time and Motion Study" (Kubis and McLaughlin, 1975; Brooker, 2020). While the qualitative data of the transcripts and interviews may have unique insights into living and working in space, they are yet underexplored.

Surely, the myth of a mutiny in space is intriguing, and the documentations are convoluted but plentiful. This thesis turns to Science and Technology Studies (STS) to investigate the relation between the 'social life of a spacecraft' (Vertesi, 2020) and the construction of time. As we will see in the following chapter (1.2. Research Questions), this research will focus on the specifics of the social construction of time of the Skylab IV mission, more specifically in the days that were identified by Brooker as the period of the alleged strike, but also the following few days in order to grasp the supposed aftermath of the labor dispute. As Adam wrote,

"Conflicts over time-control can be observed throughout the history of strikes where the duration of the working day, week, year and working life, the pace of work and break-times, overtime and time off, holidays and paid leisure time are at the centre of the disagreements" (Adam, 1995, p. 26).

Skylab, as a case, allows for insights into the unique circumstances that reshape organized, collective research due to the vast sociotechnological barriers and hazardous environments in which they are enacted. It also allows us to draw a historical comparison with numerous visions for living in space under the umbrella of the “new space age” (Jeevendrampillai, Kozel and Gorbanenko, 2025, p. 1) and the research on current-day space endeavors. To understand Skylab’s labor conflict, time is a promising perspective. I will explore how the social construction of time can be analyzed in the following chapters by means of archival research and document analysis. Findings will be described and discussed. In a final section, I will then lay out an answer to my research questions as well as present the unexplored trajectories of this thesis.

1.2. Research Questions

For this inquiry into the Skylab IV case of an outer space labor dispute, I developed the following main research question as well as three sub-questions that guide specific parts of the research. For my main question, I chose a question that would suffice both as including the different theoretical dimensions that sensitize my research as well as construct a clear focus on the specifics of my master’s thesis.

How and to what end is time constructed in the management and labor practices that influenced the Skylab IV labor dispute between astronauts and mission control?

First, this question is rooted in an understanding of time through ‘timescapes’ (Adam, 1998). In her concept, Adam identifies multiple timescape features such as time, temporality, tempo, timing and the modalities of time with past, present, and future. These features shape the temporal experience of actors in which conflicts between technosocial constructs of time such as ‘clock time,’ ‘network time’ and ‘embodied time’ (Adam, 1995; 2021) may be performed. As Adam states, modern labor conflicts are, at their core, conflicts about time-control (Adam, 1995) and a time-sensitive investigation of these conflicts would need a suitable approach as time-based analysis deeply affects its research subject (Adam, 2021).

Second, this question is focusing on the relations between time-related practices and the infamous labor dispute of the Skylab IV mission. This focus is based on the hypothesis that labor relations and practices are closely knitted in capitalist societies to temporal experience (Alhadeff-Jones, 2021) and that the commodification of time or speed has a strong impact on the individual’s experiences, practices, and institutions within the academic sector (Burneva, 2021). Further, as time is processual, it is often encountered in the referred experiences of human actors as well as in its construction through practice. This main research question therefore helps to follow and recognize diverse practices and their underlying temporal logics and study them within conflictual processes (Adam, 2021) in a sociotechnical, institutional, academic, and research-focused timescape such as Skylab.

To account for every aspect of this main research question, I formulate the following sub-questions to guide my research:

What logics of time can be identified that constitute the co-production of Skylab's Timescape during the Skylab IV mission?

This question sensitizes this research endeavor to statements or organizational aspects of time, timing, temporalities, and other aspects of timescapes (Adam, 1995; 1998; 2021) that are presented in the research material. Specifically, this question guides my focus toward reasonings for and ordering of temporal principles that affect and govern the temporal experience. Understanding why specific adjustments, re-orderings, or new associations in the timescape of Skylab IV may happen is crucial to identifying underlying issues in the organizational process that may have led to the labor dispute but also introduces the notion of co-production (Jassanov, 2004) in order to account for the embodiment of such principles or rationales within the design of the space station and supporting infrastructure of its assemblage (Law, 2004) of technologies, further shaping the social life during the Skylab IV mission in specific ways. This research question also informs the next group of subquestions, in that we see how logics of time are produced and practiced.

How did management, labor, and knowledge-making practices during the Skylab program – particularly during the labor conflict on Skylab IV – enact, constitute, or reconfigure the program's timescape, and how did these practices shape astronauts' temporal experiences?

This subquestion stands in a close relationship with the first subquestion, as it identifies how different logics of time produce a variety of practices in relation to other actors but also non-human actors who become, by practice, associated with the timescape or shape the practices of human actors to operate under different logics of time. In a time-sensitive understanding of practice, we may find best what conflicts arise in the complex managing and labor efforts of Skylab IV. They act upon and within the assemblage and timescape by ordering temporalities, creating new time frames, and managing synchronization efforts by timing, to name a few examples. A timescape is of a processual nature and needs constant enactment by both human and non-human actors in order to take form. The specific practices of management, labor, and scientific knowledge production (as the astronauts were working as scientists and engineers) triangulate the practices in which I assume we find insights into the specific construction of time aboard Skylab and its role in the labor conflict.

What specific moments led to the labor dispute between astronauts and mission control on the Skylab program?

The last subquestion associates different practices with the logics of time that operate in the Skylab IV Mission and tries to form a time-sensitive narrative in which specific *moments* allow us to make sense of the labor dispute.

„a moment refers to some form of constancy within the course of time; it constitutes a common element shared by a series of instants, events, or circumstances“ (Lefebvre, 2009, p. 640).

This is not only important for an understanding of which instances the timescape of Skylab became visible during the Skylab IV mission; significant moments may be referred to by astronauts or mission control in order to make sense of the situation or conflict. Temporal experiences may further be understood through means of alterations in between influential moments. Although we may not know how impactful these moments were in the lived experience of the astronauts, they can be traced through the documentation of the Skylab program and understood in their situated context. As such, moments may be referred back to and recognized as formative for decisions and practices performed in the present, or being referred to in comparison to anticipated future events. Through this question, this thesis can access the modalities of past, present, and future from the perspective of actors engaged in the labor conflict.

To move from the formulation of my research questions to the broader academic context of this thesis, I now situate the Skylab IV case within existing scholarship on outer space as a social and organizational field. This chapter has outlined how I approach the labor dispute as a conflict over the construction and control of time within a specific sociotechnical assemblage. Building on this perspective, the following State of the Art chapter expands the view to research in STS, sociology, and related fields that conceptualizes outer space as a site of labor, governance, infrastructure, imagination, and temporality. By reviewing these strands of literature, I position my analysis of Skylab within ongoing debates on the social organization of space missions and the temporal regimes that structure scientific work beyond Earth.

2. State of the Art

In recent years, the social study of outer space (SSOS) has emerged as a growing field, with scholars turning their attention to the infrastructures and risk management, imaginaries, and everyday practices that shape scientific work beyond Earth. Rather than treating outer space as an abstract or purely technical domain, the works discussed here understand it as a site of labor, governance, and imagination – where the production of knowledge is inseparable from organizational forms, political economies, and cultural narratives. This review brings together ethnographies, in-depth sociological inquiry, theoretical interventions, and methodological proposals that each offer distinct but overlapping insights into astronautics as a form of collaborative scientific work conducted under extreme conditions. Particular attention is paid to research that addresses temporal regimes, institutional logics, and the framing of human and non-human actors in space missions. Further, this chapter also introduces research that focuses on time in many different sites of research, such as academia, to focus more on the aspect of *collaborative, organized scientific research* in relation to *time* in order to see what aspects of academic work in outer space may share or differentiate from earthly research. Contributions from STS, feminist technoscience, organizational sociology, and critical policy studies serve to both contextualize and complicate the ways in which outer space has been studied – as infrastructure, as a workplace, and as a projection surface for sociotechnical imaginaries of vastly different actors. The following selection of texts and studies has been curated not only for their thematic relevance to the case of Skylab, but also because they demonstrate different methodological and conceptual strategies for analyzing organized scientific work.

To achieve this, I introduce a few trajectories from SSOS to present a general idea of how outer space becomes a site of social inquiry. I will introduce astrosociology, the historical-material perspective, feminist and technoscientific approaches, and space archeology, as well as organizational studies of outer space, and position myself within the boundaries of these trajectories (2.1. Trajectories of Outer Space). What follows is an in-depth look at the relation of scientific knowledge production and sociotechnical organization in outer space research (2.2. The Social Organization of Outer Space). Both of the works discussed in this section were major influences and informed my perspective on Skylab when looking at organized research. Namely, we look into NASA's Mars Exploration Rover (MER) mission exploring the construction of 'Mars Time' (Mirmalek 2020) and the comparison of two NASA teams on how science is shaped by institutional culture (Vertesi, 2020). Within the next subchapter (2.3. What makes a Space Station?), I will then lay out two of the major fields of study within SSOS approaches to the field, namely Infrastructures and Imaginaries, and present publications that inform my perspective on Skylab as a space station: What it means to be engulfed in sociotechnical systems as an astronaut and what it takes to allow for space travel. But also for Skylab as an imaginary, how Skylab performs and enacts ideas of outer space research within and how it may be implicated in geopolitical issues and future-making practices. Following this conceptual understanding of space stations, I will then go into detail about what social life is like in outer space through a section on ethnographical research (2.3.1. Understanding Astronautics), focusing on the work in space travel agencies and space stations, such as the work of the ETHNO-ISS team, producing insights into astronautics and life and work on space stations in LEO today. Allowing also for a comparison between temporal practices and operational logics at play in space agencies. I will then extend the ethnographic work on space stations with a subchapter (2.4. ASOS in Space) on Brooker and Sharrock's work on Skylab (2019-20; 2023; forthcoming), going into more detail into their research, what to expect from their work on Skylab in the future, and where my research follows their call to action to work with the Skylab material. The last subchapter of this section will explore current research on timescapes co-shaped by academia, on how academic institutions' temporal logics operate, on how they co-construct time, and on how temporal resistance is practiced by academics (2.5. Inquiring into Academic Timescapes). This should tie together the social analysis of time of academic institutions with a picture of the current developments of research. Ideally, this chapter introduces the current discourses in outer space sociology with research on the relationship of time and knowledge production, bridging both fields with this thesis. In Chapter 6 I will then add to these discussions.

2.1. Trajectories of Outer Space Research

The SSOS is a relatively new topic for the discipline of science and technology, but also for sociological research as a whole. Recently, outer space has increasingly become a site of technosocial inquiry. In this subchapter, I will examine Castaño and Santana-Acuña's (2023) discussion of the three different approaches to the SSOS. Further, I will introduce other directions of sociological research that are left out by Castaño and Santana-Acuña (2023) and position this master's thesis in between those trajectories. My intent here is to paint a rough picture of the possible fields of research and explain why I chose to follow a certain path of research.

The first approach discussed by Castaño and Santana-Acuña, Astrosociology, is understood by both as contributing little to sociology and criticized as having a lack of empirical contributions and embracing utopianism and colonialist efforts (especially in relation to Mars) towards outer space. Astrosociology, as an industry-near scientific endeavor, mirrors many themes in the discourse around the exploration and exploitation of outer space, especially those found in 'NewSpace' (Valentine 2012) narrative. A number of, sometimes conflicting, imaginaries exist alone in the Euro-American context around space. Some of them frame outer space as a frontier, a market, an accelerator of innovation, and so on. All mediating what to expect from outer space research, technologies, enterprises, and institutions. Iterations and motives of these are found and reproduced in high-tech conventions as well as popular culture such as science fiction (Popper 2021; Salazar and Gorman 2023). Astrosociology as such is a cluster of institutions that look into the question of how to colonize space, rather than understanding social life in outer space.

The second approach outlined by Castaño and Santana-Acuña (2023) is a historical materialist as well as a dialectical approach that is mainly derived from Marxism. With a focus on 'social power' and 'capital,' this theoretical approach paints a picture of elites and their historical relation to the cosmos as well as contemporary efforts to control planetary activities through outer space technology by cooperation between the private and military sectors. This approach is criticized by both authors for its homogenous view of elites as a social group as well as for lacking an empirical agenda (see Castaño and Santana-Acuña, 2023). In my mind, such a historical and materialist perspective is utilized productively in the feminist studies and technoscience of outer space as described by Gál and Armstrong (2023). The field foregrounds the often-invisible forms of labor (Rosner, 2018), such as the overlooked role of women in the production of space technologies or the resistance of indigenous groups to telescopes and rocket launch sites. For example, a study by Gál focuses on the story of the first Skylab crew, in which the damaged thermal shield could only be repaired by one of the engineers through the knowledge of his mother's sewing work but was solely attributed to the "genius" of his expertise, "ultimately reinforcing a narrative of technological solutions being born out of the individual expertise of sole white male geniuses" *(*Gál et al., 2023, p. 163*).* Technoscience can also be credited for showing how space technologies are not neutral agents but reflect and reinforce social inequalities. Many cases reveal how colonial, capitalist, and patriarchal logics underpin dominant imaginaries of space exploration – where nature is framed as passive, extractable, and feminized. Environmental justice perspectives expose how space infrastructure often infringes upon indigenous land rights, perpetuating extractivist violence both on Earth and in projections into outer space. Two such publications from recent years are Sammler and Lynch's

“Appartuses of observation and occupation“ (2021), looking into the relation of settler colonialism and space science in the case of the Mauna Kea observatories in Hawaii, and Maile (2021), an autoethnographical study on the notions of ‘lateness’ and ‘cruising’ while negotiating divestment against the construction efforts for a telescope in the name of the Kānaka Maoli with investors as well as other practices of resistance towards settler colonialism related to space research in Hawaii. Space archeology also deploys a material-historic lens. The discipline is defined as “the material culture relevant to space exploration that is found on earth and in outer space (i.e., exoatmospheric material) and that is clearly the result of human behavior” (Darrin and O’Leary 2009, p. 5). As described by Gorman (2023), space archeology is an intersecting field that hits most of the same marks as outer space studies from a feminist-technoscience perspective but introduces the archeological methodology to such investigations in order to understand the ideologies of space exploration in categorizing space sites, spaceships, and space debris as archeological artifacts. Showing how material remains of artifacts and landscapes ‘weave place and people together.’ Special attention is given here to machine landscapes and the impacts of space technology on indigenous people (Gorman 2005; 2007) through material remains. Gorman sees archeology in that sense as a method to also “decolonize” space exploration by making these relations tangible.

This last approach discussed by Castaño and Santana-Acuña (2023) is best understood by studies like Vaughan’s (2007) research on the Challenger disaster, which analyzed how institutional norms and work practices influence risk assessment and even normalize deviance. From this trajectory, a number of publications focus on past and present space stations (Castaño and Santana-Acuña, 2023). Inspired by STS scholarship and Vaughan, Vertesi studied in “Seeing Like a Rover” (2015) and “Shaping Science” (2020) the relation between the organization of institutions and the knowledge they produce through an ethnographic methodology. Her study of “how a team’s daily work, interactions, hierarchies, leadership, and decision-making affect the very discoveries we make about the world“ (Vertesi, 2020, p. xi) is of utmost importance to this thesis as I study the day-to-day science-time relationship between the crew and ground team at the Skylab IV mission, allowing for this thesis to discuss how scientific knowledge production is in co-relation with how Skylab was organized. “Seeing Like a Rover” (2015) introduces us to the role rovers take in everyday research at NASA, how they co-shape research, and how they become part of the social life of the researchers, as they are treated as co-workers, taking over astronautic and research work in the field. I will dedicate a subchapter to both Vertesi (2020) and Mirmalek’s (2020) recent study in order to discuss how they both have a unique impact on this thesis, going into detail about how the organization coproduces scientific knowledge (Vertesi, 2020) and constructs time (Mirmalek, 2020).

With this thesis' focus on making the temporal practices relating to the work of astronauts and ground crew visible, while considering how space technologies enact such a timescape and reflect fringe or dominant imaginaries, my research follows this historic-material approach. As detailed in the following subchapter, this allows connecting technoscience with the organizational study of institutions, such as NASA, through a focus on management and labor practices.

2.2. Organizing Outer Space Research

Building directly on the preceding discussion of the social organization of outer space research, this subchapter shifts the analytical focus from these broader configurations to the organizational and temporal practices through which scientific knowledge is produced within NASA. To develop this perspective, I draw on two influential STS studies that treat organization and time not as neutral backgrounds but as constitutive elements of scientific knowledge production. The first, "Shaping Science" by Vertesi (2020), follows the long line of study of the relation between ordering societies and ordering knowledge production (e.g., Jasanoff, 2004; Knorr-Cetina, 1999; Lynch, 1993; Pinch, 1984) by comparing the organizational features and culture of two NASA teams – Helen and Paris – during a decade of their scientific work. The second study, "Making Time on Mars" (Mirmalek, 2020), is an ethnographic investigation of the MER missions and a case study in the sociotechnical construction of 'Mars Time' as a result of 'co-producing' (Jasanoff, 2004) the possibility for scientific knowledge about planet Mars within all the intricacies an earth-based rover mission needs to encompass.

2.2.1. Shaping Science

In her publication, Vertesi introduces her framework of principles for organized science. The basis for which is her decade of ethnographic work. She shares her insights on the team's daily work, interactions, and decision-making processes that co-produce the technological instruments and scientific findings. How missions can be studied as organizational field sites, how they bring diverse groups together to make decisions, how informed consensus is reached through ‘institutionalized dialogue’ (Heckscher, 1994), how teams are managed, how they are held accountable, and how scientists assert their own epistemic values to shape local responses to overarching scientific goals of NASA. Further, Vertesi and others show how NASA can be understood as a ‘confederation of cultures’ (McCurdy, 1994) that internally compete for the status of lead center and resources. This thought can be extended to the ‘multiplicity’ (Mol, 2005) that is in place in different teams and institutes of NASA, leading to vastly differently organized teams from science- to engineering-dominated centers. While Vertesi focuses in this publication on NASA in the 1990s and onwards, already replacing bureaucratic management – in which decisions need to go through the hands of higher-ups in order to be accounted for – with internalized discipline through work culture, Skylab might add to the understanding of a hierarchical institution in transformation towards a more plural institution with ‘heterarchic’ (Girard and Stark, 2003) decision-making processes, due to the change that the introduction of scientists and researchers from outside the institution provoked. Two other interesting features discussed by Vertesi concerning mission work, is that scientific work can expand to all aspects of life, acting as a ‘total institution’ (Goffman, 1961), and how working groups might have distinct “*idiocultures* – local practices, knowledge, and interactional norms in addition to the shared concerns, rituals, and practices of the mission as a whole” (Vertesi, 2020, p. 55). Vertesi‘s study of the Helen and Paris teams may be extended to ground teams working with astronauts, as both team and crew are engulfed and engaged in different ways by mission work. With a focus on time, one may understand how temporal practices and logics might coproduce the decision-making process. From a technoscientific perspective, this study can inform our understanding of management practices and sociotechnical artifacts shape scientific findings and temporal practice. For the Skylab IV mission, a concept like ‘sociotechnical torque’,

> “a phrase with a hybrid origin. The technical term is derived from engineering and refers to how one element of a system can put undue pressure on another, straining or even breaking the system as a whole. Yet it has also been imported into the social sciences to explain the “tremendous strain on individual biographies” that results when individuals and social categories do not align” (Vertesi, 2020, p. 48).

In Helen’s case, the scan platform for a drone could not fit due to budgetary concerns, a decision that would lead to strain on the probe’s wheels and fuel due to an extraordinary amount of requests to rotate the probe, but would also put strain on the schedules and daily work practices of the researchers, that needed certain instruments to be in specific positions. Especially interesting for the methodology with archival material is that sociotechnical torque is sociotechnically experienced. “The trauma of this incident was not limited to the moment the scan platform was cut but reverberated through decades of spacecraft use.” (Vertesi, 2020, p. 48) Meaning that these moments of sociotechnical torque bringing a system to the verge of collapse may be referenced for a long time by participants after the event has taken place.

Following Vertesi’s principles of organized science, especially “since scientific organizations shape scientific outcomes, the organization of a science collaboration is consequential for its scientific findings.” (Vertesi, 2020, p.152), a study on how different aspects of time are organized during mission work, might highlight unique relationships between the organizational make-up, the management and division of scientific labor and the scientific findings of such research in a mission’s timescape. To summarize Vertesi’s understanding of organized research; each collaboration enacts interactional norms to legitimate decision-making upon being challenged in the fields of research, these organizational elements shape data, publication, member’s reputation and, through ‘looping effects’ (new scientific outcomes become new team inputs for further research), are reintroduced into the formation of new scientific knowledge. Further, all of these processes naturalize social, scientific, and technical arrangements to appear to be a simple, streamlined way of producing knowledge (Vertesi, 2020, p. 265).

While Vertesi’s analysis foregrounds organization as a key site where scientific knowledge is shaped, it leaves comparatively implicit how *time itself* becomes an object of organization and contestation in mission work. Yet, as her discussion of schedules, deadlines, and moments of sociotechnical torque already suggests, temporal ordering is deeply entangled with organizational life at NASA. Decision-making, accountability, and coordination are structured through time: through rhythms of work, sequencing of tasks, and the alignment of human, technical, and institutional temporalities. To make this temporal dimension analytically explicit, the following section turns to Mirmalek’s (2020) research, which places time at the center of organizational analysis and demonstrates how temporal regimes are actively produced, negotiated, and stabilized in the course of scientific work.

2.2.2. Making Time on Mars

Where Vertesi’s work reveals how organizational arrangements shape scientific practice, “Making Time on Mars” (Mirmalek, 2020) places temporal organization itself at the center of analysis. Based on ethnographic fieldwork with NASA’s MER mission, the authors' in situ research reveals the process of constructing ‘Mars Time’ as an organizational need. For both technological and organizational reasons, such as the Mars rovers' need for sunlight due to the installed solar panels and their initial positioning on both ends of Mars, the mission became dependent on the day-and-night cycle of Mars – A Sol – where a rotation takes 40 minutes longer than on Earth. Mirmalek introduces the differences between agrarian and clock time and the specifics that make adjusting to Sols via clock time a complex and issue-inviting task for researchers and engineers on Earth. Further, the book establishes NASA's highs (e.g., winning the space race) and lows (e.g., the Challenger catastrophe) to highlight the relation of work and time as a prominent factor in all of NASA's missions. This book, although different in methodology and conceptual frame, became an inspiration for what one might expect from and what to look for in a time-sensitive investigation of organized scientific work in outer space. Mirmalik identifies a number of aspects and themes that were present within the organization during the MER mission, including the naturalization of clock time and Taylorist management logics in which clock time is determining productivity and efficiency. Deadlines that, although time never really runs out, were reinforced by policy, technology, everyday work practice, and national interest. Clock time, deployed to create a sense of timing or temporal rhythm for work on Earth, failed as the Mars rovers' dependency on sunlight and therefore solar time shaped the work at MER in ways clock time could not account for. Coping strategies were developed, not only for organizational reasons, such as frequently adjusted 'tactical timelines,' but also to manage one's own standing in the organization.

During the mission, rovers were treated as colleagues, being the only members in the mission to physically Mars' atmosphere. Workers at NASA took badges of valor and heroism in dealing with time-work related issues, due to their picture of how NASA scientists should act from previous missions and pop culture. Time-work issues were attributed to individuals instead of organizational failure in such a way that Mirmalik describes the MER mission as plagued by 'stigma management.' By many means, clock time as an organizational principle of the work-time relationship shaped the temporalities of MER and its members. "Making Time on Mars" shows not only how time is 'terrestrially contingent' (Jeevendrampillai, Kozel and Gorbanenko, 2025), but also how a time-sensitive investigation in outer space missions can develop a critical perspective on the most naturalized socio-technical aspects of working culture, such as the adherence to a clock. Such a perspective might support imagining different ways that put more autonomy in the workers' solution-making by being able to question the very fabric of their work relations in time.

Taken together, Vertesi's and Mirmalek's studies demonstrate that organization and time are not merely conditions under which outer space science takes place, but processes that structure how knowledge is produced, authority is distributed, and labor is experienced. By highlighting organizational and temporal features, these works make visible the often-naturalized infrastructures of decision-making, scheduling, and coordination that underpin scientific work in outer space. These insights provide a crucial analytical bridge to the study of space stations. If missions can be understood as organizational field sites and time as a sociotechnical construct, then space stations emerge as particularly dense configurations where organizational logics, temporal regimes, and social life intersect.

2.3. What makes a Space Station?

Unlike rover missions or ground-based collaborations, space stations combine scientific work with long-term habitation, rendering the organization of research inseparable from questions of dwelling, embodiment, hierarchy, and social relations in LEO. The following section therefore shifts the focus from organizational and temporal coordination in mission work to a few major themes in SSOS. The first section of this subchapter is dedicated to recent works in SSOS, following the question of how life in outer space is made possible but also what justifications ground such endeavors in different socio-political domains. What follows in the next section then is an in-depth look into space stations as a social space in which time, labor, and authority are lived, negotiated, and contested on a daily basis.

Two ever-present themes in the SSOS are the socio-technical imaginaries and the infrastructures that make various research possible. Often, these themes go hand in hand, as imaginaries legitimize the existence and maintenance of resource-heavy superstructures such as spaceports, rockets, satellites, space stations, and so on, while infrastructures allow researchers to grasp the socio-material and political implications of these sites. Moreover: "They [Infrastructure][1] are what makes the species' space endeavors possible" (Damjanov, 2023, p.329), because outside of earth's habitable atmosphere, "any and all activity must be technologically mediated" (ibid.). As such, afore-cited Damjanov's interest in governmental regimes seizing power over the arena of human life, especially the biopolitics of space, is placed with understanding the unique conditions of extraterrestrial infrastructures such as the extreme environment (Olson, 2018), demonstrate „The necessity of establishing comprehensive protocols of control and care alongside the development of space infrastructures emphasises their tendency to act as a 'gathering force', as an 'intermediary' that fuels the historical evolution of biopolitical regimes.“ (Damjanov, 2023, p. 330).

[1] Word in brackets added by the author of this thesis for better reading comprehension.

Damjanov reminds us that astronauts are engulfed in sociotechnical systems that see humans as a vital part of their functionality and therefore take constant concern and care in the well-being of humans, paying continual attention to the spacefarers mind and body, with space stations such as the ISS refining practices of 'careful surveillance' (Richardson et. al., 2017), „entangling acts of watching, caring, and controlling within affective and calculative techniques of life management." (Damjanov, 2023, p. 332).

This tendency to uphold human life in outer space is also prevalent in the role astronauts' bodies take in space flight and other extraterrestrial endeavors. During missions, astronauts are made test subjects for medical inquiry and experimentation to ensure safe living in extraterrestrial settings but also understand the unique physiological and psychological challenges of living in outer space – in a space ship or station – in an on-going process of auditing and monitoring through countless instruments to measure the body, before, during, and after a visit of outer space (Bunch, 2025). For an understanding of Skylab's timescape, it is therefore important to consider how human (and non-human) life is not only embedded in sociotechnical networks but also which rationales are at work that enact multilayered logics of control and care under laboratory conditions. How rationales of safety and progress interplay and concerns for risk and security are negotiated despite the 'logistical nightmares' (Rossiter, 2016) that extraterrestrial programs and the threat of obliteration that they propose when systems designed to be 'fail-safe' do fail (e.g. The Challenger catastrophe of 1986) can be related to questions of mistimings in the countless calculations of time in a space mission and anticipation of hazards. Preparation, therefore, becomes a necessary temporal practice. Not only in terms of designing a 'fail-safe' system, but also the rigid training astronauts receive for security protocols in order to manage crisis situations. It is important to note that these aspects do not only become relevant in times of crises but shape the sociotechnical arrangement of a space mission from the very beginning in order to mitigate risks from the design of the spacesuits, tools, and spacecraft to the close monitoring of mental and physical health and rigid experimentation on astronaut bodies by ground team members, researchers, and medical experts. A temporal perspective on Skylab's labor conditions may add to this inquiry by grounding experimentation on astronaut bodies beyond the timeframes of experiments, looking into how they enact care, control, and measure their bodies through technoscientific instruments, as well as protest and contest the production of knowledge by means of their own bodies through temporal practice.

Space infrastructures do not only shape space travel; they are grounded within earthly affairs and have impacts on communities and environments in which they are present. Contexts in which these large-scale infrastructures are present are often rendered 'wild' or ‘rural’ and ‘empty,’ from rocket sites in the colonial territories of French Guinea’s jungles (Gorman, 2007) over the mountain ranges of Hawaii (Maile, 2021) to the subarctic regions of Sweden (Ojani, 2024). The construction of space infrastructure is displacing and affecting the environments of indigenous communities, despite their protests, and disrupting and destroying wildlife. Like in French Guinea, where the work needed to construct and maintain space infrastructures can be economically incentivized, creating a socio-economic dependency of thousands of locals on the maintenance and security of these sites, which is sometimes met with resistance and sabotage by local actors in order to stay independent from foreign actors (Gorman, 2007). Local communities in French Guinea were met with no other choices than to work for the spaceport, resist, or be displaced, in either case losing their current livelihood and way of living as landsites are transformed into mega-infrastructure and closed off from space industry outsiders by means of military force (Gorman, 2007). The geopolitical impacts of space infrastructure are manifold, not only in the direct impacts of the infrastructure on the land they are built upon, but also in their role as joint enterprises between governments and corporations. Klimburg-Witjes shows that the Ariane rocket program is understood by government actors as a “key element in and enabler of strategic autonomy in Europe” (Klimburg-Witjes, 2024, p.4). Her research investigates controversies about Ariane through the lens of ‘sociotechnical imaginaries’ (Felt, 2015; Jasanoff and Kim, 2015), allowing her to explore the visions and attainable futures tied to the European Ariane Rocket and investigate how the vision of strategic autonomy works as an incentive for innovation and enhanced security integration that unites competing European countries. Klimburg-Witjes also refers to the issue of ‘dual-use:’ “Innovations that are designed to be used in multiple contexts. Often, dual-use in space technology binds spacefaring with military endeavors, “blurring the line between civilian and military innovation”” (2024, p. 1). This issue goes beyond the use of technology, as this connection can also be seen at an institutional level. I will allow myself here to introduce from the material I worked with an early finding that exemplifies this close relationship between the war machine of a nation and spacefaring on an institutional level. At Skylab, infamous Nazi rocket engineer Wernher von Braun was still active at NASA in a leading role. As Gorman (2005) describes, he evidently considered the labor of nearby concentration camp prisoners to build parts of a long-distance rocket during the 2nd WW. During the Apollo program (1961-72), astronauts like Edward Gibson (Skylab IV) worked closely enough with him to feel confident to state the following in an Oral History Interview;

> Gibson: “And here’s a guy [Von Braun][2] that I had grown up to admire from his contributions he had made to rocketry because I’ve studied it for some many years and read a lot of his writings and his philosophy and his technical approach to the space program. I really admired him” (Gibson et al., 2000, p.24).

In that sense, the intertwined history of rocketry in military and spacefaring has long-lasting consequences for their institutions, beyond the issue of dual-use. The Earth Resources Experiment Package (EREP) of Skylab can be understood as an early attempt to catalogue and archive the earth’s resources, making them visible not only to scientists but also for the U.S. government. While the usage of data produced at Skylab for such reasons may be speculative, the role of satellite technology and rocketry in imperialist politics and the information networks of militaries around the world cannot be denied (Ojani, 2024). Skylab presents one of the first cases in the U.S. in which scientists were working as astronauts at NASA, an institution that was dominated by military personnel at the time. To look at the way military, engineering, and academic personnel are intertwined in the production of knowledge and co-shape the rationales by which scientific activities are conducted aboard Skylab has the potential to deepen our understanding of how different rationales of different collaborators are brought together in mission work. How those actors are brought together in order to produce scientific knowledge is especially interesting in a context of mission-oriented policy, drawing on frontier knowledge to solve ‘wicked problems’ (Mazzucato, 2018). While Skylab’s end goal is not of the nature of a long-term commitment to, for example, transform to a green economy, it is nonetheless confronted with the challenges that encompass having human actors live in LEO for a set amount of time. With Skylab being more archetypal of what mission-based research may look like, its mode of scientific knowledge production connected to the specific aim of understanding human life in outer space is reminiscent of contemporary mission-oriented outer space research. Ideally, this would also bring one closer to understanding the discourse of already existing rationales that influence the realization(s) of space futures. As such, these realization processes are in full progress as we speak, evident in Europe’s attempts to establish itself as a key player for outer space activities (Klimburg-Witjes, 2024), but also globally as space entrepreneurs try to realize space as a new market. In his work, David Valentine (2012) investigates from an anthropological perspective the imaginaries of NewSpace industries, identifying imaginaries prevalent in neoliberal capitalist markets, tied to promise-making and profit-seeking practices framing outer space as a new ‘economic’ frontier. Imagining spacefarers as colonial settlers

[2] Name in brackets added by the author of this thesis for better comprehension while reading.

or tourists confronts this industry with the same questions as Skylab. While policymakers and investors head straight into a ‘new space race’ (Klimburg-Witjes, 2024).

How scientists, even small collectives, become part of shaping the realization of outer space futures can be seen in Saperstein's work (2021), which highlights the role of a few scientific actors and their impact on how we realize these visions. In the case of the Jason-3, Saperstein shows how the geopolitics of outer space is more than a ‘vertical’ view of “realpolitik” or just the product of large political institutions or economic enterprises. Instead, the way scientists imagine Earth through outer space research can be tied to ”[...] a group of scientists and [who][3] had the power to plan, create and deploy satellites - to define outer space as a realm of their own.” (Saperstein, 2021, p. 743). Backed by NASA, the Bretherton Committee would establish a new discipline: Earth System Science (ESS) “[...] on the premise that Earth is a singular global system that can be known” (Saperstein, 2021, p. 735), linking satellite technology to the epistemic framework of such an interdisciplinary science and backing it financially with narratives to investigate the ‘making’ of climate change requiring global datasets through aforementioned satellites, while also defining NASA’s role (on their request) in these endeavors. This account of the history of the ESS – or the committee in charge of making this science a reality – pieces together an imagined ‘global’ by bringing together different disciplines (oceanography, land studies, etc.) and large volumes of satellite data to make sense of.

The landscape of future visions for outer space is diverse, being an amalgam or ‘monolith’ (Popper, 2021) of science fiction, myth, geopolitical projections, epistemic assumptions, and narratives of innovation and progress, to name a few, with dominant rationales such as NewSpace understanding of outer space as a new economic frontier or a driver of innovation. These are complicated through historical analysis (Gorman, 2005) or outright contested with movements such as Astrofuturism, where artists, scientists, and storytellers seek out ways of re-imagining outer space, challenging dominant imaginaries that coproduce the socioeconomic and geopolitical realities of outer space regimes and industries with histories and narratives from outside or neglected by the western hegemony (Eshun, 2003; Salazar 2023). While the preceding discussion has outlined the broader sociotechnical, technoscientific, and geopolitical conditions that sustain human activity in outer space, these dynamics ultimately materialize in the everyday organization of mission work. The following chapter therefore turns to the social arrangements through which outer space research is

[3] Word in brackets added by the author of this thesis for better reading comprehension.

carried out, focusing on how scientific labor, authority, and time are coordinated and stabilized within mission environments.

2.3.1. Understanding Astronautics at Work

Just recently (2025), Jeevendrampillai, Kozel and Gorbanenko published a book, "Exploring the Ethnography of Outer Space. Methods and Perspectives." Here, they collect a wide variety of ethnographical work that concerns itself with "[...] the rise in outer space interest in society at large, as the commercialisation of space, expansion of space infrastructures and rising momentum in human spaceflight mark the so-called 'new space age'" (Jeevendrampillai , Kozel and Gorbanenko, 2025, p. 1). This book comprises methodological reflections and insights produced from ethnographic studies of outer space, many of which are produced within the context of the ETHNO-ISS team, who conducted a multisited, large-scale anthropological study of the ISS over the last five years. In an earlier methodological reflection, Buchli, a member of ETHNO-ISS describes the ISS as "[...] the longest-lasting extant extraterrestrial society in Low Earth Orbit." (2020, p.18) and as more than a place of scientific discovery but a 'place of dwelling' (ibid.). Skylab can be understood as a predecessor of the ISS and described as such, with the exception that Skylab was still in the process of homesteading (Hitt, Garriot, and Kerwin, 2008) Low Earth Orbit. As such, contributions from the ETHNO-ISS are one of the few studies that focus on the social life of a space station.

One chapter that is worth special mentioning from one of their members in this context is "Transcendence, Bodies, and Estranged Labor in Outer Space" by Giles Bunch (2025). As my research is dedicated to analyzing sociotechnical relations between astronauts and mission control with a focus on the ordering principles of time(s), Bunch provides, with his own inquiry as well as insides from Weibel (2019) and Contella (et al., 2018), a portrayal of astronauts, by which he seeks to understand what and to which outcome characteristics of hierarchy are performed and embodied by astronauts and space flight operators.

Especially insightful for the research on Skylab is the portrayal of contemporary work and training practices between flight controllers and astronauts, in which astronauts are abstracted from the scientific inquiry and estranged from the labor they perform when it comes to the production of scientific data, echoing practices of scientific management in the institutional makeup of ISS missions, NASA, and ESA. Narrative accounts from astronauts, like 'chasing the red-line,' raise concerns of the temporal features that comprise a specific mode of labor organization by Taylorist rationale. Further, this publication sensitizes one to the attribution and distribution of expertise in space labor. While Vertesi (2020) is concerned with the organizational features of post-bureaucratic or ‘heterarchic’ (Girard and Stark, 2003) institutions of mission work in ground teams, the work of Bunch and Weibel, but also Castaño (2023) and Buchli (2020), studying the ISS in their many ways of knowledge production, is insightful when comparing astronautics of the past with recent developments in work culture, hierarchies, and management of astronauts on board a space station that entangles a dwelling environment with the dedication to the production of scientific knowledge.

The astronaut’s role in this environment can be understood as a “[...] biomedical test-subject, whose body serves the production of data-points associated with the impacts of long-duration spaceflight on the elite human” (Bunch, 2025, p.24; Weibel, 2019). Olson (2010; 2018), in examining the biopolitics of space on the ISS, introduces the concept of the ‘space normal,’ developed by medical experts in response to the persistent physiological harm caused by long-term spaceflight in a damaging environment such as space, as well as the continuous monitoring and experimentation conducted on astronauts’ bodies. The term designates an astronaut to be understood in a different category to allow for treating astronauts as something other than ‘sick’ in an environment that is devoid of any ‘natural’ features (Olson, 2010; Bunch, 2025).

‘Space normal’ is just one part of the marginalized ‘bodily sovereignty’ of an astronaut, characterized by Bunch (2025) as “potential to refuse” (ibid., p. 25) but rarely actualized, or “a measure of the power of exception” (ibid. p. 28). Interestingly, for a study on Skylab’s timescape, Bunch describes one of the few moments in which this potential was realized as ESA astronauts renegotiated schedules of tests and recovery activities. He writes; “Such instances are illustrative of a tension between the priorities of the biomedical researchers who are eager to obtain their data in the correct time-specific windows, and the astronauts who seek some time away from the continuing, highly managed schedule.” (ibid., p.25). Bunch’s article becomes a portrayal of the ESA and ISS astronauts of recent times, an interesting piece for comparison to Skylab when it comes to power, health, and bodies in outer space, to which I like to add a time-critical perspective.

Further insights into space as a dwelling are provided by Gorman’s article on space archeology (2023), which sensitizes readers to a few unique aspects of outer space places, such as the characteristics of “mobility or velocity in relation to a notionally immobile Earth’s surface” (p.45), the “invention of timing” in relation to the invention and wide-range use of satellite networks for communication (ibid. p.44) and the specific temporalities that complicate notions such as past or present, with satellites or other space objects' afterlife as space debris, loaded with the potential for destruction or interruption of the present day and future of instruments and life in LEO, while other socio-technical artifacts may outlive the lifespan of earth itself (ibid. p.45-46, see also Klimburg-Witjes, 2025).

Sociological research of astronautics at work comes in many colors. One such example is the paper "Managing Transitions between Tasks" (Mesmer-Magnus et al., 2010). The authors introduce current themes of working on the ISS in 2010 by a series of interesting quotes from astronauts to topics such as time pressure and other time related experience. Working in space is understood as a tight timeline, being part of an imagined web of interdependence between oneself, the ones before, and those who come after, as well as the constant work with material artifacts like schedules, computers, and sensors. The authors then focus on the sequencing and transitions of tasks, identifying factors like social ties and technological factors as what makes people switch tasks and how much effort a switch may cost between different types of tasks. The paper displays pros and cons of simulating such work but downplays factors that may only be faced in space. It assumes that outer space explorations will go longer and longer distances into outer space, highlighting the autonomy that astronauts need as communication to the ground becomes more difficult. In the end, the authors are occupied with running space stations more 'effectively', by making task transitions more efficient. I refer to this paper for two reasons. The assumptions largely connect to contemporary outer space imaginaries and present the prevalent problems of work in outer space as technological in nature, with efficiency as the greatest good. The authors point toward labor and time issues with quotes in their introduction:

"Space sure is a busy place. I'm sensing a common theme: non-stop days. There are only two days in a week on ISS: Monday and Friday, with a couple of hours in between" (Mesmer-Magnus et al., 2021, p. 1).

In the face of such material, not to ask why and to what end such experiences are produced and then neglected and instead to focus on the little ways such things can be more efficient seems to be another – sometimes frustrating –- common theme in outer space research (Brooker, 2019-20).

Taken together, this body of scholarship conceptualizes outer space research as a deeply sociotechnical and geopolitical undertaking in which scientific knowledge production is inseparable from infrastructures, imaginaries, and institutional arrangements. Rather than an abstract or neutral frontier, outer space appears as a highly organized environment in which human and non-human actors, bodies, technologies, and temporal regimes are continuously aligned to make life and research possible under extreme conditions. Skylab, as one of the earliest sites of long-duration human spaceflight, offers a particularly productive vantage point for examining how these dynamics are enacted in practice: How scientific labor is organized, how authority and responsibility are distributed, and how time, risk, and bodily vulnerability are managed within mission settings.

2.4. ASOS in Space

Brooker and Sharrock's "Living and Working in 'The Great Outdoors'" (2023) is one of the few publications from the social sciences that directly engages with Skylab, and specifically a period of the Skylab IV mission: the second EVA (Extra Vehicular Activity) on the 29th of December of 1973. Brooker's writing on Skylab is expected to be extended soon by a book with a working title: "An Ethnomethodological Study of Skylab" (forthcoming). In the aforementioned publication, he exemplifies this ethnomethodological approach with a focus on work and astronautics, demonstrating how the EVA required „the dynamic nature of the communications system and the work required to navigate it; the operational need for bodily expositioning by the EVA crew; how talk sequences and paces tasks; and reporting 'normal troubles' as scientific labor where 'good enough' is a working standard" (Brooker and Sharrock, 2023, p. 394). Work in Brooker's and Sharrock's writing is more broadly referring to all forms of 'doing' and practical activity (Brooker and Sharrock, 2023, p. 389). They complete their discussion by directly criticizing the shortsightedness of the time-related habitability studies (e.g., M151) during Skylab, as well as recent studies by NASA on sequencing and scheduling astronautics tasks, as not only Taylorist in nature but also that they don't account for in situ problem-solving in which astronauts need to bend the protocols and respond to their extraordinary setting. Under the topic ASOS IN SPACE (2019–2020), Brooker covers the five days of the alleged 'strike' from the 26th to the 30th of December 1973 by discussing his conversational analysis of the four transcripts of inboard and air-to-ground communications that also form the backbone of my material. His main interest here, stated in the beginning of the series, is in the multiplicity of meanings in the conversational transcripts around the alleged strike. He is especially critical of the way NASA's research is based on quantitative research and how this focus is neglecting, ignoring, and obscuring insights that may only be results of qualitative data analysis.

During an interview (2025), Brooker was so kind as to give me insight into his current writing process and send me a few forthcoming chapters. Especially a chapter dedicated to the M151 piqued my interest, in which he discusses how the video material of two Skylab astronauts suiting up for an extra-vehicular activity (EVA) could be repurposed. By comparing the M151 with an ethnomethodological investigation of his own, he showed how the study aligned with Taylorist principles, focusing on atomized movements and repetition to perform tasks more efficiently, while it neglects the interactional methods by which astronauts handle near-zero gravity environments. A study not concerned with controlling or avoiding the astronauts' expertise and autonomy would instead paint a picture of how vital both aspects are to the astronauts' work (Brooker, forthcoming).

In these publications, Brooker positions himself as an advocate to go beyond 'human-factor' analysis and repurpose the existing 'data'; "exploring them from different perspectives stands to yield much new insight on what the work of doing astronautics comprises" (Brooker and Sharrock, 2023, p. 395). They advocate for practice-oriented, especially ethnomethodological, research that focuses on the 'local' in order to be grounded in social life. As such, this thesis is more or less in direct conversation with Brooker's research and draws on his position as well as insights, as he is not only one of the few academics with a social studies background that can be called an expert on the case, but I also find his arguments convincing. I hope that with my perspective, I can add to the understanding of astronautics as organized collaborative scientific work in hazardous environments. Separating myself from him by way of theoretical, conceptual, and methodological level, while playing in the same ball court of qualitative research, reconfiguring the 'data' produced by NASA as well as producing new findings for the case. Moreover, as I understand from the interview that I had with Brooker, he is more interested in the case from an ethnomethodological perspective, opening the field for new ways of exploring outer space research and drawing attention to Skylab as a case where insights into the social life at a space station have survived more through anecdotes in the institutional memory of NASA and individuals than scientific studies.

2.5. Timescapes of Research

Skylab is not only a spacecraft or program but also an academic space and laboratory, bringing together academics, researchers, and scientists in a unique constellation and setting. As life on a space station is an entanglement of dwelling and research, temporal practices of academia's universities and institutions may also be practiced in outer space laboratories. Vostal's (2021) collection, "Inquiring into Academic Timescapes," is not only one of the most prevalent entries to the discourse of timescapes in research settings, but it also shapes this master's thesis on a theoretical (e.g. Adam, 2021) and methodological level (e.g. Alhadeff-Jones, 2021; Dakka, 2021), as seen in the next chapters. Beyond its methodological and theoretical considerations, academic timescapes are insightful to the entanglement of research and work in outer space. Vostal, for example, connects in his introduction this publication to the discourse around 'slow science,' criticizing such an attempt for neglecting the multiplicity and complexities of time and the relationships of power that are also temporally present within academic spaces and a focus on 'uneven times.' A good example of this is the research on the relations of work and time in academia, which exposes the logic of 'social acceleration' to be present in academic timescapes, seen in the acceleration of ever-new technological innovation, institutional reforms and university mergers, and constant experiences of 'hurry' and a lack of time evident in the social life of academics (Ylijoki, 2021). This trend is also critiqued in publications of the "slow science movement," but slow science advocates for Vostal (2021) are vague on their terminology, often not differentiating between what 'slow' means other than longer durations for projects.

This discourse, although bedded in a different context, might also be insightful to mission work at research institutions outside the academic sphere. And vice versa, these insights from programs such as NASA might highlight the complexities of time in academic research, with Skylab inviting academics to do research through the program as representing a starting point for outer space research to an entanglement of industry and academia that has only grown in modern academia in the wake of the 'entrepreneurial university' (Etzkowitz, 2013), shaping new academic disciplines (e.g., Saperstein, 2021). Further, the 'mission' as an organizational model inspired by the history of NASA has come to be a mode of research-driven policy-making in the EU in the last few years (e.g., Mazzucato, 2018). The discourse is, in that respect, insightful, as it sensitizes us to see both academics and astronauts as scientific workers in a neoliberal economy, for which the solution of time-based issues goes beyond the simple solution of "going slow" but needs a more nuanced perspective. How time affects actors in different positions in academia differently is seen in Ylikoki's publication (2021) on the work culture of early career academics. She analyzes the latent will-to-speed by juxtaposing project time vs. process time and showcases how academic institutions reproduce social inequalities in tensions such as 'temporal safety vs. vulnerability' or 'autonomy vs. subordination' and reinforce academic hierarchies while building a career in academia due to their class position and wealth (Ylijoki, 2021). Exemplary is one observation cited by Vostal in the preface: „There is slow for some (tenured, professors) and speed/acceleration for others (PhDs, postdocs, ECRs) who would often work on activities that were “off-loaded” by those positioned higher in the academic hierarchy.“ (Vostal, 2021, p. 5; see also, Araújo’s et al., 2021).

While these conflicts firsthand seem detached from the work of astronauts, they do connect, as astronauts may struggle with building and modifying their biography to the tenets of their work and their position in a rigid hierarchy with other scientists more established than the astronauts in their respective fields and military personnel in command. They also might develop different answers to issues in the realm of time, as they labor in differently organized institutions, while experiencing similar issues such as transgressions through ‘impositions of time’ (Innerarity, 2012), as tasks might be “off-loaded” to them through their chain of command. Like in Araújo’s et al. (2021) case on “Time for a PhD,” astronauts may develop tactics to adapt and divert from time regimes of their institutions. As discussed by Brooker (2019-2020), tactics like *delaying* and *waiting* are already featured in the communication strategies of the astronauts in the labor conflict of Skylab IV, while shortcuts (Araújo et al., 2021) may also feature in the material as the astronauts find new ways to manage their situation. Other practices of the academic sphere, such as ‘trading time’ (Burneva, 2021) as well as juggling, managing, and reshuffling time, schedules, plans, and timelines (Vostal, 2015; 2021) might also provide insight into how astronauts make time for themselves or contest a system – that reminiscent of contemporary academia – may only know clock time. Especially time trading as a practice may highlight unique interactions when it comes to the negotiations between the crew and the ground team.

“The individual valorizes their time, ascribing value to the possible future (projected in the past) and the present time and resorts to ‘trading’ when the value prescribed to the future (projected in the past) is higher than the value of the present. Certain processes set the conditions for this time trading valorization of time, corporatization and acceleration of work, and a conflict in perceptions and experiences” (Burneva, 2021, p.157)

Understanding the management practices aboard and below Skylab (figuratively speaking), we may also look at how timescales are produced and subjected to reconfigurations. Mitterle (2021) demonstrates that these are important socio-material tools with a rich history of stratification among institutions of higher education with vast implications for academic life. As tools of imposing time with their deadlines and ordering of time in specific units, timescales may hold vast implications for astronauts, as Bunch’s (2025) study suggests, in which astronauts on the ISS are chasing ‘the red line.’

Helpful for this reflection is Iparraguirre’s (2021) assessment of the western imaginary of ‘urgency’ and its connection to ‘development’ as a temporality, an ordering principle that is imposed by the means of standardizations, such as global hour reckoning and calendars. As a temporal ordering principle, the notion composes the past in terms of ‘origin’, the present as ‘becoming,’ and the future as the ‘destiny’ of a given process. This temporality has in Iparraguirre’s writing a hegemonial position and informs the imaginary of urgency. For academia, “[...] “urgency” can be connected to notions such us “time pressure,” “working time,” or “time compression” that push every single activity toward deadlines and to fulfill schedules; it allows to exemplify a cultural rhythmic inside academic temporalities.“ (Iparraguirre, 2021, p. 64) and „As a net of symbolic components, urgency is built around categories such as speed, rush, acceleration, immediacy, stress, anxiety, and deadlines, among other similar ones“ (Iparraguirre, 2021, p. 65). These considerations are particularly useful in discussing Skylab IV and how it is embedded in a temporality of ‘development.’ How the imaginary of ‘urgency’ transforms outer space geopolitical debates today can be seen in Klimburg-Witjes and Kürten’s (2025) publication “Pacing Space: futuring practices and temporal ownership in the European Space sector” in which they find “[...] Europe’s bureaucratic complexity and its mandate for consensus-based decision-making, locked in constant temporal friction with the existential urgency of catching up in today’s accelerating space race” (ibid, p. 5). How these notions impact scientific day-to-day knowledge production in outer space, though, is yet to be understood, but with its ongoing influence on the socio-political sphere, it seems that the temporality of “development” has far-reaching effects and an unbroken history in academia from day-to-day scientific practice to political decision-making.

The work in hazardous environments and the resource intensity of outer space may especially be an argument that ‘slow’ science, in many cases, is a slogan difficult to deploy when it is paired with economic rationales – both in academia and the research laboratory of a space station. While contemporary research focuses on timescapes in an academic setting (e.g., Vostal, 2021; Felt, 2025), these unique constellations of collaborative research in extreme environments that are represented in Skylab may have specific insights into the time-work relationship. Questions of care and control, as previously discussed, are interconnected when it comes to managing food and oxygen supply, while invisible hazards like radiation might only be understood in terms of possible (exposure) time (Adam, 1998) before the risk for the astronauts' health is deemed too high.

I want to make clear that, although this case study is placed in a unique setting, with practices and rationales tied to the context and unique practices that outer space allows for, I nonetheless examine a case of organized and collaborative research that may share characteristics with academic spaces, as scientists branch out to work with astronauts or become astronauts themselves. I think to compare this setting to higher education and institutions dedicated to the production of knowledge is a productive point to venture forth, allowing for broader implications and bridging to fields of study that may share temporal features, but keeping in mind the unique sociotechnical arrangement that is an outer space mission and the contemporary unfolding of space as an economic frontier in the new space age. Taken together, the literature discussed above establishes a diverse and increasingly nuanced field of sociological inquiry into outer space, one that reorients our understanding of astronautics from purely technical achievement to situated, contested, and institutionally mediated forms of labor and meaning-making. What follows now is a discussion of the concepts and theoretical perspectives that are utilized in my research on Skylab IV.

3. Theoretical Perspective and Sensitizing Concepts

In the following subchapter, I will introduce *timescapes* (Adam, 1998) and *chronopolitics* (Innerarity, 2012) as key concepts to my analysis of the way in which time is constructed during the Skylab 4 mission. I will explain why both concepts add to a better understanding of the labor dispute by focusing on the notion of *rhythmicity* as a key way to understand time as a social construct. Further, I will discuss how chronopolitics may be understood in different ways and why I use Innerarity's (2012) understanding to focus on rhythm and draw attention to power-related disputes in the labor conflict of Skylab IV through *heterochronies.*

In the second subchapter I introduce the sensibilities of Actor-Network-Theory (ANT) and specific concepts from the post-ANT tradition in STS to account for the missions' sociotechnical make-up that co-produces the rhythms aboard Skylab and advances an understanding of what end, time was constructed and negotiated by both human and non-human actors in specific ways during the labor dispute. Both subchapters deploy knowledge from a first subliminary investigation of the material as well as other research on the case (e.g., Brooker, 2019-2020; Brooker and Sharrock, 2023) in order to shape the theoretical perspective and concepts to fit the research questions as well as the specifics of the case.

3.1 Practicing Time; Timescapes and Chronopolitics

This research builds on the theoretical notions of timescapes as established by Barbara Adam (1995; 1998; 2021), as well as chronopolitics by Daniel Innerarity (2012), both of which understand time as a multifaceted, plural, and socially constructed dimension that can be experienced and reshaped by actors. Adam' concept of a timescape references landscapes due to the way that actors live in and re-/shape the landscapes they partake in. To picture a timescape, is to dissolve dualisms, handle in-/visibilities, pay attention to the assemblage of multiple temporalities, and bring to the forefront the construction of times past, present, and future by focusing on axes such as temporality, timing, timeframes and tempo (Adam, 1995). In short, temporalities encompass ways we experience time, from the notion of ‘clock time’ as a decontextualized and rationalized time to ‘cyclical time,’ which is deeply embedded with the rhythms of bodies and planet earth. To avoid dualisms from the beginning of this work, all temporalities are more or less implicated in a modern, western understanding of time and fuel the logics of time in which we think, experience, and practice time. The other three mentioned axes are implicated when thinking about ‘rhythmicity.’ As Adam states,

“Thinking about time, therefore, involves rhythm with variation, a dynamic structure of framing, timing, synchronization, duration, sequence, tempo and intensity” (Adam, 1995, p. 17).

When studying rhythms, Adam points out that the multitude of rhythms and all their expressions have to be appreciated together for a sense of how time relates to topics such as the body, health, and death (1995). Rhythms, whether planetary, bodily, or constructed through a ‘time machine’ (Adam, 1995; Felt, 2025), permeate and enculture each other. Therefore, it is inevitable to view them from a relativist angle. In terms of the Skylab mission, this perspective suggests, if not demands, investigating the different temporalities and practices that form the rhythms of the humans involved in the mission. While my primary focus is on the astronauts’ crew, their experiences, and resulting efforts that try to reshape their own rhythms to fit their own understandings of what is ‘best,’ attention is also needed for an assemblage of actors that negotiates such attempts with them. NASA’s ground team, the sociotechnical aspects of the Skylab vessel, their own bodies, and many more make up for the many rhythms that combine into the mission's timescape. This means a vast array of actors, both human and non-human, become an integral part of understanding the role of time in the labor conflict and its resolution. Alhadeff-Jones (2021) contributes to this perspective, informing us that rhythms make humans sensible to time. They sense differentials of durations, like a high and low intensity of change expressed, and can express these patterns as temporal experiences such as *accelerations.*

While Adam stresses the multitude of rhythms*,* Innerarity’s chronopolitics is a way to understand the shaping of social rhythms by making actors and power dynamics visible but also by focusing on the way in which constructions of past, present, and future are negotiated and utilized to shape societies and provoke specific conflicts. With his theory of social rhythm, he draws the attention to the plurality of ‘heterochronies’ in societies*,* people's diverse experiences of times that are “revealed through the conflicts between individuals and groups or a lack of synchronicity between diverse social systems” (Innerarity, p. 82, 2012). This asymmetry between groups and individuals may then reveal how power is exercised through control over other people's times. One example is traversal of borders, which for some social groups may take minutes, while others may have waiting periods of years. As such, chronopolitics is a way to sensitize us to a “new axis of social conflict: the imposition of time“ (Innerarity, p. 79, 2012). In contrast to Innerarity’s focus on social rhythms, Salazar (2023), with his focus on the study of outer space, utilizes the term ‘chronopolitics’ in the tradition of Kodwo (2003) and Phillips (2019) in how outer space is constructed within colonial and capitalistic temporalities or made into a temporal frontier by means of NewSpace (Valentine, 2012) narratives, sociotechnical utopias, and so on. I want to be clear that the way Innerarity utilizes the notion of 'chronopolitics' is, for the reasons above, a way more suitable approach to my research. While Skylab certainly can be analyzed in, for example, the context of 'sociotechnical imaginaries' (Felt, 2015; Jasanoff and Kim, 2015) and be critically engaged with from this perspective. But Innerarity's theory of social rhythm is grounded in practice, not discourse, and as such contributes better toward an analysis where the research focus is not discursive but of a practical nature. It goes without saying that Skylab 4 as a legacy project of NASA might also be interesting from this perspective. Notably, I also engaged in a previous essay with the topic from this perspective. Further, the notion of chronopolitics as utilized by Salazar (2023) or Felt (2025) still calls attention to how actors adapt and contest temporal regimes and how control over time represents a battleground where power struggles unfold. But for the sake of my research focus, I utilize Innerarity's notion in this thesis.

Together, Adam's and Innerarity's concepts sensitizes us to view time as something complex but tangible that exists as a process and is re-/defined in practice. As such, the role of time in Skylab's labor dispute can be thought of as a constructed phenomenon, a timescape, which can be shaped by reconfiguring rhythms through actions, such as managing, negotiating, memorizing, promising, etc., and is recognizable by experiences and recollections of moments of acceleration, lateness, pressure, and waiting, to name only a few. Rhythms are crucial to the time-based analysis of the conflicts aboard Skylab's labor conflicts. As established in the beginning, modern labor conflicts are often, in their essence, conflicts about time-control (Adam, 1995), which is supported by the findings of Brooker's conversational analysis on the Skylab IV case (2019-2020). The importance of time, as seen in the previous chapter, cannot be underestimated. As such, highlighting the imposition of time and the logic(s) by which such practices operate may reveal the larger role of time-construction, mostly invisible to different ways of understanding the dispute. While actors tend to operate effortlessly between multiple temporalities on a day-to-day basis, it is a challenging inquiry to open one's research up to the plurality within a timescape. The complexity, nonetheless, is necessary to understand how past events are recreated in a given moment, how the present is shaped both by anticipated futures and recollections of past events, and how futures are altered as events unfold. Further, it gives an understanding of how practices are involved in each of these modes. In addition, to draw on chronopolitics is a solid way to understand motives and logics that such practices are grounded in. When looking into a labor dispute between astronauts and the managerial ground control, chronopolitics allows for a focus on the moments conflicts arise, rhythms clash, and temporalities can no longer be effortlessly navigated. It highlights moments when actors need to put effort into operating in different temporalities. Moments that paint a larger picture of the power dynamics at play, the way time construction practices shape the experiences and life of the astronauts, and the mission as a whole. Through this lens, conflict over time-control can be seen when astronauts question the authority of ground control. When they ask, why do they need to subsume time management and follow deadlines, timetables, and schedules? When they challenge the proposed sequence of tasks, predict outcomes or complain about the efforts to stay synchronized with ground control and so on. Beyond practice, experiences of accelerating work pace, waiting, delaying, etc. may be utilized strategically in labor conflicts. They also affect actors, infuriate them, or make them nervous. As introduced in the case chapter, Brooker and Sharrock put an emphasis on strategic 'weaponization of the communication system' (2023). A time-based strategy in which delaying information was designed to put pressure on ground control. Understanding such practices and how they affect the actors through timescapes and chronopolitics may answer why this strategy was utilized in the conflict and to what end.

While I primarily feature timescapes and chronopolitics as theoretical groundwork for this research, a number of assumptions and concepts from the ANT tradition take the backstage in my analysis. Not only do I utilize terms like "socio-technical assemblage," "non-human actor" and so on, but I also find it key to include the defining socio-technical aspects of the mission in order to grasp the timescape within which the astronauts and other human actors operate.

3.2. An ANT in a Spacecraft

From my preliminary analysis of the a-g transcript and pc-transcript of the Skylab IV mission, it is clear that many defining features of the mission's conflict are grounded in the technoscientific assemblage of Skylab. Its web of technological artifacts is made of actors that take a key role in understanding the practices and rhythms engaged in the labor dispute. For making sense of the transcripts and specific moments such as the so-called "mutiny" or what Brooker (2019-20) described as the moment in which the crew "'weaponized the communication system," the sociotechnical make-up of the mission has to be understood as enabling, directing, or co-scribing actions that structure and construct time aboard Skylab. For example, communication with ground control was made possible only in certain timeframes because of a huge infrastructural network of antennas placed around the globe, which, in turn, influenced the rhythms of the crew, as communication to the team on the ground was a limited resource in terms of time span and frequency. Only in these timeframes may ground and crew exchange information via sending audio records, scans, or by direct communication. In Adam's terminology, managing timings became an important feature of the mission's timescape and everyone involved in the mission because of the limitations of the technical setup. Further, time-sensitive strategies, like delaying information, are only to be understood in terms of a sociotechnical network that attributes a social role to the technological systems. For example, the way that communication technology during Skylab IV was designed to be transparent to the U.S. American public, by publishing transcripts after a short amount of time to journalists, made *timing* and the uncertainty of what is in a given recorded message a viable strategy to apply pressure to ground control and NASA's higher-ups (Brooker, 2019-20). Therefore, to understand the sociotechnical dimension of rhythms and moments is crucial to a time-sensitive investigation into the Skylab IV labor dispute.

To allow for such a perspective, this thesis utilizes the principles of ANT, namely generalized symmetry, generalized agnosticism, and free association (see, Michael, 2017), through which socio-technical networks of heterogeneous relations may be analyzed without assumptions that place a hierarchy between actors and non-human actors, the way they relate, or the agency they have in the network. Therefore, the principles of ANT are the first step in recognizing those aspects of non-human actors, who allow for the specific ways time is constructed on board Skylab.

Latour's "Reassembling the Social. An Introduction to Actor-Network-Theory" (2005) or Callon's "Some Elements of Sociology of Translation: Domestication of the Scallops and the Fishermen of St. Brieuc Bay." (1984) act as key works for actor-network-theory and provide useful vocabulary and framings, such as the concepts of program, translations, enrollment, and obligatory passage points, in order to understand the sociotechnical systems used in societies to close controversies. Within conflicts such as the labor dispute, aspects of the sociotechnical system may be questioned and changed, allowing also for restructuring of a timescape. In addition, management practices, such as scheduling or sequencing, that are negotiated between ground and space stations require documents, lists, etc. that are frequently referred to and make human actors act according to their fellow non-human actors, who frequently travel between both teams. The focus on materiality in the ANT tradition allows for looking at non-human actors like spreadsheets that perform tasks of homogenization in order to draw things together (Asdal, 2008).

Last but not least, to really understand to what end time is constructed by actors in the mission, ANT contributes the idea of a program. A sociotechnical network is composed of actors following subprograms, which themselves are assembled in order to fulfill a certain function or goal that is the reason to assemble the network in the first place (Latour, 2005). For example, the goals stated in the press kit of the mission (NASA, 1973a) may be understood as to why the network that is Skylab IV was assembled. But hidden agendas or the placement of the network into the scale of geopolitics may complicate this notion of one definite goal. For example, the space race was a pressing issue during the time of the mission, and a speech by Nixon dedicated to the astronauts and the American public at the beginning of the mission asks for the broader implications of Skylab's assemblage in the military-industrial complex or the American media. In Latour's terminology, as a subprogram, which program does Skylab serve? One methodological move for this scaling issue is to describe only what is in between the limits of one's academic inquiry (Latour, 2005). In this case, anything connected to the specific timeframe of the labor dispute aboard Skylab and the way time is constructed during the mission. This includes how time is practiced and to what end the timescape of the mission is shaped, but excludes questions of what the broader implications a change in program might suggest for institutions such as NASA, the space race, or geopolitical conflicts at the time. Recognizing that all research can only provide a limited perspective based on the practical limitations of academia and one's own ability to invest time into one's inquiry. For other problems concerning programs and criticism voiced against ANT, I want to introduce two concepts that developed to tackle some of ANT's most pressing issues.

The first notion I want to introduce is from the critical theory of technology: the 'symmetry of program and antiprogram' (Feenberg, 2017), which is useful to navigate one of ANT's most dominant problems: that ANT does not acknowledge power dynamics and may favor the dominant actor network. As explained above, outer space programs as well as other forms of bureaucratic institutions have a tendency to follow a certain motive. These motives differ in terms of which role they inhabit as part of the institution, but the key program of an institution or project can be challenged by different parties. As different understandings clash, like 'profit versus worker health' in the case of market-oriented institutions, new roles are mobilized in new kinds of formations (e.g. unions). Where there are labor conflicts, one can utilize this concept rather nicely to understand the contestations and reasonings in practices, catering to one program or the other (Feenberg, 2017). This also fits with Innerarity's concept of social rhythms and allows for a view by which socio-technical networks impose time, the reasoning behind such an imposition, and why such impositions become renegotiated within a given network in times of conflict.

Second, it is important to recognize that not only do programs differ, but an understanding based on different ontologies may also lead to controversy and conflict. The way time is experienced by different actors in a network may differ tremendously. As such, the reality one lives by and experiences is subjected to a 'multiplicity of ontologies.' This concept, introduced as a contribution to post-ANT by Mol (2005), guides this study as to how different programs and ideas are enacted within technoscientific networks. This allows for practice-oriented research in which one can understand outer space assemblies as processes that are not only reproduced by any given actor through action but also provide an epistemological understanding of how reality is constructed. For example, the maxim "more science per unit time" (NASA, 1973-74c, p. MC1554/3) is mentioned as a reason why optimization efforts are needed in the mission, but the way in which this is achieved differs in the perspective of the crew members and ground personnel, due to the different perspectives on what that sentence means. Even though they may all be part of the same mission and look at the same data. This echoes also in Adam's concept of 'timescapes' (1998), which understands time to be context-dependent in a similar way that Mol understands reality and facts to be context-dependent, allowing for different temporal experiences within one timescape. Mol's and Feenberg's concepts both enrich the ANT tradition by allowing for conflicting and even contradictory components within one network, even in times where there is no imminent reconfiguration of one actor-network. Instead, they argue that reconfigurations are practiced and experienced even in a stabilized network. Both additions are important extensions of a traditional understanding of ANT in order to deal with the multiplicity of timescapes and chronopolitics.

Taken together, timescapes, chronopolitics, and post-ANT sensibilities provide a theoretical lens through which time aboard Skylab IV can be understood as a sociotechnical and practiced phenomenon. By focusing on rhythms, this framework allows the labor dispute to be analyzed not as an exceptional conflict but as a moment in which heterogeneous temporalities, programs, and ontologies became misaligned and explicitly contested. Time emerges here not merely as a background condition of work in space but as an object of negotiation, discipline, resistance, and strategic intervention co-produced by human and non-human actors, institutional programs, and technical artifacts. The following methodology chapter builds on this theoretical perspective by outlining how these concepts are operationalized empirically. It specifies how the transcripts, archival materials, and secondary analyses are approached in order to trace rhythms, temporal practices, and sociotechnical mediations, and to examine how conflicts over time were enacted, stabilized, and partially resolved in practice during the Skylab IV mission.

4. Methodological Approach

In this chapter I will outline my methodological approach for the master's thesis. First, I will establish the methodological influences and highlight the respected theory that formed my approach for this thesis, namely rhythm analysis and practice-oriented document analysis, and why I chose these methods for my inquiry. After establishing a methodological basis, I will then explain the ways in which I practiced online-based archival research, the limitations I encountered, and how I circumvented problems during the process. Followed by my process to make sense of the acquired documents and which tools I used. In the end, I explain how I coded the material in order to produce the findings of the following chapter.

4.1. Methodological Basis

As established in the beginning, I needed an approach suitable for analyzing conflicts about time-control that would fit my focus on archival material as well as a methodological and theoretical foundation to analyze the dimensions of time through documents. Therefore, I tried to come up with a way to be both sensitive in my approach to time and to the material I have at hand because this case study is about a case that happened 50 years ago, observing the practices that are focused in my research in a less-mediated manner has become impossible. Instead, I'm left with documentation of what happened at Skylab, mainly produced by the institution that depended to some extent on the mission: NASA. To be able to analyze this material, I developed a mixed-research approach from rhythm analysis and practice-oriented document analysis that is capable of handling the context and content of the documentations but also complements concepts such as timescapes in the analysis. The second is important because, as Adam describes it:

> "Most challenging would be the realization that time cannot be simply added to existing theories and approaches, that a time-based analysis will affect the ontology, epistemology and methodology of the subject under investigation." (Adam, 2021, p. xxi).

The first methodology is helpful in drawing together practiced logics of time and time-related practices in the documentations as well as in the documentation process that co-shape the reading of the temporal experiences at Skylab. As discussed in a previous chapter, Skylab as a documented phenomenon is in need of special attention for the work that is embedded in the documents I use as material. While practice-oriented document analysis is complementing the focus on contents with aspects such as document work and the contextual elements that inform and enact a document (Asdal and Reinertsen, 2022), I was using this style of practice-oriented document analysis to understand the transcripts and other documents both as an actor and as material. The goal here is to allow for a time-sensitive read of practices that shape the labor conflict within the context of the documents' production and usage in the Skylab IV mission. Once I identified a number of key moments that are associated with the labor conflict, I was able to better understand the temporal experience of the crew and the ground team over time in the Skylab IV mission through rhythm analysis. This type of analysis forms from an understanding that humans experience time through rhythms; therefore, temporal phenomena such as an acceleration or deceleration (Alhadeff-Jones, 2021) are only able to be understood in relation to moments in the past and present.

„rhythms make humans sensible to time; it is through rhythm that humans can perceive it. From a rhythmic perspective, temporal experiences – such as acceleration or deceleration – can, therefore, be conceived as differentials of durations (e.g. alternance between strong and weak beat and high and low intensity of change) expressing patterns (this notion will be defined below) that can be perceived through our senses." (Alhadeff-Jones, 2021, p. 25).

This style of analysis was also helpful in order to provide a full picture of the timescape(s) existing during the Skylab IV mission, due to the many ways we experience time.

„Accordingly, rhythm does not provide us with an abstract measure of time (as a watch); it gives it a concrete and oriented reality." (Alhadeff-Jones, 2021, p. 26).

Combining practice-oriented document analysis (Asdal and Reinertsen, 2022) with rhythm analysis (Alhadeff-Jones, 2021) in a multistep approach, therefore, may grasp the different ontological, epistemological, and methodological implications of time as an object of analysis. But my findings would not have been complete if ANT had not been implicated also as a methodological framework. The major methodological move ANT introduced was the way to describe an actor-network as pioneered by Latour (2005). With historical research through publications on the subject of Skylab (Hitt, Garriot, and Kerwin, 2008) in combination with the material (e.g., Hutchinson, 2000; NASA, 1973a) I could establish during processes of relational mapping a network that would show the communicational structure, interests, displacements, and spokesperson of the program. Through these methodological moves I was able to describe the actor-network of the Skylab program. In the preceding subchapters, I will go into detail on how I found the material and how I inquired into the rhythms of Skylab's timescape.

4.2. Online-based Archival Research

Finding the material came with its own challenges. While most documents were readily available through online research, confirming their legitimacy as documents from the Skylab program came with its own challenges. While the existence of these transcripts was also described by NASA personnel as “readily available” (see, Uri, 2020), to have personnel research the paper archives of NASA’s Johnson Space Center is costly and involves a lot of time. Luckily, John Stoll began a major digitalization project through which some of the transcripts (NASA, 1973-74b & 1973-74c) were made available through the Internet Archive. After some online research to find the other two transcripts (NASA, 1973-74d & 1973-74e) through regular means, I could only acquire them through my contact with P. Brooker.

While looking for more documents, I stumbled upon the press kit in a Google search but uploaded by an unreliable source. To confirm its legitimacy, I had to use the Wayback Machine of the Internet Archive website, by which I was able to access the old online archive uploads of NASA, which also comprised the press kit (NASA, 1973a). The NASA space flight forum (NSF) was also an excellent way to acquire documents, but legitimacy could only be established in such cases as the flight-plan-as-flown (NASA, 1973-74f) by comparative analysis, following the date of upload, the documents’ signatures, and the timecodes. Checking if the documents line up with transcripts and other sources. In contrast, pictures and graphic material were available and tagged within NASA’s existing image and video archive. Other material, like the Johnson Space Center (JSC) Oral History Interviews (e.g., Hutchinson, 2000; Carr, 2000), was also easy to track down on NASA’s website of the JSC if one knew what one was looking for. While yet other publications, like the ‘lessons learned’ document (NASA, 1974g), were hidden by the sheer size of the hyperlink network within NASA’s website and stumbled upon by sheer accident. In summary, to acquire the material was a long process of finding the material through means that would legitimize the material through connections to NASA as an institution and comparative analysis.

4.3. Making Sense of Transcripts

NASA’s documents can be complex, filled with acronyms and time codes, with transcripts being thousands of pages long. To make sense of the material, I recorded my analytic memo-writing process while engaging in an exploratory, qualitative analysis of a large and heterogeneous archival corpus related to the mission and used an exploratory, didactic, and iterative research process in which I worked through a large, heterogeneous archival corpus related to Skylab IV. Rather than following a linear or exhaustive reading strategy, I moved between different source types: air-to-ground transcripts, onboard voice recordings, operations briefings, press conferences, flight plans, and press kit materials. Comparing each source to contextualize, triangulate, and problematize the others. Early attempts at chronological coding proved analytically unproductive, which led me to adopt a moment-centered approach that focused on analytically dense events, most notably the operations meeting of 30 December 1973 and the surrounding mission days. Throughout this process, I treated time as a sensitizing concept rather than a predefined variable. I reconstructed daily workloads, compared planned vs. executed schedules, and examined how different activities were classified, counted, or excluded as “science” (e.g., housekeeping, personal hygiene, and pre/post sleep activities). This involved tracing specific experiments and tasks across documents (medical tasks, EREP, ATM observations), aligning transcripts with time codes and communication windows, and attending to interruptions, data loss, and technical breakdowns as ‘document sites’ (Asdal and Reinertsen, 2022) where temporal logics became visible. I used provisional coding, mapping, and ANT-inspired actor-network diagrams to organize emerging themes without fixing categories prematurely. Repeated movement between empirical reconstruction and conceptual abstraction allowed me to refine key analytical themes while remaining grounded in the material. In this process I coded the material according to specific concepts that later would allow me to group findings according to themes. Both these processes, the memo-writing and the coding, were simultaneous processes, in which the first would support my sense-making of the various specifics and unique characteristics of the documents while the other helped me to group my findings for analysis and interpretation.

A recurring struggle in this process was simply finding a workable way into the material. My first instinct was to go through everything chronologically and code as I went along, but this quickly became confusing and produced a lot of notes without giving me a clear analytical picture. I often found myself unsure whether I should already be making concrete analytical claims or whether I first needed a better overview of operations and context. Aligning the different materials also proved difficult: transcripts, voice dumps, schedules, and technical references all follow slightly different temporal and organizational logics, and matching them required repeatedly going back and checking where things actually lined up. I also struggled with how much technical detail was necessary, since many issues initially appeared as small operational or technical problems but later turned out to be important for understanding broader organizational and temporal tensions. Much of the process, therefore, involved stepping back, reorganizing my notes, and trying new entry points into the material until patterns slowly became visible, rather than emerging in a straightforward or linear way.

4.4. Navigating Codes

To work through the material, a number of different coding practices were needed to develop a full picture and answer a multifaceted question, such as the research question of this thesis. As explained in the research question subchapter (1.2.), the subquestions allow us to concentrate on different aspects of the research question: time, practice, and the dispute or conflict at Skylab. Drawn together, they allowed for an analysis of Skylab's timescape during a brief period of time in the mission. The chosen codes follow the same method. First I developed a catalogue of temporal codes, which are oriented on the theoretical underpinning of timescapes, as discussed by Adam (1998) and Felt (2025). These are *time(frames), temporalities, tempo, timing, and the modalities of time: past, present, and future.* Further, I flagged the material for clues to *impositions of time* to account for Innerarity's concept of chronopolitics, including contextual flags, such as *who* practices those impositions on *whom*. I also added connotations to the codes, such as *tempo*>*speed* or *timing*>*LOS,* that would help me navigate the documents. Through my software (TAMSANALYZER), I would comment in more detail on why I flagged something in a specific way and what I found interesting in the highlighted passage. To account for time construction in management and labor practices as well as for my second subquestion of what practices shaped the temporal experiences, I used *action* and *process* coding techniques to find *direct actions* and *more summarized actions,* as is common practice in grounded theory, to identify practices that construct Skylab's timescapes. As research went on, I specified and named certain types of practices, relating them to different aspects of timescapes if possible, such as *scheduling* or *sequencing*>*shopping_list* to highlight practices.

As the labor conflict and its temporal dimension are the focus of this research, *conflict* and *issue* coding are prominent in this research; relating social groups, temporal experiences, and practices as oppositions allows us to see how such conflicts are navigated in practice. Codes like *Ground vs. Air* and *Astronaut vs. Astronaut* or *PI vs. Astronaut* identify the group dynamics in such conflicts, where the dynamics of Skylab's timescape are contested and fought over by the different actors. They also account for a key difference in communication, as the ground team is often represented by the PAO and more mediated than other discussions that happen aboard Skylab. Conflict coding as an approach later proved useful to account for the influence of non-human actors as a technosocial factor. Other conflict flags, such as *clock time vs embodied time,* are flags that combine conflict coding with temporal codes. In this case, *temporalities>clock time vs. embodied time.* A nested approach such as this allowed me to go more into detail as research went on and merge different aspects in order to answer the main research question. *Issue* codes followed a similar pattern. Using codes such as *timing>issue:sequencing>ATM* to identify the topics of recurring conflicts in said disputes over the matter of time and the way it was constructed during the mission. *Issue* coding also allowed keeping track of *moments* that were constructed in situ between the three astronauts and/or air as *issues* that led to the labor dispute. Rehearsing moments in referencing the *past* developed as a way to give significance to moments or events in the temporal experience of the astronauts and as a motivator to take actions that would later lead to the events of dispute between the astronauts and managing teams and their higher-ups. Often I identified these by overlapping flags, such as *modalities>past, timing>issue:sequencing>ATM,* and *rehearsal>ATM.* In addition, if a non-human actor was part of an issue, a flag was developed to trace their impacts on the mission and allow for a bigger picture of the actor-network involved in Skylab's timescapes. Once again, context flags allowed me to identify involved *actors,* place moments, and develop timelines of Skylab. Last but not least, I used *vivo* coding in order to trace back topics that would develop in the analysis of the coded material. Quotes such as "*more science per unit time"* were useful flags to navigate logics of time that underpinned the management and labor practices during the mission, incorporating multiple features in the construction of time and justifying actions accordingly.

Throughout this coding process, I repeatedly struggled with finding the right balance between keeping the coding open enough to capture the complexity of the material while developing a coherent analytical structure. Especially in the beginning, it was difficult to decide whether passages should simply be flagged as technical or operational details or already be treated as analytically relevant moments related to time, conflict, or management practices. Through the coding software, flags became numerous but hard to trace back. Especially in the case of the transcripts, where I would not be able to mark text but only positions in the document. So I had to write contextual passages that summarized the findings a lot in order to not reread passages again and again to make more explicit how certain situations fit my analysis and supported arguments or a train of thought.

Taken together, these methodological steps establish the analytical foundation for examining Skylab IV as a temporally structured and contested socio-technical environment reconstructed through documents rather than direct observation. By combining practice-oriented document analysis, rhythm analysis, and actor-network theory, and by operationalizing these perspectives through iterative archival work and systematic coding, I developed a framework capable of tracing how temporal orders were produced, negotiated, and challenged during the mission. The following empirical chapter builds on this foundation by presenting the results of this analysis, moving from methodological considerations to an examination of the concrete practices, interactions, and moments through which Skylab's timescape became partially visible.

5. Empirical Section

From here on, I have already provided an introduction to the Skylab program and the Skylab IV mission as well as provided context for Skylab's position in the sociopolitical landscape in order to help readers navigate the following in-depth analysis of Skylab's timescape in this chapter. Further, I discussed other researchers' work on the topics of outer space social research and research specific to Skylab as a case. In the previous chapter, I detailed and discussed the methods and codes in order to produce the following findings, guided by the main research question of *how and to what end is time constructed in the management and labor practices that influenced the Skylab IV labor dispute between astronauts and mission control?*

In this chapter, I will present findings grouped around themes and topics. These all derive from my subquestions of what temporal logics can be identified, what practices shape temporal experiences, what moments led to the labor dispute, and how the labor dispute changed Skylab's immediate timescape (Subchapter 1.2.). The decision to focus on topics, rather than individual questions, is due to the complexity of the actor-networks relationship with the multiplicities of time(s), as discussed in the theory section of this thesis. As temporal features and logics only become visible by changes in rhythms and temporal experiences that are formed in relation to specific moments or processes, it is unproductive to isolate these findings. Instead, findings are grouped around temporal features, logics, and moments, enacted in practices and relationships that shape Skylab IV's timescape. The findings will focus on the dissonance between the crew and the larger Skylab program, covering the dates from 29.12.1973 till 2.1.1974 through the in-depth analysis of all four types of transcripts as well as the 'flight-plan-as-flown,' Interview transcripts from the Johnson Space Center (JSC) during NASA's oral history program that feature all three astronauts and other stakeholders, a later interview on the supposed labor strike from the BBC, and press releases from NASA, such as an informative press kit before the mission start as well as video releases from the JSC. Further, I will draw into consideration a paper published by NASA called "Lessons Learned on the Skylab Program," which allows us to understand what NASA drew in conclusion to some of the findings discussed. Starting off this chapter will be findings concerning the Skylab program as understood as an actor-network and the position of the Skylab IV mission within the program. This will provide an understanding of how the program is structured to be an obligatory passage point, how key actors of the mission are defined and enrolled, what strategies of interessement are applied, and how the primary goals and program of action are formed.

The second subchapter will look into the task of synchronizing earthly rhythms with the rhythms of Skylab as a space station. This chapter goes into the specifics of how a multiplicity of rhythms is at play at Skylab, and the programs need to synchronize most of these rhythms in order to produce scientific data (5.2. Synchronizing Earthly Rhythms with Skylabs Revolutions) and will examine the importance of training for astronauts to synchronize with other present 'sociotechnical rhythms' in order to fulfill their function within the network.

The third subchapter, "The Labor Conflict: Clocking in for Science," will derive from a collection of findings concerning features of time during the period of the labor conflict, one of the most prominent temporal logics at play in the Skylab program, and how it relates back to the actor-network structure of the program. Here, I will show how the main derivative of the mission is placing clock time above other temporalities in its evaluation of scientific production and how different temporal features of the Skylab program are interrelated to practices in planning and managing Skylab. Further, I examine how the crew formed, under the premise of multiplicity of programs, an alternate version of the dominant program of action leading to dissonance in Skylab's timescape and how the experiences of the past are producing unrealistic standards for the crew during the Skylab IV mission.

5.1. Ready for Take-Off? Skylab from an ANT perspective

For this case study it is necessary to ground an aloof concept such as time into its sociomaterial context in order to identify larger ramifications of the program's structure for Skylab's timescape. Looking from an actor-network perspective allows us to understand the Skylab program and NASA's many actors at the time, how they are defined and enrolled into the program, and what makes a space mission special in terms of these features. It also provides how relationships are structured and how power is distributed in the institution's network by understanding which actors are displaced by whom and how they are represented. This is critical in order to understand potential heterochronies, in which actors face different challenges in terms of time and how these are imposed. A lot of insights for the subchapter come from an analysis and mapping of the data coded from "Living and Working in Space: A History of Skylab" (Compton and Benson, 1983) and "Homesteading Space" (Hitt, Garriott, and Kerwin, 2008), the aforementioned transcripts of the JSC Interviews (Gibson, 2000; Carr, 2000; Pogue, 2000; Hutchinson, 2000; Hughes, 2000), the Skylab IV Press Kit (NASA, 1973a), and a series of videoclips from Skylab and Oral History Interviews that I edited for my preliminary investigation video essay "Science Per Unit Time: Insights into Living in Space” (Appendix A) in order to understand the actors' positioning within the mission’s framework.

5.1.1. Defining the Apollo Applications Program

For understanding Skylab’s sociotechnical makeup, we need to look at its history, especially the later stages of the Apollo program and its cut in funding and length. With its potential end on the horizon, many engineers, scientists, desk workers, and other groups were facing layoffs. To maintain jobs and have the engineering power built over the last years not go to waste, NASA created the Apollo Applications Program (AAP), a work group established to reuse the developed technology during the Apollo program, and after phases of funding and funding cuts at later stages due to other U.S. American imperial concerns (such as the Vietnam War) (Hutchinson, 2000), the Skylab program was established. The program was designed to send a research space station and three crews into orbit with the stated goals to determine man's ability to live and work in space, extend the science of solar astronomy, improve techniques for surveying earth’s resources, and increase knowledge in predetermined science and technology regimes (NASA, 1973a; Hutchinson, 2000). In ANT terminology, the AAP workgroup established the Skylab program as an obligatory passage point for its many actors and defined their roles in the program. The reuse of technology and manpower as its main program developed a series of sub-goals that would fit the technology and expertise at hand. Most prominently featured in the work routines of the crews, as seen in e.g., the “flight-plan-as-flown” (NASA, 1973f), were technical artifacts such as the Apollo Telescopic Mount (ATM), a solar observatory running on film that was used for producing scientific data on the sun. The ATM and other technologies from the Apollo program were established as key actors, informing the goals and requirements of the mission.

Another important requirement for purposes of this thesis was not only a crew that would operate the space station in outer space but also one that would incorporate civilian scientists. So, the Skylab program introduced scientists from the U.S. American public to become astronauts, creating a new role for the enterprise, called ‘science pilot’ (SPT), which was occupied by Edward Gibson during the last crewed mission, Skylab IV. The subgoals of the last mission in the program were stated to the press as performing unmanned operations using the Saturn equipment, reactivating and manning Skylab, obtaining medical data for use in missions of extended duration, and performing more than sixty in-flight experiments (NASA 1973a). Further, the experiments are specified as solar observations with the ATM, Earth Resource Experimentation Package (EREP) with sensory equipment, the observation of the comet Kahoutek, and other experiments. Different scientists from different scientific departments in the United States formed research groups in order to develop experiments for and analyze data produced by Skylab. Most experiments that were enrolled into the program did so under the observation of a lead scientist in the role of Principal Investigator (PI). These scientists shared an interest in researching the sun, earth, zero-G, and the comet Kahoutek from the data acquired by the instruments and astronauts during the program. Moreover, as flight director Hutchinson (2000) states, scientists were comparable to customers, introducing packages of experiments and equipment that had to be integrated into the planning processes of NASA, including simulations and planning.

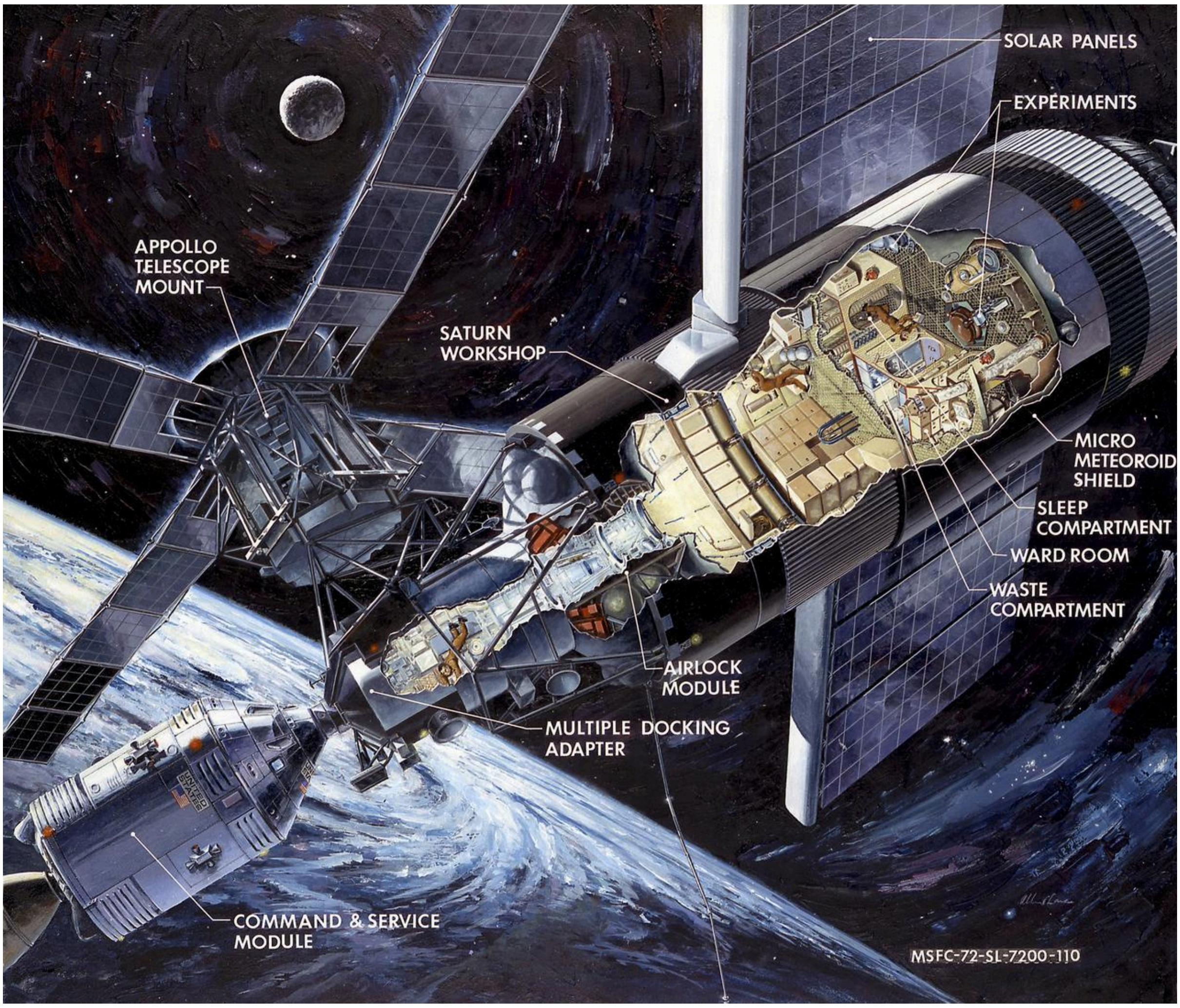


Figure 1, 0101536: *Skylab: Cutaway Illustration* published by NASA.

Hutchinson describes scientists as a new community that had to be integrated into the fighter pilot society, a struggle that Gibson also focuses on from the perspective of a scientist (Hutchinson, 2000; Gibson, 2000). I'll go more into the details of this struggle between the two communities in section “Training, Trust and Preparedness” (5.2.2). Also medical advisors were enrolled, and special importance was attributed to the medical experiments, as this mission was designed to have the astronauts in outer space for the longest period in time, up to the completion of the mission in 1974. Even though the AAP’s goal was in maintaining expertise, technology, and jobs, the Skylab program, as its OPP, transformed the overall goal, measuring its success and allowing for potential further funding for NASA by its scientific performance. To ensure a maximum output of data, ‘real-time planning’ (NASA 1973a) was established as a strategy that would allow for day-to-day adjustments on tasks, sequencing, and responding to time-critical events, a strategy that was a mediated result from the organization's history with the Apollo program, which focused on maximizing results in a short timeframe (Hutchinson, 2000).

To manage the crew during the Skylab program, a well-established role from previous missions called Capsule Commander (CC) was also utilized in this mission to communicate with the crew on a regular basis. The CC position was monitored by an array of actors, sometimes even by the flight directors of different workgroups themselves as Monitoring Capsule Commanders (MCCs). Also, a globespanning network of antennas, from Hawaii to Madrid and Guam (to name a few), was enrolled into all Skylab missions in order to have a digital connection to the crew at Skylab as often and stable as possible. This meant a vast array of infrastructure had to be orchestrated in order for the communication data from the space station to be transmitted back and forth to the ground control center. This network also had to transfer voice recordings and used a teleprompter for sending and receiving files from and to Skylab. This would lead to many time-sensitive issues, as described later, because the timeframes for communication often were only around fifteen minutes; in the worst case, a disconnect between the space station and an antenna during a transmission would lead to a total loss of some of the transferred data. The voice recordings, as stated in a press conference transcript (NASA, 1973b, p. PC-21G/1), were transcribed by the “gals.” This means, at least in Flight Director Hutchinson's understanding, this work is primarily or even exclusively done by female-presenting human actors that are mentioned in this instance when it comes to incomplete or contradicting parts in the transcript.

5.1.2. Interessement and Enrollment of the Crew

With a focus on the crew, the Skylab program does not only have to define their roles; it also has to create interessement in all actors involved and sever, at least for certain periods of time, the connection to other networks (see Latour, 2005). Carr states that they were training for a full period of three years. They not only “had to learn the command and service module system. We also had to learn the Skylab system, the workshop systems. And on top of that, we had experimental systems that had to be learned.” (Carr, p.12-26, 2000), but also to “be a competent performer, if you want to call it, or executor of the experiment.” (Carr, 2000, p. 12-28) by studying theory, practicing on cutboard dummies, and learning from experts in their respective fields of expertise. An interesting finding when looking at an outer space mission (such as Skylab) this way is that the interessement can be understood in two phases with increasing severity. The first stage is when astronauts are in training. They spend their days in halls full of engineers, equipment, and scientists and are obliged to a series of tests assessing the qualities of the astronaut. Carr (2000) states that these training periods were challenging and took a lot of time. He also describes his multi-day journey traveling across the country to go to the NASA HQ. Further highlighting the physical distance one might end up away from other social networks. Hughes (2013) even states that a lot of divorces happened at this time. In this time, potential astronauts are not only drilled to the institutional rhythms of their employers but also cut off a lot of time from their families as well as other networks. For the scientists in the program, extensive flight training with the US Air Force was also obligatory (Gibson, 2000).

Then, there is the second stage after the lift-off. From here on, to connect with other networks is only possible by a lot of effort and only through mediation from the primary actor-network that they are now engulfed in – Skylab. The astronauts are isolated in their workspace, communicating with Earth only through the channels of their employers, spending most of the time with their co-workers. This is also true for non-human actors. A space station such as Skylab is very much the 4th astronaut during the mission. Its hardware is first and foremost in exchange with its crew, and only by means of the infrastructure on the ground and by its software is it ‘connected’ to NASA. Even though alliances may be shaken and non-human and human actors may dysfunction or “refuse to work,” other than the space station, there is not much else to interact with on a physical basis in outer space other than the heat and radiation of the sun and sparse materials drifting around.

In terms of Callon’s “sociology of translation” (1984), the crew and its space station were displaced, as they are only in auditory and technically mediated contact with CC’s operator.

From Carr's interview, we also understand "this was the first opportunity for people who were not capcoms to speak to the crew" (Carr, 2000, p. 12-27), a novelty for PIs and other scientific staff to talk to the crew. Astronauts were further displaced in the overall network of the program by recordings and the work of the transcriptors and then represented by transcripts in front of mission control and the press. The spokespersons for the program became the attendees of the Skylab News Center, who represented them to the public, answering questions for the press or other colleagues, such as one of NASA's Flight Director Hutchinson. With the exception that all transcripts are also made available to the public after revisions. Also 'revised summary flight plans' were produced in order to be distributed to the JSC Newsroom on a daily basis (NASA, 1973a)**.** In this position, the astronauts were subjected to an all-encompassing interessement and their power in the relationship was marginalized.

But, if their motives would not pin onto the program's larger goals, they would also have little obligation to remain faithful to their alliances. Taking SPT Gibson as an example. As he states in a recorded interview (Burns and Gibson, 2021), he enjoys solar physics, and he is a published solar physicist with a book on the topic called "The Quiet Sun" (1973). As part of the larger solar physics community, an obstacle-problem in his field was the atmosphere and the limitation in equipment, time, and money. Of course, this relation is more complicated. In his interview with the JSC (Gibson, 2000), he states that he only grew during his time at NASA an interest in astrophysics having no clue about the field at the time of enlisting. He studied the topic with the sole purpose of getting a seat on a space flight. He learned this practice from his time at NASA during the Apollo program, where all enrolled scientists tried to perform as geologists in order to get 'a ticket to the moon.' He argued that he did not get the chance to be in an Apollo mission as a geologist, as they had a PhD-level geologist already in Owen Karriot (Gibson, 2000)**.** So he had to build an expertise in solar physics that would be his entry ticket to Skylab. With his education in physics and a background in plasma physics (applied and theoretical), he saw an opportunity in the AAP, in which one of the key items was the ATM. Again, the role of the ATM here is shaping how Gibson's biography could be made fit to become an astronaut. But not to get ahead of ourselves. It's important to note that, first and foremost, Gibson states he wanted to be a pilot and learn to fly, but with his case of osteomyelitis, he was not able to be a pilot for a long time. This changed, as his disease was categorized as dormant when he enrolled in the training program for scientists at NASA. In many ways, he *became* a representative for the solar physics community. Even writing 'The Quiet Sun' started out as a primer for his colleagues on solar physics and only later became a fully fleshed-out textbook, which he hoped would earn him enough credit to become an astronaut (Gibson, 2000, p. 29-30). In his role as an astronaut for NASA, he surpassed many obstacles, scientific and personal, in the Skylab program. For him to be disloyal to this network as a representative of a community and for him to question or outright reject the role during a time in which he so keenly enrolled, there needs to be a strong argument or reason for it.

Carr (2000) also states in an interview that the Skylab crew had all been training for years to become astronauts and worked in the Apollo program in different roles; for example, Carr and Gibson both worked as CCs during the Apollo 12 mission, and Gibson designed procedures and tools (Gibson, 2000, p. 22), and Carr himself was “floored” to be the first rookie commander since Armstrong at Gemini VII, taking pride in his role and following in the footsteps of one of the most famous astronauts in U.S. American history. Pogue (2000), having been part of the AAP committee for a while, also had personal stakes in the mission’s success, as this mission would reflect his own work and career. Further, both Carr and Pogue were loyal to NASA for a long period of time. They were all already invested in the institution's perseverance and program success and took joy and pride in their work.

5.1.3. Moments of Dissidence aboard Skylab

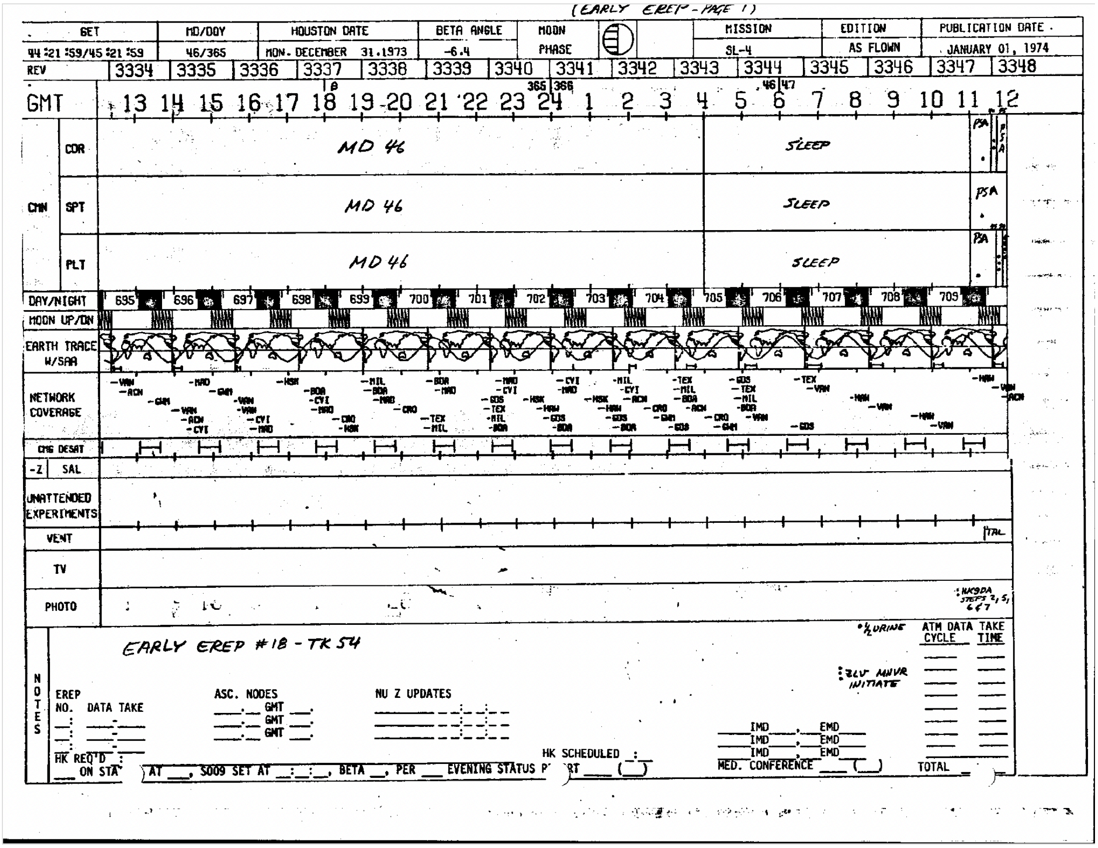
The work-related conflict, incorrectly quoted up to this day as the ‘strike in space,’ provides through the dissidence within the network a unique opportunity to open the black box, that is, the Skylab program, by means of how actors raise issues, discuss and negotiate their position, and form new alliances or by following different goals. To understand how time was constructed during the Skylab IV mission and to what end, one needs to understand under which temporal logic(s) the program operated. In analyzing the material at hand sensitive to time, a major outcome was the ability to identify imperatives of time that would inform the practices that shaped the temporal experiences of astronauts and how they conflicted in such a way that all parties thought it to be necessary to host "the first sensitivity session in space" (Burns and Gibson, 2021), as Gibson would later quote Carr in the BBC interview, decades after the mission. In what was officially called the “OPS conference” or flight planning conference (NASA, 1973c), Carr, as the representative of his crew and the Skylab space station actor-network, would try to work on solutions to previous problems with the ground team, represented by CC. In this moment of dissonance, different interpretations of the mission’s goals and the way the mission needs to be accomplished clashed. In what followed over the next two days, features of Skylab’s timescape were to be renegotiated, providing insights into the construction and reformation of time within the Skylab program. Taking the lived experience of the crew into account under the dominant program of action during the mission, the crew may have formed an ‘antiprogram’ (Feenberg, 2017) for a brief period of time that would be re-incorporated into the dominant program, but not without providing changes to Skylab’s timescape. The incidence also shows the presence of multiplicity in temporal experiences; the different teams encountered in their different settings and processes shaped their own interpretations of the mission goals and how they needed to be achieved by interacting only through the chain of communication, detached from each other by rhythms and space. Further, they provide insights into interessment strategies in close relationship to Skylab’s temporal features. The following subchapters are dedicated to understanding the timescape during and around these moments of dissidence.

5.2. Synchronizing Earthly Rhythms with Skylabs Revolutions

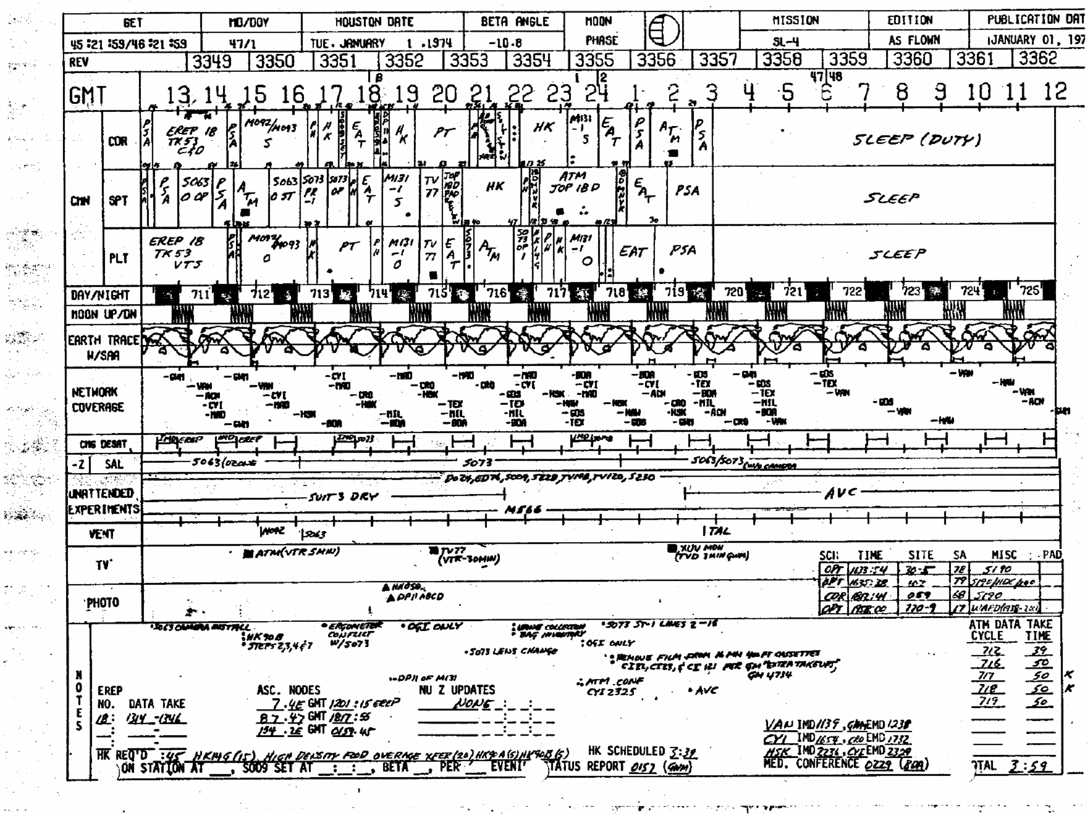
Before we go into the nitty-gritty of the labor dispute, I first want to establish how the program encompasses and interacts with the multiplicity of rhythms aboard and below Skylab. Therefore, we will look at a few findings that focus on 01.01.1974, the first day after major discussions focusing on the labor relations in the program. We will look at a few rhythms that are foundational to the daily activities at Skylab IV as part of a collective and organized scientific endeavor. In contrast with programs such as the Mars Rover mission (Mirmalek, 2021; Vertesi, 2020), these findings focus on the specifics of utilizing astronauts as human actors with circadian rhythms in the actor-network of the mission. As such, this subchapter starts with an imposition of time from the ground team to the crew, specifically a new time for a ‘wake-up call,’ in order to show how rhythms intertwine and produce extraordinary moments in terms of effort that allow for the acquisition of new scientific data of planet Earth from LEO.

The new Skylab wakeup call was going into effect with the New Year, because the program wanted to adjust to daylight savings time. Carr comments, a day before in communication with the ground team, that the crew has no issue with this change coming into effect. But the crew was still affected by these adjustments (NASA, 1973c, p. MC 1571/1). Deriving from the flight plan (NASA, 1973f), the scheduled sleep period was only seven hours because of this change, resulting in an ‘early’ wake-up call. It is a common practice on earth, in which we do adjustments on the numerical scale, ‘often sleeping an hour less or an hour longer,’ to have our clocks harmonized with the shifts in our day-and-night cycle to fulfill our circadian needs. But for Skylab, this change from a 12 GMT wake-up call to an 11 GMT one did only make sense in that sense for the ground team, as the space station revolves around the earth about fifteen times per day, living in an environment that experiences “night" – the absence of daylight on earth – every half an hour. But this does not mean the day-and-night cycle – or the relative position of Skylab to the Sun – did not affect the space station. Different routines are established for more or less cyclical events. One of which is the relative position of the Sun to the space station. For example, Carr suggested on the 30th of December that he wished to know when they should turn off the lights on the space station in order to compensate for the 'high beta period,' a time when the space station is at a particular angle to the sun, causing it to continuously be exposed to sunlight. They agreed to notify Carr, with the addition that he should also notify them when he turns the lights off in order for them to track thermal activity in the station (NASA, 1973c, p. MC-1565/2)**.** Sunlight aboard Skylab becomes a factor affecting the space station and the crew, as the radiation heats both instruments and astronauts.

The change to daylight saving time with the beginning of the new year would have traditionally been scheduled for the 6th of January in the US, but flight planners induced an earlier change for both the ground team and crew due to an upcoming experiment from the Earth Resources and Experimentation Package (EREP) series. One can see an emphasis in the flight plan as flown (NASA, 1973f), and on the page of the Mission Day (MD) 46, an 'early EREP' is noted twice, and the documents are unusually split. What we see in the following excerpt is the second page of MD 46, which leaves out all details of the day and instead focuses on the new set of activities starting at the new time of the new wake-up call, which is lost on the document detailing MD 47.



Excerpt 1, Mission Day 46. Flight-Plan-As-Flown (1973f).



Excerpt 2, Mission Day 47. Flight-Plan-As-Flown (1973f).

The movement of Skylab revolving around the globe and the crew's ability to gather data on specific regions utilized complex timing strategies, not only synchronizing the day-and-night cycle but also the ever-changing movement of Skylab station through its revolution(s) around the earth. Further, an exact steering of the space station's instruments was needed in order to position the sensors, as well as the ability of the crew to understand what they saw through the equipment or confirm a position with the ground team. All these rhythms are further prone to earthly moments and rhythms, such as weather events, like cloud movement or – as during EREP 18 – wildfires that may obstruct the execution or create new opportunities for data collection. These opportunities are further affected by seasonal rhythms but also by institutional rhythms of the ground team at NASA. As we know, the Skylab program flight planning is itself designed to be cyclical and orients itself to the day-and-night cycle with three teams: planners at night and an in-between shift that is concerned with producing a detailed version of the plan for the next day, while a third team of executors works on the plan's execution as explained in the press kit (NASA, 1973a). If a weather event or emergency would disrupt experiments or observations, the task had to circle back to the planners in order to find a new timing in which the experiment could be performed again. The flight plan's printing scheme draws together some of these aforementioned rhythms in one document and displays them through a linear timeline. Note here how the flight plan becomes an active participant in displaying rhythms as linear, how they compare different rhythms, and how these documents allow for sequencing tasks accordingly.

The linear model of time is also deployed here to signal specific overlaps. The three-letter codes in "network coverage," for example, show where and when Skylab is in reach of one of the communication networks' antennas, allowing for managing time windows in which data can be transmitted. But all these rhythms are by far not an all encompassing picture of what needs to be synchronized in one specific moment in order to produce this kind of data. Hence the next quote.

> CDR: "We're still on the Pacific side, huh?"
>
> CC: "Negative. You're on the Atlantic side."
>
> CDR: "Okay, we've got about a minute to go." (NASA, 1973-74e, p.2050)

The ability to pin down a specific moment in time and enable a timing specific to scientific data production was also influenced by the rhythms of the crew (such as the circadian rhythm or routine operations), their day-and-night cycle to be aligned with the institutional rhythms of the ground team, and the ability to calculate the movement of the space station in order to understand its future position. Only then to get told by CC or through teleprompter messages when to take a specific picture(s) from outer space at the right exact moment. To create this precise timing, astronauts' work can differ immensely. Take Pogue's (2000, p. 12-29) description of the practice of using the EREP's instruments. He described them as mechanical, in which his role was following procedures with the only input of the astronaut being controlling the viewfinder tracking system with a joystick in order to pinpoint a location on Earth and then flipping a switch at the right moment in order to activate the tracking system. Here, the instruments were taking on a huge role, in which astronauts followed procedures, "flipping switches" at the right time. This alone can be understood as a monumental effort to achieve synchronicity between actors of the ground team and the crew. Between pictures in the series, the camera needs to be adjusted, and technological artifacts may cause certain problems. Here, the whole actor-network was structured and managed to succeed in its goal to acquire and generate specific locational data. Failure then is understood as such: if not every obligatory actor (human or non-human) is synchronized to be ready at the moment of execution.

> CC: "Did you manage to get in that first Falkland, the one at 16:34?"
>
> PLT: "Negative - negative; I did not. I didn't even see that first time there."
>
> CDR: "Okay, coming up on 24:34 pretty quick here. We'll be going to SHUTTER SPEED, FAST."
>
> CDR: "Okay, on my mark it'll be 13:24:34."
>
> PLT: "DAC's on."
>
> CDR: "Stand by."
>
> CDR: "MARK. SHUTTER SPEED going to FAST."
>
> PLT: "And I don't see anything." (NASA, 1973-74e, p.2052)

To avoid becoming desynchronized, human actors like the astronauts had to be prepared for the operation of their non-human co-workers. These trainings were realized by forming a relation with the instruments to produce the tempo and time-specific execution of experiments. More complex handling of instruments was further prone to the 'technosocial rhythms' between machines and astronauts following protocol. This was especially true for a series of experiments and instruments bundled in what was called the 'Joint Observation Program' (JOP) for solar observations, which would require the astronauts to handle multiple instruments simultaneously (Gibson, 2000, p. 12-28). As Gibson recalls, they would work in five- or six-minute cycles, and the crew had to manually operate and switch diffraction gratings inside instruments, while also following the procedures that would instruct them. Mistakes were 'frustrating' for Gibson in the sense that the astronauts had to work a full cycle in order to get back to where they made a mistake (ibid.). These *mistimings* could also happen when communicating with the ground, as Gibson recalls, as one of the astronauts had to be present and operate the communication console for answering calls from the ground team. In short, the automated sequence of these instruments had its own rhythm that Gibson needed to be attuned to in order to produce the desired scientific data from the PIs on the ground.

Taken together, these observations show that scientific work aboard Skylab was a matter of maintaining fragile synchronizations across a dense network of rhythms. Orbital mechanics, institutional work schedules, circadian regulation, instrument cycles, communication windows, seasonal and meteorological events, and the material constraints of spacecraft systems all intersected in narrowly defined temporal niches in which data could be produced. The flight plan, voice loops, and instruments functioned not merely as coordinating tools but as temporal mediators that translated heterogeneous rhythms into executable sequences. Yet these translations were never automatic. As the examples from EREP 18 and the Joint Observation Program demonstrate, even minor deviations – missed visual cues, delayed confirmations, or mistimed switch activations – could fail an entire observational opportunity. Synchronization, in this sense, was an ongoing process.

5.2.1. Strained Synchronization and the Technoscience of Skylab

Up to this point, I discussed the daily, normalized rhythms that would shape Skylab's day-to-day timescape. In this section, I highlight 'sociotechnical rhythms' that were produced as a solution to a broken element in the hardware of the Skylab space station. As discussed in the previous section, to produce scientific data in the shape of specified pictures, astronauts had to pinpoint a location on earth and flip a switch, activating the tracking system of the station (Pogue, 2000, p. 12-29). For the system to lock or 'pinpoint' the station to its object of observation (such as the earth or the sun), it used an instrument called the

Control Moment Gyroscope (CMG), but this vital component in controlling the space station broke during the previous mission (Skylab III) (NASA, 1973-74b; Gibson, 2000), leaving the astronauts of Skylab IV with work to mitigate that the station's viewfinder would slowly drift away from its target.

The CMG, even before it partially broke, had an interesting effect on the relationship between astronauts and technology and scientific output, as it would limit the timeframe in which it would stabilize the station. In Gibson's (2000, p. 39) perspective, the decision to why the astronauts were marginalized in their agency to produce scientific data from their own observations was that the ground team knew they would only have a few revolutions, before Skylab would start rotating. With timeframes being a limited resource, scientists and ground teams prioritized data that they would expect and that the instruments were designed to produce, not allowing the crew to "tinker" with these sophisticated machines. Especially when time was understood as a limited resource, machines and the reduction of astronauts to the role of 'scientific executors' were often seen as the best way to produce valuable data in relation to the investment one took for the mission.

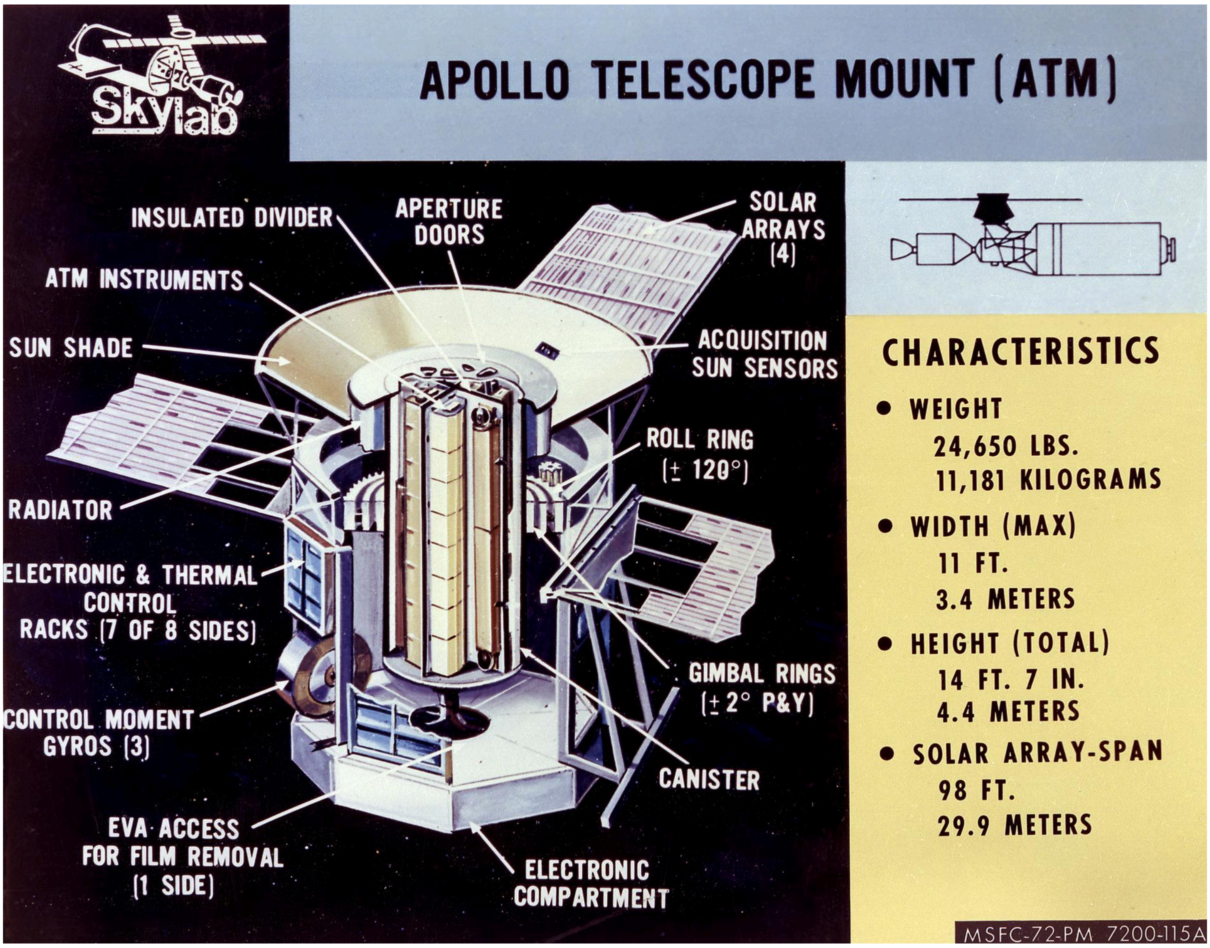


Figure 2, 0101321: *ATM: Cutaway Illustration* published by NASA.

With the CMG broken, synchronicity between Skylab Station's revolutions and Earth's rotation was marginalized. The solution proposed by mission control was that a second member of the crew needed to monitor maneuvering. A solution that prioritized the flawless execution of data acquisition but would have ripple-down effects for the rhythms of the crew, as they needed to wait for each other. Astronauts were familiar with this simple, yet issue-laden, consequence, as medical experiments had confronted them with the same problem. The loss of time was immense, as the already packed schedules could lead one crewmember to be late to the scheduled teamwork, leading to time "wasted" by the other member waiting for his crewmate. Effectively, this problem would be a key issue in the OPS conference, discussing the scheduling problems of the Skylab IV mission on 30.12.1973. In here, CDR Carr would highlight this issue when he reports why the crew did not want to cut time on the preparation time of major medical experiments more than fifteen minutes. As these experiments required two crew members, CDR states that they would often require waiting periods that would "lose time and it ends up with dominoing all the way down" (NASA, 1973-74c, p. MC1596/2). On the 31st of December 1973, Carr and his crew had a follow-up meeting to discuss a solution proposal to the issues that were raised a day before in the work relation between ground team and astronauts. Note, this discussion was following a day that scheduled 27 hours of science for the three astronauts (NASA, 1973-74b, PC-80). In this session, we find new proposals of the crew to make the schedule more bearable. Before the proposal of the crew would be even announced, CC Crippen would have already told the crew that they would no longer have a second crew member monitor maneuvering to point the ATM or other sensory equipment in different directions for solar or comet Kahoutek observations. This change allowed another crew member to be occupied with a different task during that timeframe, and CDR states that the crew sees no issue in working alone on these maneuvers. This change in the distribution of labor might make them more prone to error, but the crew seems to see an advantage in not having to put effort in synchronizing their timeframes (NASA, 1973-74c, p. MC 1565/2). In their proposal to drop the monitoring, they argue that it would free "¾ of a man hour" (NASA, 1973-74c, p. MC 1570/1). If success depends on the crew's ability to anticipate orbital motion, internalize procedural tempos, respond to real-time corrections from the ground, recover from inevitable mistimings and the ability to synchronize their rhythms through inevitable waiting periods, then training and preparedness emerge as foundational infrastructures of rhythmic alignment. The following section therefore turns to the practices through which astronauts were trained to attune themselves to the temporal demands of Skylab – learning not only to operate instruments, but to embody the timing, discipline, and anticipatory skills required to keep human and non-human actors synchronized.

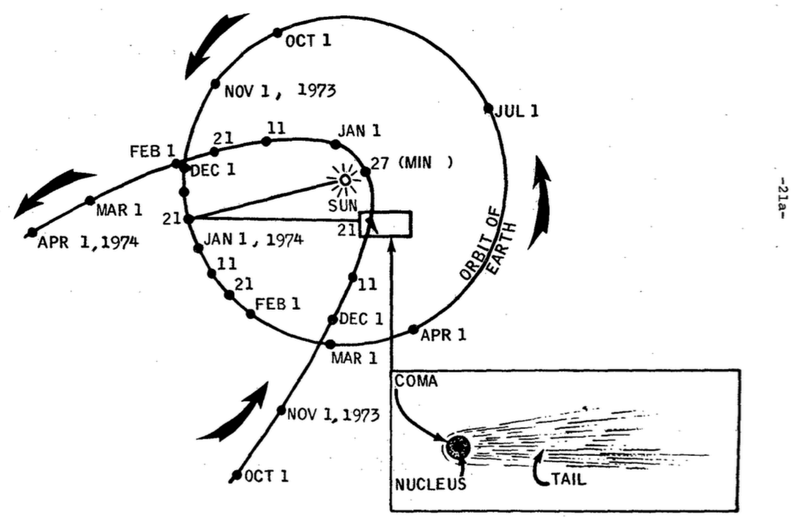
5.2.2. Training, Trust and Preparedness

During a solar observation at the end of the 31.12.1973, technically speaking on the 1.1.1974 counting GMT, Gibson struggled with an experiment set up. He seemed to be frustrated, as a lot of swear words (probably watered down by transcriptors (see, Brooker, 2019-20)) are voiced in between descriptors for the experiments equipment.

> SPT: " [...] I'll tell you, this thing isn't real. There's no way you can learn something like this except by doing it. And here again I'll say we've had no simulators - no frapping simulators. Well, it's just a question of learning on the gear." (NASA, 1973-74e, p.2044).

Gibson would go on and explain that with no proper training, the first few times using the equipment could be defined as training sessions but using the very limited and precious flight gear and flight film. He also argued that he handled more complicated gear, such as the ATM, the difference being that he trained with the ATM on the ground. He went on to complain that instructions by themselves are not enough to operate time-critical actions. He stated that, in his mind, for something that requires manual dexterity and remembering time-critical action, proper training with simulations is needed (NASA, 1973-74e, p. 2044). Gibson's complaints are reminiscent of what can be described as a lack of 'tacit knowledge' that would have needed to be taken into account during the training for every piece of equipment. Especially if the equipment required specific timings in his actions. The piece of equipment in question (derived by comparing the flight plan and the press kit (NASA, 1973a; 1973-74f)), was SO63, an ultraviolet airglow camera, which was designed to "obtain ultraviolet and visible color photographs that can help determine the distribution of selected constituents in the coma and tail" (NASA, 1973a, p.19) of comet Kahoutek**.** To achieve these photographs, Gibson needed to synchronize his workflow to the technical artifacts' rhythm. Failure to form this time-specific co-relationship was a frustrating experience, especially for Gibson, as the space station resources like flight film were limited due to being in outer space. Film is frequently mentioned, and with its importance in producing data, it was a valued resource aboard Skylab. As most sensory equipment, such as special cameras like the ATM, was only able to produce data by using film. Highlighting how important film was in this mission is a recollection of Pogue during a JSC interview (2000, p. 12-53).

ORBIT OF COMET KOHOUTEK (1973f), 1973-1974



Excerpt 3, Orbit of Comet Kohoutek. Skylab IV Presskit (NASA, 1973a)

He stated that the crew had a procedure in place for when he was operating the ATM, and he would read a potential for a flare to rise from the sun from an X-ray instrument. Pogue would switch positions with Gibson, as he was more skilled at detecting a potential flare rise, and Pogue did not want the responsibility of switching the camera into flare mode, where it would burn rapidly through the film cassette, using up to 80% of the material. Not only were resources limited, but the periods where Kahoutek was observable in different states of the comet's orbit were also limited. So there was little option for reprogramming these observations into upcoming dates due to the movement of the comet. These limitations put pressure on the operators of the ATM, as mentioned by Carr in the following statement.

> Carr: “Particularly Owen Garriott and Ed Gibson were getting a lot of flak from experimenters wanting to make sure that we understood they had invested a lot of their money, probably most of their budget on this thing, and they didn’t want it screwed up” (Carr, 2000, p. 12-29).

Preparedness in that sense was not only time-intensive but also a prerequisite to avoid conflict with PIs. That Gibson was placing blame on the training design over the air-to-ground channel, where a PI or representatives were listening in, waiting for results from the Kahoutek experiments, makes sense. Further, Carr characterized the atmosphere as “competitive” between PIs, so Gibson and the other science pilots had to make sure that they would prioritize experiments correctly to avoid conflict. Still, conflicts were so frequent that PIs had to sign and agree to a document, the ‘Joint Operating Procedures,’ that would establish a sequence and a protocol for the rescheduling of experiments in the event of failure and allow for sequencing that would minimize conflict between PIs who would use most of their budgets on these experiments and NASA’s planners (Carr, 2000, p. 12-29).[4] As many PIs pushed their experiments, planners had to cope with experiments or observations failing due to various factors; they needed to make sure that they would later have the chance to have them rescheduled. The JOP was a safety mechanism for the scientists on the ground, needed in order to trust the Skylab program's certainty in terms of data output. “It was almost like signing up to a truce or a pact” (ibid.). Previous findings suggested a strained relationship with PIs. But even if an experiment was scheduled for a later point in time, repetition was still bothersome to astronauts. The JOP therefore acted mainly in order to satisfy on-the-ground scientists, while the astronauts and planners had to make time in order to redo an experiment.

> Carr: “We knew, we were sure experimenters on the ground were grinding their teeth when we would have to report, “Well, I didn’t get this experiment done because in my rush, I put the wrong filter in” or I did this or I did that. We found that it was almost to the point where you almost had to schedule when you could go to the bathroom, it was that tightly scheduled” (Carr, 2000, p.12-47).

In the ‘lessons’ learned, the JOP concept was considered to have worked “excellent and resulted in the production of maximum data for minimum Principal Investigator/crew interface during the mission.” (NASA, 1974, p. 92). The only problem identified here was that the JOP was not able to be changed to account for instrument malfunctions or to exploit knowledge gained during the mission. This ‘lesson’ provides various insights, from making explicit a rationale of time structuring the mission (see, subchapter 5.3.) to the ‘lesson learned’ being in conflict (or total neglect) with what Carr attributed to JOP as a social ‘pact or truce’ that would produce a feeling of fairness through its strict sequencing. While the JOP was a solution to PIs’ immediate distrust of the organization, which was handled by the careful construction of a timeline through the JOP, the lack of trust and PIs’ interest in the ‘fail-proof’ handling of instruments by astronauts would be present in instrument designs.

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[4] From my understanding, the Joint Operating Procedures is part of the Joint Observation Program (JOP), which bundled experiments for solar observation. Carr is also referencing the procedure in the context of the ATM experiments. But it could also be that he describes the JOP here and was, in retrospect, not using the right acronym.

The impact of this choice in design can be exemplified by this frustrated statement of Gibson:

> Gibson: “Earth observations equipment was designed to be operated just by pushing buttons. You'd get the instructions up from the ground and you'd go to Z-local-vertical, and you'd just start pushing the buttons on command. We had a tough time convincing them that if we saw three-quarters cloud cover, maybe we shouldn't be taking the data, and they didn't want to let us have that judgment.” (Gibson, 2000, p.38).

While they would build up expertise on how to produce qualitative data with the handheld camera or the ATM, they would act like ”automatons” during other experiments (Gibson, 2000, p. 38-39) when handling more sophisticated gear. Gibson commented that he did not see a reason for this (ibid.). With the design of the program and the space station to produce rigid synchronization and timings combined with the existing lack of trust in astronauts, the trade-off was, at least in Gibson's perspective, a lack in the quality of data. And as we see in the short scene from the EREP 18 at the beginning of this subchapter (5.2.), in situ, the handling of the equipment was more difficult than pushing a button.

The lack of trust is backed by Hutchinson’s insights on the simulators and the introduction of scientists to the cadre of fighter pilots and engineers that managed and worked on Apollo (Hutchinson, 2000). By referring to scientists, he mentioned during his interview, “[...] if you a flight director, they’re [scientists][5] are your customers” (Hutchinson, 2000, p. 40). He stated that the team on Skylab had to accommodate for new types of simulators, equipment, and personnel for training astronauts in the many experiments, needing to come up with solutions to simulate ‘the sun,’ for example. He admitted that the program struggled with the integrity of simulations, as they operated with more budgetary constraints while needing to account for new, sensitive equipment. The mentality of scientists as “customers” and the difficulties of accommodating and preparing the astronauts in the simulators certainly add to the problems Gibson faced. On one hand, Hutchinson (2000, p. 40) opens up an interesting comparison between the rigid and disciplined mentality of flight operators vs. scientists, who would need time to think when discussing troubles of the space missions' real-time aspects. During the interview, Hutchinson would compare the two communities and often describe the pressure they felt from working with scientists, in the sense that the scientists did not trust these military ‘fighter-pilots’ – like Carr and Gibson – to handle experiments.

[5] Word in brackets added by the author of this thesis for better reading comprehension.

On the other hand, Gibson, who enrolled as the first cadre of academics years before Skylab, stated that there was a “lack of acceptance” (2000, p. 15) and that he felt flight training was a way to root out the scientists as they;

> Gibson: “[We] were not regarded as really instrumental to what was going on; that's an understatement. I then realized that maybe they sent us off to flight school hoping we would quick flunk out or kill ourselves, or, anyway, not show up back here, because, quite frankly, the way it worked is we were rammed down NASA's throat by the National Academy of Sciences. They didn't want to do it.” (Gibson, 2000, p. 17)

Gibson emphasized that there was a clear divide between scientists and pilots (ibid.). In a sense, one can see Gibson and the other scientists who enrolled in the Apollo program and were trained as pilots and cap comms not only as a means of preparing them for the job as astronauts but also as a rite of passage that would position them later as mediators between the staff of scientists and fighter pilots. Gibson’s frustrations do not simply register as individual complaints about inadequate training or poorly designed equipment; they expose a deeper structural tension in the Skylab program between timing, trust, and authority. The demand for rigid synchronization collided with the situated, embodied knowledge required to operate time-critical equipment under conditions of scarcity and irreversibility. Training regimes that privileged procedural compliance over experiential attunement left astronauts to ‘learn on the gear,’ turning moments of high-stakes data production into improvised training sessions. As Carr describes,

> Carr: “We found that a lot of the PIs [principle investigators] knew nothing about human factors and they knew nothing about being weightless, so they would prescribe things to be done that just weren't practical at all in a weightless environment. So we worked very diligently with those fellows, trying to get their experiments in a configuration that could be easily accomplished, and I think they appreciated our willingness to do that. For us it was important, because we wanted success” (Carr, 2000, p. 12-28).

They were preparing PIs to be aware of the tacit knowledge that astronauts would bring to the designs of experiments but also built a relationship in which both groups ensured that in order for the program to have its desired outcome, the expertise of NASA’s astronauts had to be recognized and incorporated. A relationship that would be time and time again tested during the mission.

A few findings from this subchapter seem to be most relevant to me at this point to understand Skylab's multiplicity of rhythms; first, rhythms were experienced in different ways by actors, such as day-and-night cycles, which were different in frequency and effect for the crew in outer space than they would be for the ground team. But at the same time, rhythms were synchronized through an abstraction via clock time. Second, in order to produce the goal of the program in terms of data production, astronauts are familiarized and synchronized with non-human rhythms. Third, institutional rhythms are produced to manage the different temporalities.

The temporality of clock time certainly plays a large role in this accomplishment in being able to produce the 'right time.' Timing here is only achieved by synchronicity between the temporalities of hundreds of actors. In its goal to acquire data that is valued by the institution – in this case NASA – the temporality of clock time as an invention and social construct supports the program's design and desired outcome. As argued here, the Skylab program's design at its core is well adjusted to create a lot of moments where new data specific to these moments can be collected. Last but not least, the multiplicity of temporalities is present, and clocks demand effort by other actors within this co-created timescape, shaping rhythms in such a way that it is possible to be ready at a certain time or moment in which only its abstract description of the moment is prescribed by the clock. Clock time, as a temporality, is incredible for achieving synchronizations due to its grade of abstraction and standardization. At the same time, it is a first hint on how a timescape that would value such features might have affected the relationship between scientists, astronauts, instruments, the production of knowledge, and its evaluation. Cock-determined thinking may also produce friction between different actors. As was the case for Gibson in synchronizing to the SO63's rhythms while being synchronized to the ground team, Earth's rotation, Skylab's revolution, and the beat of the clock. Gibson's position as a scientist-astronaut thus becomes emblematic: trained to embody multiple temporalities and epistemic cultures, yet operating within a system that struggled to accommodate such hybridity. Preparedness, in this context, was not merely a matter of technical skill acquisition but a contested process of aligning bodies, instruments, and institutional expectations.

5.3. The Labor Conflict: Clocking in for Science

In the flight planning conference of the 30th of December 1973, with the crew, Carr stated that the crew's well-being was at stake, leading to a previous intervention into the program (NASA, 1973-74c; Carr, 2000). On the previous day, he requested an 'off-the-books' session and a review of their performance. This goes hand in hand with feelings also voiced in the discussion, of “feeling rushed” and “under the gun,” (NASA, 1973-74c; Carr, 2000) as stated later by Carr during the session. In his interview with the Johnson Space Center (JSC) team, Carr (2000) stated that he requested this conference with the medical advisors, while the transcripts of air-to-ground communication suggest the request was being made by a teleprompter message (NASA, 1973-74c). Here we find that, although the interviews are a useful tool to contextualize the situation, they are recorded more than 20 years after the incident, providing inaccuracies and therefore making the analysis of the transcripts essential in understanding the labor conflict. The usage of the teleprompter as the tool of choice for this request fits the request for an ‘off-the-books’ session, as these were the only way astronauts could effectively delay the publication of their request, as transcripts were published within a 24-hour cycle, as seen in the discussions during the press conference (NASA, 1973-74b). As Brooker (2019-20) also suggests, delaying the publication of information was a temporal strategy to have the public only involved after the conflict was resolved or handled more privately. Higher-ups denied this request, not wanting to compromise their image as a transparent institution (NASA, 1973-74c).

The reason for the request was that the crew on the space station could not comprehend why they were subjected to this kind of workload and therefore asked for a performance evaluation (Brooker, 2019-20; NASA, 1973-74c). This subchapter investigates the most prominent operational logic as a reason for the experiences that Commander Gerald Carr (CMR) issued the message to the ground team, which would result in the OPS conference between air and mission control. This operational logic is best summarized as a frequently used phrase during said conference: “science per unit time” (NASA, 1973-74, p. MC 1554/3). Here voiced by the active capsule commander and ground representative, Dick Truly.

During the conference of 30.12.1973, the following topics are discussed between Carr and Truly: differences between the ‘pre-mission plan’ and the actual flight plan, accomplishments, performance, and the workload of the crew. Other items included were timeframes for physical exercise, preparations, scientific activities such as observations and experiments, and leisure. The last item on the list of discussions was the usage and control over the onboard voice recorder conflicting with the data transfer from air to ground. In all issues being raised, time was of the essence, making it a conflict over time-control, as is typical for modern work issues (Adam, 1995). For all issues, solutions are proposed by CC and the ground team during the session, in small discussions, and in a follow-up OPS session during the upcoming day (31.12.1973).

The following findings from this conference depict how ‘science per unit time’ was the dominant operational temporal logic of Skylab IV, how it was composed of different temporal features most closely to the temporality of clock time, and how it was intertwined with the overall program’s design. In subchapters, we will then investigate how ‘science per unit time’ was influencing evaluation standards and practices. Further, I will share findings of how ‘science per unit time’ maps onto an overall understanding for the production of knowledge in defining the science-time relationship of the mission.

5.3.1. More 'science per unit time'

As a result of CMR Carr’s request to discuss their current issues with the flight planning and management from 29.12.1973, the OPS conference was hosted during the end of 30.12.1973. Both CC Truly and CMR Carr had the time and privacy to evaluate the situation with their respective teams. Also ‘higher-ups’ including the shift's Flight Director Phillip Egelauf, Director of the Johnson Space Center Dr. Craft, and Flight Crew Operations Chief Donald K. Slayton, were all listening in during the conference, as mentioned by CC Truly in the beginning remarks (NASA, 1973-74c, p. MC 1553/2). The introduction speech, as stated by Egelauf and Truly, was representative of the whole ground team’s experience and understanding of the situation. At the end of the first back and forth between Truly and Carr, after admitting to errors in flight planning, discussed later in this chapter, Truly repeatedly used a specific phrasing, which can also be understood as the dominant principle under which the program operates and the Skylab timescape was structured, best illustrated in this quote:

> CC: “[...] I’ll go ahead and use this 30 seconds to touch on the next subject, which is the next paragraph or so which **talks about the number of accomplishments which we think is important for the hours invested**. The message is real simple there. I think the paragraphs say that, and as you guys feel that the prep or post time for any of these science en - endeavors can be shortened, we want you to feel good about them, but if you find that you have the free time, naturally that - that ends up allowing us getting us **more science per unit time**. [...]”[6] (NASA, 1973-74c, p. MC1554/3)

[6] Bold text passages are not bold in the original transcript. The author added a bold text style to emphasize parts of the quote.

In this statement, Truly asked the astronauts to find optimizations in the timeframes of the preparation and post-activities for experiments to make room for flight planners to fit more experiments into their schedule. The way time was talked about in the discussion is reminiscent of the way that the temporality of clock time features in most work spaces. From the social effect of equating money with time to the resulting valorization of ‘speed’ (Adam, 2021, p. 6), or valuing tempo as a key feature within a timescape. If it's the closing statement at the end of the discussion of the conference:

> CC: “[...] they are very happy with the way you are doing business, and I think - they think we’ve made a million dollars tonight” (NASA, 1973-74c, p. MC/1557/2).

Or in Carr’s recollection of the events;

> Carr: “part of the motivation was; "My gosh, it's costing $20,000 an hour for you guys to be up there. We've got to get things done." And we agreed with it” (Carr, 2000, p. 12-50).

Or in Flight Director Hutchinson's description of multiple accounts of scientists as their new customer base, taking issue with the problems Skylab I faced only with the problem that they would not produce any scientific data in the time they repaired the station, while they “had here this multi-hundred-million-dollar Apollo Telescope Mount [ATM] for looking up and all this Earth research, and we weren’t touching any of it.” (Hutchinson, 2000, p. 44). The resulting valorization of speed was ever present in the OPS conference. The relation between time, the valorization of speed, and scientific data production aboard Skylab makes 'science per unit time’ the mission's understanding of how work is evaluated. This principle understands time as investment, with scientific data as its return. Scientific data was measured by quantity in terms of how many experiments are conducted and the amount of data produced. Its quantitative logic, in its execution, operates in ways in which time efficiency is determined by arbitrary number timeframes set by the planners. Here again, its logic was primarily based on the temporality of clock time, which understands time as standardized units, detached from any rhythms or anything that does not neatly fit on a timeline. “It is invariable and pre-set by the designer” (Adam, 2021, p. xx). It is important to note that both the crew and the ground were operating under assumptions, dictated by the understanding of time that came from the temporality of clock time, as seen in the following statement of Carr.

> Carr: “We feel like we’re doing a more efficient job up here, we’re making less mistakes per man hour than we, when we - or under the gun earlier” (NASA, 1973-74c, p. MC/1555/1).

The crew themselves wanted to perform efficiently in the same sense, using the same language as the planners, subscribing to the institutionalized understanding of time in the Skylab program. In the foregoing statement, they were equating efficiency to how many mistakes they made in a given timeframe. The logic of 'science per unit time' is also explicitly shown and, in some sense, rejected by the crew by the attempt to shorten ‘prep and post time.’ These are periods of time in which the three astronauts did not act as ‘scientific executors’ in their purest sense and were repeatedly pressured by flight controllers in order to make room for more experiments. This was also true for the durations of pre- and post-sleep periods, in which interruptions with new requests to produce scientific data became so frequent that CDR interrupts CC during the conference once they mention this scheduling practice.

> CC: [...] And if we could - if there were times and I’m not talking about every night, but if there were times that we could stick a specific one in there, for instance at 8:30 at night of half an hour or 45 minutes duration and pay you back at another time of day, there are very definitely are some advantages to the science gain for that And -”
>
> CDR: “Yeah, we can appreciate that too Dick, and I think the reason why we started hollering is there was just getting to be too much of that, almost every night, we were running almost every night, we were running almost until bedtime.”(NASA, 1973-74c, p. MC 1555/2).

We find this logic again in the chain of operations, in which flight planners have the agency to fit experiments into certain timeframes. Planners had the final choice in sequencing and constructing timelines. They operated with the numerical parameters and estimates from previous missions. Parameters on how long an experiment would need to be conducted were given by principal investigators and other scientific experts. These numbers, as discussed by Brooker (2023), were largely derived from simulations and comparisons from previous space missions. But to understand how 'science per unit time' as an operational logic is enacted beyond a quantitative comparative study, we need to take a look into the practice that produced the flight plan.

5.3.1.1. Insights into Real-Time Flight Planning

Real-time (RT) flight planning as practiced by NASA during the Skylab program was one of the most integral practices in shaping Skylab's timescape. The labor dispute during the midpoint of the Skylab IV mission can be understood as an intervention into practices formed by this enactment of 'science per unit time.' RT flight planning enacts, in many ways, the temporal features of 'science per unit time' as its operational logic, as it is designed to "yield the highest experiment data return" (NASA, 1973a, p. 25). Planners are primarily working to "enhance data gathering for particular experiments" (ibid.). They themselves draw on complex data sets to forecast, predict, and react to the rhythms and moments (ibid.). In that sense, RT flight planning co-produced a timescape that understands time first and foremost in terms of clock time, abstracting other temporalities and processes to their numerical values to sequence experiments in the most efficient way. It is nonetheless concerned with other temporalities, such as the circadian rhythm, including everyday practices such as eating, hygiene, and sleep, but also rhythms that are unique to outer space, such as practicing physical exercise due to the near weightlessness and the accompanying muscle and bone loss, and weather events that obscure the view of planet Earth or even solar rhythms, such as the likelihood for solar flares (NASA, 1973a). Planning in the case of Skylab IV also encompasses a variety of other rhythms and utilizes prints of the flight for record keeping (NASA, 1973-74f).

As discussed in the previous subchapter (5.2.) planners follow an institutional rhythm in which they work in cycles. At night, planners draft a "summary flight plan for the <u>following</u> crew work day." (NASA, 1973a, p. 25). During the day, flight controllers executed a plan for the immediate day, and a third team – the 'swing' shift – worked on a more detailed version of the flight plan produced during the first shift that was then given as extra instructions to the crew on the following day (NASA, 1973a; Hughes, 2013). As such, RT flight planning at the Skylab program was not only a process or a multitude of practices; it summarizes an institutional rhythm that incorporates a multitude of processes and practices. It was composed of three shifts. Summarizing a complex construct of actions: the first shift is in charge of planning, which means preparing a flight plan composed to maximize scientific output in this case. The second shift is managing the crew in their roles to execute experiments. The third shift translates so that the crew has detailed instructions in order to execute the plan.

From an oral history interview with flight planner Francis E. Hughes (2013), we understand that the plan itself was based on two software programs on which he worked: the "Mission

Operation Planning" (MOPS) and its subset, the "Activities Scheduling Program" (ASP). The latter was able, with the processing power of the time, to create "schedulable entities" (Hughes, 2013) with designators such as precursors and successors that would limit planners in designating activities to certain periods of time. For example, a pre-sleep entity would always designate a sleeping entity and so on. This method of planning in segments on a fixed timeline is also seen in the flight-plan-as-flown (NASA, 1973-74f). The ASP was designed to make Apollo flight planning more efficient, saving time on the end of planners. Important to note is that, with this technology in place, flight planners were able to shuffle or move – for the first time in space flight history – tasks by re-/ordering entities and have them printed or shown on a display instead of rewriting a plan by typewriter (Hughes, 2013). Pogue (2000), in his JSC interview, also highlighted the role of 'procedures' in the daily work at NASA, writing and rewriting complex sets of instructions as step-by-step guidance for astronauts during his days at mission control. Hughes, in this interview, also focused on the fact that the ASP changed the flight industry and later the personal lives of everyone using management software today. A task of the third shift, the shift that would work on the detailed plan, was translating the flight plan into the ASP, dedicating "boxes" for each astronaut so that by the time the crew would wake up, "there might be 30 feet of teleprinter paper floating out of this thing" (Hughes, 2013, p. 13). While not mentioning the ASP, Gibson (Burns and Gibson, 2020) took serious issue with the way they were micromanaged through the teleprinter's listing "detailed instructions every morning" (Burns and Gibson, 2020) that astronauts would have to cut up and go through, taking up more and more time from their post-sleep time periods. The quantitative rationale of the Skylab program is best understood in contrast to the 'lessons learned' document, in which it is stated that:

"[...] If possible, uplink each crewman's messages on one continuous piece of paper. This minimizes sorting. Flight controllers should have some independent authority in communicating via tele-printer (or teleprinterlike devices). Minimize the number of interfaces required for a flight controller to transmit information to the crewmembers in orbit.

<u>BACKGROUND:</u> In the course of the Skylab Program, nearly 4000 teleprinter messages were uplinked, each of which varied from less than 15 to over 1000 lines in length. Information concerning every phase of mission operations items was transmitted. A significant amount of crew time was required to keep the FDF[7] up to date." (NASA, 1974g, p. 89).

[7] FDF = Flight Data File.

We find that RT flight planning in Skylab IV is per design focused on data output and quantitative data and therefore more concerned with some rhythms and numbers while being more ignorant to others up to the point where they may become issues. While the ‘pre-flight plan’ served as a guide, planners tinkered through management practices on the enactment of the plan to maximize data output. What is seen as a “normal Skylab crew workday” (NASA, 1973a, p. 25), including eight hours of sleep, a day off every seven days, 1.5 hours of PT, two 15-minute periods for personal hygiene, a set timeframe of 8 hours of experiments, and an optional “rest and relaxation” (ibid., p. 26) of an hour a day, is in – flight-planning – practice, within an actor-network designed with the goal to produce ever more scientific datasets, seen as a hindrance to scientific data production and is therefore subject to compromise, negotiation, and ever-shifting sequencing of tasks to maximize the number of hours in which experiments and observations were practiced. We find that speed is valued in the number of experiments present in one day, while synchronization is only valued in terms of scientific execution of experiments and management through flight controllers. Flight planners have the most trouble with all rhythms and processes that are not tied to abstract periods of time. This is best seen in how PT is made an issue during the conference by CC:

> CC: [...] We did want to make the point though about the unbroken PT and what that does to us. Picture if you will building a Flight Plan starting with nothing in it with the requirement of giving a guy his - let him eat a meal at a reasonable hour then adding on at least 1 hour and then adding on another hour and 45 minutes, and then trying to conflict that hour and 45 minutes against all the list of things, and mainly vehicle stability and ergometer conflicts and it just turns out that is really hurting us. [...] But the simple reason that we’ve kept asking you is because it’s given us so much trouble.
>
> CDR: “ Okay, Dick, let me cut in on this one. Picture if you will a guys who’s just had a big breakfast and has to get on a bicycle and dump 5000 or 6000 watts and he’s got to do it in - in jig time and then he’s got no time to clean up afterwards. So you can see we’re in the same kind of box here.
>
> [...]

> CC: “ [...] We did want to mention though that on the surface it may look like paying the extra 15 or 20 minutes for personal hygiene after PT is - is a bad thing for us but there are - there are believe me there are days when we’d glad to pay that extra 15 minutes in order to get some opportunity - some corollary opportunity or something that just happened to pop up at a particular time” (NASA, 1973-74c, p. MC-1555/2).

As I will go into the details of the proposed solutions both during the 30th and 31st of December 1973, we will discuss how temporalities and rhythms clash, in which this dialogue is also valuable to keep in mind. For now the quotes support a common theme during Skylab IV, that all elements that are associated with bodily rhythms during the mission are problematized by planners. They see an uninterrupted period of exercise and hygiene as obstacles to their goals, not only arguing in terms of planning but also enrolling the control over the space station as an issue. A supposed fact that was debunked by SPT during the following day (NASA, 1973-74c). CC also included the crew to be beneficiaries of the suggested proposals, as they are seen to be producing time-critical scientific data, here exemplified by observations from the aforementioned Komet Kahoutek. Interestingly, CDR subscribed to the enrollment of non-human actors as reasons for conflicting rhythms, but from the perspective of the crew's bodily rhythms, certain sequencing proposed by CC makes it more difficult for them to produce a certain amount of energy on the bicycle due to the lack of consideration for their digestive cycles. The last insight for this dialogue in terms of planning is how the logic of 'science per unit time' is not only enacted within the institutional rhythms and practices of planning but also present in managing. Before we look further into the practices of the ground team and the counteractions of the crew around the OPS conference, we first need to look at the last feature of timescapes: the modalities of past, future, and presence to understand how time is re-/constructed during the session of 30.12.1973 in order to alter the timescape of the mission during the dissonance between the actor-networks.

5.3.1.2. Setting Standards for Skylab IV

During the OPS conference, multiple events of the past are recollected in order to introduce issues, solve problems, and produce evidence in the negotiations. At the start of the conference, two items are mobilized: the ‘pre-mission plan,’ which CC admitted is not representative of the workload. This is because, as CC explained, the plan intensified pre-flight by adding a daily conference, experiments, and operations such as science demos, handheld photos, and observations that were not accounted for. Therefore, the ‘list of accomplishments' based on the pre-mission plan is perceived as lower than the other missions (NASA, 1973-74c, p. MC 1554/1). Carr adds that a bunch of medical measurements were also not in the plan and that they received little training on these tasks, "that really turns into a time user" (ibid., p. MC 1554/2).

The second item is a quote from the message Carr sent via the teleprompter earlier, before the latest voice dump cycle.

> CC: You told us the other night: "we'd all kind of hoped before the mission and everybody had the message that we did not plan to operate at SL-III pace." [...] everybody did not have that word." (ibid., p. MC 1554/1).

The Skylab III mission at this point in time during the program was already known as the '150% crew,' as they outperformed the flight planners' schedule (NASA, 1973-74c). In reference to Skylab III, flight planners decided to schedule the same amount of science – 28 hours per day – two weeks into the mission regardless of the Skylab IV team's performance, as the output was expected to be the same. In later interviews, Gibson stated that his colleague Pogue (PLT) was working at less than his efficiency due to being sick in the first few days of the mission (Burns and Gibson, 2020). Carr, on the other hand, stated in an interview that as he swapped his more "sedentary" jobs with Pogue, "he carried his load without any trouble at all" (Carr, 2000, p. 12-46). In retrospect, CC admits that the planners' expectations were biased because of the numbers of the 150% crew and that the ground team did not evaluate them on "different ground rules" (NASA, 1973-74c, p. MC 1554/2). Further, he admits that both crews achieved the same results, accomplishing tasks in the same amount of time.

Here clock time and the embodied experiences of flight planners and crew alike converged in an interesting way due to achieving more 'science per unit time' as a guiding principle and a feeling of past success. Working by a checklist that did not include many of the tasks they needed to fulfill, the crew got a constant sense of 'falling behind' or not performing to the standard of NASA. Interestingly, in both cases, the numbers for reference were extracted from the context of the Skylab III mission and re-contextualized in Skylab IV's timescape. This is best seen in the Skylab IV press kit release, in which NASA states that learnings from the first two missions led to a shortened meal and pre- and post-sleep period, cutting 15 minutes from the former one-hour timeframes. The second learning derived from the previous missions is that housekeeping chores are not scheduled but put into a daily 'shopping list,' so that the crew has the "option to fit [them][8] into any slack time" instead

[8] Word in brackets added by the author of this thesis for better reading comprehension.

(NASA, 1973a, p. 26). It is also announced here that flight planning methods have increased the "normal experiment day from 22.5 hours to 28 manhours and are expected to yield more than 200 additional experiment manhours over a 56-day mission" (ibid.).

This ability to impose timeframes is not unique to clock time, as impositions can also be socially constructed through, for example, an understanding of cyclical time (e.g., you got a day). It is unique, however, that a quantitative value, devoid of any meaning and only produced by arbitrary numbers that are in no relation to the quality of the produced data or the lived experience of the crew, would have such trickle-down effects on the network in shaping the perception of time and well-being aboard Skylab.

Before this session, flight planning resorted, as Gibson would state in the interview with the BBC (Burns and Gibson, 2020), to micromanagement techniques in which they would get detailed instructions from the ground teams every morning in order to 'catch up' with delays in their schedule, sending them increasingly comprehensive teleprompter messages. Whether this was helpful or not for adhering to an already overloaded schedule is difficult, if not impossible, to back up, but in the light of setting overambitious expectations, fault may have been attributed down the line to the crew. The session was a needed intervention to correct standards introduced into the evaluation of the mission by flight planners' tendency to equate the work's value with an output of 'science per unit time.' It is important to note that Carr and Pogue (Pogue, 2000) have both taken on the role of working on procedures as well as working in the role of Cap Comm on Apollo missions previous to Skylab. In that sense, both were familiar with the institutional processes and a focus on 'procedures' in managing astronauts.

These findings also put many later changes into perspective, sometimes making one wonder why astronauts were not more radical during the OPS conference, as in many aspects, the crew was always offering time frames in order to see their proposed changes, even though their performance was equal to the standards of the Skylab program, as high as the famous 150% crew.

From an institutional perspective, Hutchinson (2000) makes the point that in Skylab, they carried over the organizational logic of the Apollo missions, in which they would monitor and plan every 'microsecond' in order to have a maximum in output over the short timeframe of the mission. This includes having the position or role of a flight activities officer (FAO), occupied, among others, by Hughes, who also developed the ASP (Hughes, 2013) and was in charge of timelining the crew's activities. Hutchinson (2000) admitted to planning mistakes of the mission control center, explaining that the third crew was expected to pick up where the Skylab II crew left off. In his mind, the crew would not get the time by which they could attune to the zero-G environment but were also to blame for not communicating their issues early. Interestingly, in his interview with the JSC, Hutchinson makes the so-called “fighter-pilot mentality” (Hutchinson, 2000, p. 46) responsible for the latter issue. They would try to fix problems by themselves instead of complaining to the ground team, when really, the problems were, according to Hutchinson, in mission control centers’ scheduling. While Gibson (2000, p. 60) agreed that the problem was in part that they would try to work through their issues on their own, he attributed this decision to the problem that they had no way to privately communicate their problems (the very same reason I can analyze the scripts now), hindering the crew in admitting to issues to the U.S. American public through Skylab’s communication channel. This issue is referenced in the ‘lessons learned’ document, where an option for private communication is seen as mandatory for future mission work (NASA, 1974g).

Hutchinson also stated that sickness as something to disprove in the image of fighter pilots being associated with toughness, which further hindered communicating discomfort while attuning to a zero-G environment.

“But, you know, it was still kind of spooky then, guys getting sick and you know, not the fighter-pilot image.” (Hutchinson, 2000, p.46)

Hutchinson approves of the way fighter pilots take orders and operate in real-time, even highlighting how at Skylab II, they schedule time down to the minute, attributing to the system this ability to take total control of the astronauts and their activities in order to produce "enormous amounts of scientific data” (ibid. p. 45). The past of the institution and the Skylab program both act in the OPS conference as a reference point to the experiences of the Skylab IV program. By reusing Skylab II and III as a benchmark without recalibrating its conditions, flight planners reproduced expectations that systematically framed the Skylab IV crew as lagging behind, despite equivalent outcomes. The conference thus functioned as an intervention to correct standards rather than to redistribute agency, revealing how deeply clock time and procedural logics were embedded in mission operations. While some adjustments followed, the negotiation largely remained bounded by the same temporal rationalities that had produced the conflict in the first place. This sets the stage for the following chapter, which shifts focus from standards and expectations to the concrete practices through which time was actively negotiated, redistributed, and operationalized aboard Skylab and how these practices reconfigured power, agency, and the lived experience of work in orbit.

5.3.2. Practicing Time-Control aboard Skylab

This section is dedicated to how time-control is practiced by ground control, how they shaped Skylab's timescape, and in which ways astronauts intervened in these practices in order to renegotiate the relationship between astronauts and ground control during the labor conflict. In Skylab's timescape and under the program's operational logics, negotiation of time-control was practiced as an intervention. This is due to the program's structure and displacement of astronauts' agency discussed in the previous subchapter. A huge issue at Skylab was that time periods were reshuffled first and foremost by flight planners, who sought to optimize sequencing by re-/ordering timeframes. With the aforementioned ASP (Hughes, 2013a) in existence, flight planners were able to rearrange time schedules faster but also limited by the software's programming to only allow for streamlined planning and force limits on how timeframes were sequenced. Controllers reposition time in a similar sense to their planning counterparts but need to negotiate with the Skylab crew, as time management otherwise creates more friction with the crew. For planners, understanding time via the framework of clock time, units of time can be exchanged for different periods; flight planners handle problems by moving tasks around on their schedule, potentially disrupting other rhythms.

During the OPS conference, the timeframes for physical exercise (PT) were problematized. Planners had various issues with timeframes for PT, not only with the length of the training sessions but also with the fact that the crew wished to have exercise uninterrupted and with personal hygiene (PH) sequenced right after PT. CC asked the crew to picture flight planners that would need to fit PT and PH with all these different tasks and that they would have trouble with experiments while they also had to fit in all these other entities, meals, eating, and pre- & post-sleep (NASA, 1973-74c). Although Hughes (2013a) only mentioned that the ASP was never running as well as intended, one can speculate that the limits forced by the strict sequencing protocol of the software in arranging timeframes for various activities would make it, in practice, difficult to sequence entities that would take up a lot of space in the timeline. Therefore, the ground team tried to negotiate not only for smaller periods for this activity but also regularly reposition the activity on the timeline to make room for experiments. Both sides incorporated past moments and experiences into the discussion. While planners argued that the Skylab IV team was getting much more exercise than the team during Skylab III, Carr and his crew were valuing the past experiences of previous crews, stating that, when the past crews came back to earth, they were "pretty wobbly, pretty weak" (Carr, 2000, p. 12-36). So they increased the exercise period for both crews from half an hour to an hour and now, with the third crew, to an hour and a half per day (NASA, 1973a;

1973-74c). As a side note, NASA today promotes two hours of exercise minimum for astronauts (NASA, 2025). But for this mission, with the control of time at the hands of planners, this knowledge got dismissed by the imperative logic of 'science per unit time.'

Further, the detachment of time(frames) with little consideration of other temporalities was disrupting bodily rhythms. Carr summarized in an interview both aspects:

> Carr: "they were juggling exercise around, and we ended up in several cases where we were having exercise right after a meal, and that's no time to be exercising, particularly up there, when you can't belch, because with food floating, you're liable to get it back with your belch." (Carr, 2000, p. 12-47).

Planners struggled especially with PT, as the exercises would not only affect the time periods, but the space station would also rotate unfavorably, costing them, in terms of planning, more time for the adjustments of cameras, the ATM, and other sensory equipment for data collection during EREPs. Even more, the broken CMG, at this point in the mission, made maneuvering of the space station more difficult and relied on fine adjustments by the crew (NASA 1973-74c, p. MC 1555/2). The movement of arbitrary amounts of time with little sensitivity to other rhythms had planners impose sequencing that led to *de-harmonization* between two temporalities, clock time and bodily processes, increased by the specifics of the near-zero-gravity atmosphere of LEO.

By articulating discomfort induced by the arbitrary repositioning of the timeframe of PT, Carr argued for the existence of a 'right timing' for PT. Further, SPT Gibson claimed that he monitored his own training, specifically differences between training with weights and the bike, in order to see if there was any significant change to the station. Especially testing the difference in movement between one-hour and 1.5-hour training periods in order to debunk the claim of a relation between the PT timeframes and a significant rotation of the space station. He included the ground team's authority in his argument, stating that 'they' claimed to not see any differences. Following the program, though, he also claims that he would shorten his PT timeframe if any significance were on the line. (NASA 1973-74c, p. MC1567/1). Gibson implicitly also integrated quantitative data to validate his claim by tracking time and comparing data sets.

In their proposals for changes in the management of Skylab IV, the CDR and his crew repeatedly highlighted the importance of their circadian and bodily rhythms while also agreeing to some of CC's proposals. They stressed that while they agreed to split physical exercise sessions into two smaller sessions of 3/4-hour timeframes, they would only do so if the first of each PT session is scheduled in combination with a 15-minute session for personal hygiene, the reason being that they would use the bicycle ergometer during that time, due to which they would sweat the most. Further, they highlighted that, if possible, they would rather have a full PT session of 1.5 hours (NASA, 1973-74c, p. MC1591/1)**.** Both of which CC agreed to. Here I want to show how the bicycle ergometer took special significance in these OPS' conferences and the respected follow-up. Shortening the time frame for PT also meant shortening anything but the bicycle, as it was vital for medical measurements that were needed to produce medical data on Skylab's goal to understand how humans can live in outer space for prolonged periods of time.

Figure 3, 010235: *Vectorcardiogram Experiment MO 93,* published by NASA.

There was also an interesting intermezzo on the 31.12.1973, in which the training on the bicycle was seen as disrupting voice dumps, also debunked by the crew and team, within the 'change-of-shift' press conference on the same day (NASA, 1973-74b, 1973-74c). With all these systems aboard the space station interconnected, risk from 'known unknowns' (Nielsen and Sørenson, 2017) in terms of complex interactions can be assumed to cause concern in planners and controllers alike. These effects are, again, an obstacle in the program, best avoided by planners in order to produce scientific data. Nonetheless, due to the crew's effort, the desired scheduling system for PT became common practice from this point on. As seen in the flight plan as flown, PT and PH were no longer denoted as separated entities, but rather always written as one section of “PT & PH” (NASA, 1973-74f).

A similar issue was raised by the crew during its session on the 30th with the positioning of certain tasks in the pre-sleep period.

> CC: “[...] If there were times that we could stick a specific one in there, [...] and pay you back at another time of day, there were definitely are some advantages to the science gain for that.”
>
> CDR: “ [...] I think the reason why we started hollering is there was just getting to be too much of that, almost every night, we were running almost until bedtime.“ (NASA, 1973-74c, p. MC 1556/1)

Carr (2000) also expressed during the JSC interview that going this late every night would give them problems, as their heads were still running too fast, causing them to stay awake and sleep less. In both cases, the repositioning of activities in the timeline would produce conflicts for the crew with their own internal processes, due to the flight planners handling time as abstract and quantifiable, rather than a lived experience in which changes to sequencing would affect other processes in temporalities not captured by numerical abstractions.

5.3.2.1. Imposing Work through Interruptions

'Science per unit time' also transforms what activities are included or excluded under the category of ‘science.’ While the Skylab IV mission’s third goal focused on living and working in space for a prolonged period of time, these timeframes seem not to include tasks like physical exercise, eating, cleaning, and various preparations for experiments and housekeeping. Although, technically speaking, they are experiments to test equipment and produce medical data to find out about the well-being of the crew. The time-science relationship here is transformative for the evaluation of the crew but also separates daily routines and leisure time from work. The way Skylab was organized and put into practice, the only valued scientific output is obtaining ‘data’ (NASA, 1973a), that is, data that is produced by experimenting and observations and translating them into pictures, numerical values, descriptions, etc. that can be put to use in quantitative scientific inquiry, especially when it comes to the well-being of astronauts in outer space. 'Science per unit time' and its hierarchical positioning of clock time, therefore, are reinforced by a scientific method that is mainly interested in the extraction of data and follows in its principles the Newtonian mathematical empiricism understanding to measure the natural world. Skylab, as a space station, and its actors were arranged in such a way that 'data' could be produced and extracted (as described in the previous chapter). This also affects Skylab's timescape, not only by the valorization of speed but also because these categorizations produce heterochronies.

One example of this is the conflict revolving around the timing of the voice recorder dumps during the OPS conference. The technology installed on Skylab used the communication system aboard not only to communicate between air and ground, but it was also used to record various audio notes from the crew for experiments, observations, or dictating a bunch of numbers for various reasons (for example, to evaluate the station's functions). During the time voice recordings were produced, if anyone else uses the communication channel A, they appear on the recording. But worse, if a data/voice recorder "dump" – the transfer of the data collected in the computing and recording devices of the space station to the ground – was put into action by the ground team, the recording session of a crew member is interrupted and the recording was lost (NASA 1973-74c; 1973-74d). Further, there was no immediate clue to when a dump was happening for the astronauts, except through communication with CC. In addition, the crew might not listen to the channels during a recording session, as they were preoccupied with the ever-demanding schedule of tasks of Skylab IV. This was a repeatedly addressed problem by the crew, as they were the ones that had to re-record information that might also not be as fresh in their memories as it was before they noticed that they lost the data. Even though ground could see the astronauts' record, due to the short timeframes in which ground had uninterrupted connection to the station and therefore feared losing data in a case in which the transmission was interrupted, ground insisted on its priority, whether they put a dump into action or not, to "keep up with our dump schedule" (NASA 1973-74c, p. MC 1559/1-/2). In the proposition to smooth these frictions in the session of the 30th of December, responsibility was put onto the crew. They needed to have a member to be sitting at the communications console, stop their colleague from recording, and have to answer ground "in the first - very early in the pass" (NASA 1973-74c, p. MC 1559/1-/2). As SPT put it, who communicated with CC in this part of the OPS conference, the astronauts were the ones that lost time by following this solution. Time, which was part of the aforementioned prep and post-time of experiments and observations. This also affected their scientific work, as Pogue (2000, p. 12-28) stated; answering the ground team while working with the instruments of the JOP missed the timing and had them repeat a five-to six-minute cycle.

On 31.12.1973, following protocol, voice dumps were only put into action if the crew gave permission, leading to an improvement in flow for the previously, often interrupted recording session of the astronauts. In one case CC Bob Crippen announced to SPT Gibson that later this day, he would only get a two-minute timeframe between a planned maneuver and a dump, suggesting that if it's only by a small margin of error in terms of the altitude of the space station, he should leave it and allow the ground team to take control to start voice dump procedures. This is another instance that showed how the space station's design was often not allowing for processes to happen simultaneously, requiring complex timing and effort from both teams. In a second message from CC Karl Henize, SPT warned CC that CDR was now recording and clarified to CC that if he dumped data right now, the recording called “TV 78” would be destroyed. Shortly after, the recording session was interrupted by another actor, a dysfunctioning fire alarm sensor. The crew reacted more in shock than in frustration, as they did, for example, when one of the other crew members or CC was interrupting them by talking on the same channel (NASA, 1973-74e).

5.3.2.2. Negotiating Time aboard Skylab

As we can derive from previous findings by now, all the conditions – “valorisation of time, corporatisation and acceleration of work, and a conflict in perceptions and experiences” (Burneva et al., 2021, p. 157) – were met for “time trading”, a temporal practice used by individuals by which periods of time of low personal investment are traded for periods of major degrees of personal investment between individuals (ibid.). I attribute corporatization to NASA, as they employ Taylorist management methods and other ordering practices first and foremost to increase efficiency as well as market-oriented thinking (e.g., scientists as customers). Thus, the crew themselves traded time with flight controllers in an interesting way. They not only traded periods of time (timeframes) but also traded across different categories of time in order to harmonize their rhythms. Offering timeframes in exchange for fewer interruptions by ground control. For the pre- and post-sleep periods, the crew suggested trading in half an hour of each in exchange for not being interrupted during these timeframes so they could be left alone to their morning and nighttime routines (NASA, 1973-74c, p. MC 1596/1-/2). They also put in a soft cap, so to speak, not to be bothered after 9 but “pulling the plug” (ibid.) at 10:00 GMT. To trade in periods of time in exchange for a period that is uninterrupted seems to be an attempt at harmonizing different rhythms within the logic of the flight plan. As stated previously, interruptions were a major issue for the crew; as stated by Carr, they would struggle to sleep (Carr, 2000), not allowing them to calm themselves during nighttime. A “right time” for stopping work as suggested also does not map neatly onto planners' schedules. The Skylab program documented as a result of this conflict that "A presleep period of 1 hour of mentally non-demanding activity should be planned in the crew's time line" (NASA, 1974g, p. 86), the reason being that it was difficult to "relax abruptly" (ibid.) in their 'lessons learned' document.

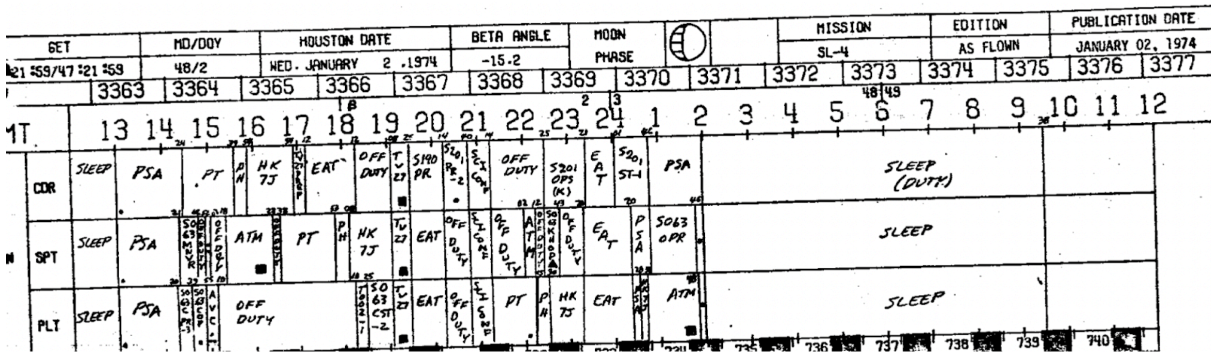
The crew would also, prior to the OPS conference, offer their days off in order to catch up with the planner's schedule.

> Carr: "Well, we gave back our day off the first three or so times [...]. We said, 'Go ahead and schedule us, and we'll try to do some makeup.' Well, we got to the point where the morale was low." (Carr, 2000, p.12-48).

The experience of being behind schedule was for Carr and his crew a discomfort to such a degree that they would trade in their "day off" in order to fulfill the (as we know, way too high) expectations on them. The imperatives of the mission regularly created experiences of discomfort for the crew that would mount into a feeling of "racing the clock" (Carr, 2000, p. 12-50).

> Carr: "We found that we had allowed ourselves to be scheduled on the daily schedule, and the schedule was so dense that if you missed something or if you made a mistake and had to go back and do it again, or if you were slow doing something, you'd end up racing the clock and making mistakes, screwing up an experiment or not doing a procedure correctly" (Carr, 2000, 12-46).

The 'days off' were repeatedly moved, and when the crew engaged in scientific activities during their free time, mission control would impose tasks on them, such as pointing the ATM at a specific event instead of the astronauts' desired location. After the OPS conference, a new day off was scheduled for the crew, officially due to a scheduled EREP cancellation (NASA, 1973-74c). Carr was told in the same message that they would have to hold a TV conference on that exact day. The practice of RT flight planning allowed impositions that were due to 'time-critical events' valued in terms of their timing overlapping with the mission's timeframe; rare opportunities to gather 'special' scientific data would lead to further interruptions on the crew's day off.



Excerpt 4, Mission Day 48/2. Flight-Plan-As-Flown (1973f).

As one could derive from this screenshot of the crew's ‘day off’ on 02.01.1974, the crew still partook in experiments during their free time; they still had a lot to do on Skylab in terms of housekeeping. And as Carr stated, these days were rare opportunities for doing personal hygiene, like taking a shower, that would – due to the experimental nature of the equipment and the challenges of zero-G – sometimes take even two people to operate and therefore, take too long during a tightly scheduled day.

> Carr: “We kind of set up a ten-day week, and the tenth day of each week was to be a day off. [...] That was to be our shower day, too.” (Carr, 2000, p. 12-47).

5.3.3. Multiplicity of Programs

Because 'science per unit time' operates as the system logic of planners and positions clock time as their primary way of managing other present temporalities such as bodily rhythms, institutional and social processes, expectations, experiences, etc. that do not neatly map onto standardized and discrete units of time or uniform cycles, as they resist being governed or measured by the tick of the clock and cause friction within the program. The findings from the session of the period of the 30th of December, 1973, to the 2nd of January, 1974, suggest an attempt to *synchronize* and *harmonize* processes and rhythms existing outside of clock-time’s beat with the ones that can be quantified.

The fourth mission’s length during the Skylab program was intended to be the longest mission for humans in outer space yet, which corresponded with the mission and program goal to produce data on how humans can live in outer space for an extended period of time. The session of 30.12.1973 represents roughly the midpoint of the mission’s period of 84 days. As such, not only were the crew already struggling with the pressure of ‘racing the clock’ for more than forty days, they would also have to expect the same duration. Carr stated in multiple sessions that the morale was declining aboard Skylab, and in the transcripts, there were even some situations to be found where insults were voiced over the communication channels (NASA, 1973-74c). Carr, in his position as commander, also had different expectations for the mission. Not only did he wish not to be measured to the third crew's standards, he did so because of the length of the mission and past experiences that previous crews’ “rate of activity for them was extremely high” (Carr, 2000, p. 12-37). He said to have made clear that for an eighty-four-day period, the work mode had to be adjusted for “endurance instead of max performance” (NASA, 1973-74c, p. MC1554/2). The need for an intervention and a reason for the OPS conference, though, cannot be understood as an ‘antiprogram’ (Feenberg, 2017) formed by the crew because the goals of Carr and the crew still aligned with the overarching goal of the program. Nonetheless, multiplicity in the interpretations of the program's goals led to conflicting ideas of how to manage Skylab. Astronauts do have agency in these systems, as Hutchinson, one of the program’s flight directors, stated during a shift debrief:

> Hutchinson: “We tried awfully hard to emphasize that and - and I think they’ve gotten the message, no matter how hard we Flight Plan down here, in the end the - the real planner is the guy that’s doing the work” (NASA, 1973-74b, p. PC_82D).

But to give this statement more context, Hutchinson’s interest here was for the crew to find windows where they could cut down timeframes and maximize efficiency on their own. Delegating agency only insofar as to keep them motivated to find timeframes to make room for new tasks (ibid.). This can be understood as an interessement strategy by Hutchinson that placed agency, but also responsibility, on the crew in order to avoid a larger fracture in or changes to the program. Further, this practice of timecuts, or breaking up tasks into smaller segments, was also already frequently used by the crew. Before the OPS conference, the most notably discussed timecuts were the crew neglecting the communication console, producing an image of a ‘mutiny’ taking place (Carr, 2000; Burns and Gibson, 2020), and strategies that would neglect personal hygiene, such as shaving, in order to create more timeframes for preparation work during the post-sleep sequence. Better conceived by the ground team was a moment, shortly after the first day of the OPS conference, when Gibson got ahead of the ground team’s schedule on 31.12.1973. In this moment, he recorded a video of the ATM, which caused confusion in the ground team and later the change-of-shift conference (NASA, 1973-74c, p. MC 1579/1-/2; NASA, 1973-74b).

Both teams assumed a mistake on Gibson's part. But as Gibson explained his reasoning, they congratulated him on being ahead of them. Breaking up tasks can also be understood as a temporal practice, by which individuals sequence parts of their activities in order to create longer timeframes for other activities. In both cases, when the crew used its agency to practice timecuts, it caused friction or confusion and needed to be justified to controllers.

In that sense, Carr, as the representative of the crew at Skylab station, used his limited leverage in order to follow a different understanding on how to achieve more 'science per unit time' by emphasizing the principle of quality rather than of quantity. In the OPS conference of 30.12.1973, Carr stated that for an efficient pace, they would need them to keep them “healthy and alert” (NASA, 1973-74c, p. MC1557/1). The statement was not only a reference to the nausea experienced or other reported physiological phenomena by the crew,[9] such as head congestion (Carr, 2000), but possibly also to the limitations put on the physical exercise (Brooker, 2019-20). Carr’s emphasis on the astronaut's health maps onto the solution proposals. For him, the best way was regular exercise and the previously discussed uninterrupted timeframes. The benefits in his perspective allowed them to be better scientists. Carr (2000) states that Gibson and Pogue were able to make up their own experiments once they had more time, producing new scientific data in situ, while fully immersed in the im/possibilities of Skylab. In that sense, aboard Skylab, negotiations about time were also about struggles to act as scientists, pilots, and humans with enough expertise to handle complex situations, rather than scientific executors.

One attempt to solve the issues that Carr saw as part of the solution to the time pressure the crew experiences was the proposed changes by the crew to the ‘shopping list’ in that they would not only have housekeeping chores but also scientific work on the list for them to sequence them on their own (NASA, 1973-74c, p. MC1597/1). This is a proposal most fitting with Hutchinson's previous statement of the astronauts as the ‘real planners.’ The crew's delegation of tasks to a different (non-human) actor can be understood as a coping mechanism to avoid procedures and negotiating efforts that would have them talking to the ground to make changes to the flight plan. As discussed before, with the CMG malfunction, PIs and planners would prioritize scientific data production close to the protocol and intended use of machinery and instruments due to the limited timeframes they could spend ‘locked in’ on a certain location (Gibson, 2000, p. 39-42). When talking about the advantages of a

[9] One should also mention that some medical experiments were taking a toll on the human body, as, for example, the lower-body negative pressure device could make an individual pass out (Pogue, 2000). The effects on the bodily rhythms from medical experiments and the near zero-G environment could also affect astronauts outside of the designated timeframes in which medical experiments were scheduled.

handheld camera, the following statement best showcases what more agency in the relationship between the technology and the program's hierarchy would have meant in his perspective:

> Gibson: "[...] you can spot ocean currents, cold-water upwelling, and some of the more obvious things, hurricanes, and fault zones, and so forth—often you can get a lot of specialized data that you wouldn't otherwise if you were just pointing straight down and shooting by the clock" (Gibson, 2000, p. 39).

Note that this sentence not only positions the production of high-quality data against the rationale of 'science per unit time' but also places more agency in the relationship to operate the technological machinery at hand. The statement is also in direct line with the training stages, acquiring the ability to spot and observe phenomena (Gibson, 2000, p. 41). In the interviews of the astronauts (Burns and Gibson, 2020), it is mentioned many times that the astronauts enjoyed looking out the window, but this is not a mere early finding of the controversial 'overview effect' (e.g. Yaden et al., 2016). Gibson stated their fascination was related to their expertise to spot more and more phenomena on earth that were tied to their lectures in all different fields of scientific inquiry (Gibson, 2000, p. 42). In the 'lessons learned,' it is recognized that when given the opportunity to act as scientists, "enthusiasm and morale were increased" (NASA, 1974g, p. 91). They also recognized that a scientific shopping list would make it possible to obtain "unique and opportune data" (ibid.), with the Naval Research Laboratory being on the record to say they got their best (qualitative and quantitative) data from SPT's ability to practice his expertise. How many of these lessons the astronauts' agency found their ways through is up for debate, as some of these 'lessons' are also in contradiction with each other. For example, one lesson was to have "filler" low-priority experiments that can be scheduled on an if-time-is-available basis by planners, the reason being that "scheduling of these activities contributed to increased efficiency in the use of crew time by providing worthwhile activities in an otherwise idle time period" (NASA, 1974g, p. 94-95). Both lessons make perfect sense in an environment that follows the principle of 'science per unit time,' but for the time-control issues, this solution attributes agency in the allocation of time with planners. There is nothing in the lessons about these "filler" experiments to be scheduled by astronauts via the shopping list, demonstrating another case of Hutchinson's understanding during the press conference, delegating time-control only to astronauts for purposes of efficiency, where "idle" time is considered an obstacle rather than an opportunity.

Taken together, the material presented in this chapter highlights how the Skylab IV mission's timescape was continuously made and remade through negotiations between crew, ground control, and the wider program. Central to this process was the operational logic of 'science per unit time,' which shaped both the evaluation of performance and the framing of conflicts. At the same time, the crew's embodied rhythms, experiences of duration, and coping strategies reveal other temporalities that did not always align neatly with this logic. The tension between these different ways of ordering time surfaced most visibly in the OPS conference, but it also ran through many smaller adjustments and compromises in everyday practices aboard Skylab. Therefore, the timescape aboard Skylab was not a single temporal order but existed as a multiplicity that required ongoing work to manage, justify, and sometimes contest. The empirical material shows how astronauts and planners alike sought to balance efficiency, endurance, and scientific output, often with conflicting understandings of what counted as legitimate use of time. These frictions provide a window into the co-production of scientific goals, organizational practices, and temporal structures in the Skylab program.

6. Discussion

In the following discussion, I will situate these findings within broader debates on time, labor, and sociotechnical organization in order to explore what they suggest about the role of the timescape in shaping both conflict and cooperation in complex projects like the Skylab program. I will discuss findings in the context of how the Apollo program's temporal logic was transferred and reconfigured in Skylab's timescape, how time shaped scientific work and findings at Skylab, and compare my findings with present-day research on the social life of astronauts. At the end of this chapter I will reflect on my chosen methodology and theoretical framework for this case study.

6.1. The AAP Re-/acted: Applying Economics from the Apollo Program to Skylab

Skylab's timescape, as the findings suggest, has been constituted by the organizational structure and memory, technologies, practices, and human actors that have history within NASA in the Apollo program. Apollo's rationale (Hutchinson, 2000) and the style of management co-constructing the Skylab program were an economic mode of thinking, namely, the Taylorist methodology, that saw the program in terms of quantitative output and equated time with money through the valorization of speed. Scientists, with their studies, were categorized as 'customers' (Hutchinson, 2000), and Skylab, with its mega-infrastructure in training and engineering grounds, warehouses, communication network, space station, and shuttle, was regularly understood in terms of numerical values and money. Even the solutions and accomplishments of closing the labor conflict were celebrated with the sentence by a CC: "[...] they think we've made a million dollars tonight" (NASA, 1973-74c, p. MC/1557/2). That Skylab IV's timescape was this tense, though, cannot only be accounted for by Taylorist management practices.

The findings suggest that a reason for the labor issue was that an economic rationale from the Apollo program, which was designed for short-term missions of a couple days, would be reapplied to the 84-day mission of the Skylab IV program. As it was the case with the technologies in terms of instruments, such as the ATM, and the management tools, such as the MOPS and ASP (Hughes, 2013). The data highly suggests here that the Apollo Applications Program, with its desired goal to reapply labor, actors, and technologies, co-constructed Skylab's timescape with too little consideration for the temporal experience and complexity that would be produced with a prolonged mission timeline. So, the AAP did not only re-apply technology and manpower but also the organizational logic of the Apollo

Program. Impacting Skylabs's timescape and the lived experiences of the astronauts in multiple ways. Pressure on the astronauts was a result of this construction of Skylab's timescape. Not only by organizing Skylab to maximize 'speed,' but also by a work culture that would give agency to astronauts only when it comes to maximizing efficiency in situ, as became clear in flight director Hutchinson's discussion during the press conference (Hutchinson, 2000; NASA, 1973-74b). More added pressure came from the timescape in terms of the relationship between PIs and the SPT, as they were made responsible when experiments or observations had to be rescheduled.

Further, the Skylab IV mission can definitely be understood as an organizational field site, bringing diverse groups together (Vertesi, 2020). Specifically, the Skylab program set the groundwork for future collaboration between the fighter pilot and academic communities to make decisions (Hutchinson, 2000; Gibson, 2000), with 'science per unit time' as a rationale being a consequence of this unique constellation in bringing the military and scientific complex together, and combining economic rationales with scientific goals. But drawing a line between these two social groups is too derivative. Although there was a multiplicity of programs and epistemic values at play, the line was not between fighter pilots and scientists but between astronauts (representing both communities), management, and scientists. As astronauts valued their agency in relation to the quality of scientific data, management and PIs instituted a scientific inquiry that was quantity-driven. Economic rationales were derived from NASA's organizational history and PIs' complex relation to NASA and the astronauts as investors (Hutchinson, 2000; Gibson, 2000). While scientists in the roles of astronauts (Gibson) or PIs subscribed to these techniques in order to participate in the assemblage of Skylab through sociotechnical means, being managed through the timeline-oriented protocols of the program, finding consent and agreement in decision-making processes through, for example, the JOP and the hierarchical organization of the Skylab program by NASA.

PIs would subordinate themselves in that sense, meaning they would have to give up the roles and practices that accompany the observations and experimenting, relying on the astronauts for data. Being displaced in their own practice and a lack of trust in the astronauts, they enrolled technological solutions that would make the astronauts 'act like automatons' (Gibson, 2000; Pogue, 2000), as their agency in executing the experiments was rendered as a disruption, neglecting astronauts' scientific expertise, in situ insights, and adjustments but also alienating them from their work. This led to a specific iteration of what I described as 'sociotechnical rhythms,' in which technologies not only make time (Felt, 2025; Mirmalek, 2020) but also have to be attuned to other actors in order for their desired goal or function to be properly executed in a predicted timeframe. In that sense, affordances become a matter not only of preparation and training to learn a skill in relation to a technology but also of practice with precision to the timing and tempo of the technology in question. This attunement constitutes not only synchronization efforts with the rhythms of the machine but, in the case of Skylab's EREP package, also harmonization with the sociotechnical communication network (Gibson, 2000; Pogue, 2000). I highlight here that the structure is sociotechnical, because it was composed of both the network coverage of NASA and the crew's ability to be at the communication console or the right communication channel as well as CC's ability to be able to not interrupt an astronaut, both with a call to action (Pogue, 2000) and a transmission of data during recording sessions (NASA, 1973-74e). Showing that not only is timing a socially produced and technically mediated phenomenon, but also making the complexity of producing timing in scientific endeavors in outer space is a component of why we call outer space endeavors 'logistical nightmares' (Rossiter, 2016).

An instrument that stresses the complexity of sociotechnical rhythms is the bicycle ergometer. Not only was the ergometer bringing together multiple ways in which it was used as a tool for physical exercise and a tool for medical observation, it was also complicating Skylab's timescape by producing uncertainties (a suspected rotation of Skylab debunked by Gibson). But as part of the station's rhythm for producing quantitative data over a prolonged time period, it would also allow the crew to argue for specific sequencing due to their need for personal hygiene and digestive rhythm.

Another insight from this sociotechnical relationship between astronauts and instruments is adding to our understanding of timescapes through the concept of 'sociotechnical torque' (Vertesi, 2020). In the Skylab IV case, sociotechnical torque is experienced – as suggested by the findings – by the astronauts from a labor perspective, in that tremendous strain is experienced by ever-new impositions of time, such as the detailed instructions in the morning and interruptions with new tasks in the work process and of leisure time, compromising their mental and physical health as described by the astronauts in an environment that would put additional pressure on the astronauts' bodies through the challenges of a near zero-G environment. The 'trauma' of this incident, where the astronauts felt pushed to discuss work issues, is reverberated in interviews (Carr, 2000; Gibson, 2000; Pogue, 2000). Technical components that added to this torque were the failure of the CMG but also standards and expectations differing between crew and ground team, all pushing the network to the verge of intervention. Actors had to be redefined (like the extension of the shopping list), and practices were renegotiated through an institutionalized dialogue

(Heckscher, 1994), representing imperatives, epistemic values, and rationales present in the mission.

How technologies enact care and control through mechanisms of careful surveillance (Richardson et al., 2017) or fail to do so, further pushing the astronauts to means of intervention, is seen in how flight controllers manage time before the OPS and their proposed solutions. Their use of calculative techniques in life management when managing timeframes for physical exercise, in which they compare effects of uninterrupted time periods of PT to the difficulties of producing more science per unit time. But also in how they treat timeframes as abstracted units of time, made possible by the MOPS software to make changes in a reasonable timeframe, and how ground control effectively argues through the anticipated rotation of the space station in a case of uninterrupted training while neglecting physical and mental needs for uninterrupted periods of physical exercise and hygiene for the benefit of producing more timeframes in which experiments and observations would fit. In terms of data, when balancing concerns of care and control, management were making decisions through their numerical understanding of these tasks, benefiting the quantitative production of data and experiments/observation periods.

The western imaginary of urgency as understood by Iparraguirre for western academia intersects with the temporal ordering principle of 'science per unit time' in NASA's research at Skylab. Iparraguirre shows that:

> "academic temporalities manifest the rhythmics of scientific production embedded in the metrics of academic behavior. *How many,* in rhythmics terms, is translated as "how *fast* can we express our capacity to produce science, models, methods, policies or whatever" (Iparraguirre, 2021, p. 64).

At Skylab IV, work practices are embedded in the temporality of 'development,' in which the present is merely a 'becoming' of a predefined 'destiny' (Iparraguirre, 2021). As such, Skylab's timescape is designed to progress towards a predefined end as fast as possible, with the data of a lot of experiments or observations predefined by their designers, the scientists and PIs that work with NASA. As we understand from the findings, to produce a timing for data collection was of immense sociotechnical effort. Partially conflicting rhythms was through schedules, timelines, and deadlines made to be synchronized in order to allow for the specificity that the data required to be produced. The findings from the EREP 18 (NASA, 1973-74c; NASA, 1973-74d) showcase these dynamics best. Here, the astronauts struggle to take pictures of predefined locations, while struggling in situ with the instruments. Rhythms have been adapted by rescheduling deadlines, among many. Sleep cycles of both ground and crew have been adapted to the revolutions of Skylab around the earth.

Astronauts had to handle immediacy, stress, and anxiety, as seen in how they describe the work culture, especially in relation to PIs (Gibson, 2000; Pogue, 2000; Carr, 2000). The more predefined the produced data was, the more complex was the production of timing in the effort to synchronize rhythms through the vast tools at NASA's disposal. Findings here suggest that a lack of trust and, therefore, the reduced autonomy of astronauts as scientists, rather than scientific executors, co-produced urgency, as the Skylab IV team were co-scribing the design of instruments and management practices, as all was pointed towards the acquisition of predetermined data. In Skylab IV, we can see how this imaginary of urgency creates cultural rhythms and how Skylab intertwines academic rhythms with economic temporal orderings that show how in the time-work-science relationship that an imaginary of urgency and alienated work are co-produced through the temporality of development and its repercussions for organized collective scientific work show themselves in the temporal experiences of scientific workers as their rhythms are disrupted, made fit, and adapted like regulating screws, with tremendous effects on the well-being of astronauts and a streamlined production of quantitative data on the verge of failure through the de-synchronization between astronauts, instruments, infrastructures, managers, and scientists.

As Iparraguirre (2021) suggests, urgency is imposed by means of standardizations such as global reckoning hours and timetables by which it pushes activities toward deadlines and fulfillment of schedules. We can see this in action in the assemblage of different governing documents like the flight plan, the experiences of the astronauts with the daily instructions, and the management strategies of ground control pushing towards the fulfillment of deadlines. What Iparraguirre attests to in academic spaces is prevalent in Skylab's timescapes. The categories of immediacy, stress, anxiety, and deadlines are referred to by the astronauts' experiences of the mission, pushing for a resolution in their discussions with NASA's ground team but also in the promissory language and framing of Skylab as colonizing outer space (Hutchinson, 2000; Carr, 2000; Gibson, 2000).

Astronauts also deploy strategies of resistance, resembling those in academic spaces; they trade time (Burneva, 2021) in order to deal with impositions, not only in terms of timeframes, but they are also willing to accept a trade-off in minutes in order to savor uninterrupted time periods. Complicating notions that understand time only in terms of quantities, as uninterrupted periods of time are valued by astronauts in the context of Skylab IV more than the total amount of a quantitative amount of time when it comes to activities that they value for their rhythmic quality and sequencing, such as physical activity periods and food and digestion. In that sense, they trade across different categories of time. At the same time, we see how time is made to be managed by flight controllers and astronauts alike through the mediation of technology, being able through management software, timetables, and a linear quantitative understanding of time to reshuffle time, schedules, plans, and timelines (Vostal, 2015; 2021). Taking 'shortcuts' is also featured in the documents, as Gibson (2000) splits up tasks, outpacing the ground team and confusing the team of controllers and planners in their rigid understanding of the timetable.

We see that the timescape of Skylab IV, whether it's in its construction or contestation, temporal logic, or moments of dissidence, features the corporatization of outer space research. Economic principles are applied to management, organization, and research. Moments of dissidence are conflicts of time-control; what impositions of time are placed upon astronauts' rhythms and how they practice interventions and deal with time-related issues. Although NewSpace (Valentine, 2012) describes an ever-increasing involvement of the private sector in the space scientific-industrial complex, the Skylab program shows that the history of NASA's research endeavors in outer space was already thought through an economics-oriented lens, influencing research and astronautics alike.

6.2. The Science-Time Relationship of Skylab

The preceding chapters have shown that the labor conflict aboard Skylab IV cannot be understood merely as a disagreement about workload or morale but must be situated within a broader constellation in which scientific work, organizational structures, and temporal practices were co-produced. Therefore, this chapter summarizes the science-time relationship from an understanding of how institutional organization shapes scientific inquiry (Vertesi, 2020) as well as how science aboard Skylab did not simply take place within time; rather, time itself became an object of organization and management through which scientific work was structured, evaluated, and made accountable (Mirmalek, 2020). The science-time relationship of the mission, therefore, was constituted through the technoscientific and organizational arrangements inherited from earlier NASA programs. At the center of this configuration stands the temporal logic repeatedly invoked in the OPS conferences: 'science per unit time' (5.3.1). This logic translated scientific success into measurable output within standardized timeframes, thereby positioning clock time as the dominant temporal ordering principle of the program. Scientific productivity was framed in quantitative terms: how many experiments were completed, how much data was produced, and how efficiently crew time was used. As a consequence, time itself became a scarce and calculable resource, continuously reorganized in attempts to maximize scientific data return.

With ‘clock time’ organized to be the hierarchically dominant temporality in understanding time, rhythms, and temporal experiences that did not neatly map to its abstractive and calculative qualities, qualities inherent to other lived experiences from other temporalities were neglected or dismissed in planning and management practices as well as in the temporal organization of Skylab. This logic shaped not only scheduling practices but also the definition of what counted as scientific work. Activities essential to living and working in space – exercise, maintenance, preparation, hygiene, and recovery – were frequently treated as peripheral to “actual” science, even though many of these activities simultaneously generated valuable physiological and operational data. Scientific work thus became narrowed to moments of direct data extraction, while the embodied, preparatory, and interpretive dimensions of scientific practice were temporally marginalized, like in the cases of how preparation timeframes were renegotiated, data extraction processes were valued more than uninterrupted work processes, and the exclusion of even potential risks during the data extraction process. The organization of Skylab therefore produced a separation between living and working, despite the mission’s explicit goal of studying prolonged habitation in space. Because time was understood as a numerical resource and equated with money through the economic operational logic of the program and the investments of PIs into the program, quantitative amounts of data and experiments themselves became a measurement of success during the mission, more than the scientific value of such data. Technoscientific infrastructures reinforced this temporal ordering. Communication passes, instrument constraints, recording systems, and data transfer procedures required precise synchronization between crew, ground teams, and technological systems. Interruptions caused by recorder dumps, communication calls, or procedural adjustments repeatedly disrupted ongoing work, forcing astronauts to restart or repeat tasks. These interruptions did not simply reduce efficiency; they shaped how scientific work could be conducted, privileging adherence to technical and scheduling protocols over situational judgment or experiential expertise. In this sense, technological systems actively participated in structuring scientific practice.

Scientific activity aboard Skylab can further be understood as dependent upon sociotechnical rhythms, in which human and non-human activity had to be synchronized in order for experiments or observations to succeed. Producing data required the alignment of these heterogeneous temporalities, and maintaining this alignment demanded constant coordination. When synchronization failed, astronauts frequently absorbed the resulting friction through additional work, repetition of procedures, or adaptation to changing conditions, further intensifying experiences of time pressure. At the same time, the findings show that the astronauts did not oppose scientific goals themselves but rather contested the temporal framework through which science was organized. Carr and his crew repeatedly argued that endurance, quality of work, and uninterrupted periods of activity were prerequisites for sustained scientific productivity. Regular exercise, adequate preparation time, and agency in sequencing tasks were framed as conditions enabling better science. Negotiations revolved not only around timeframes but also around a timescape that would favor efficiency in ways that the astronauts experienced, such as the effort to not keep the length for preparations when it came to potential waiting periods needed in order to synchronize the already packed schedules of two astronauts. When astronauts were granted more agency – through actors such as expanded task lists or situational decision-making – they frequently produced unexpected or higher-quality observations, demonstrating that scientific productivity could increase that would be valued as more rewarding work when temporal organization was adapted to situational expertise rather than strictly imposed schedules. Best showcased in their observations with the handheld camera or their scientific work during 'leisure' time.

What emerges from the Skylab IV case is therefore not a simple opposition between management and crew, but a multiplicity of interpretations of how science should be temporally organized that are technically and institutionally mediated. Planners and managers largely operated within a clock-time regime prioritizing measurable output, while astronauts experienced science as embedded in bodily rhythms, operational contingencies, and situated practice. The conflict thus concerned control over temporal organization rather than rejection of scientific objectives. Scheduling tools, communication technologies, planning procedures, and management practices were not neutral frameworks within which science occurred but actively shaped which experiments could be conducted, how instruments were used, and when astronauts could exercise scientific expertise for adjustments during experiments and observations. The mission therefore shows two central tensions. One between attempts to maximize scientific output through tighter temporal control versus the endurance and agency required to sustain scientific work and rich data sets over prolonged periods. Knowledge production depended not solely on technological capability but on managing the interplay between human bodies, expertise, technologies, institutional expectations, and the conditions of outer space.

6.3. Comparing Past and Present Astronautics

Going back to Skylab IV raises the question of how things changed in the organization of spaceflight and the scientific activities in outer space. It is striking that, when comparing Bunch (2025) ethnographical explorations of the ESA and ISS, but also comparing Mirmalek (2020) understanding of the MER missions, not much has changed in the operational logics of managing and organizing outer space programs. ‘Chasing the red line’ (Bunch 2025) aboard the ISS is reminiscent of ‘running against the clock’ aboard Skylab. Taylorist scientific management, deskilling of labor, and following procedures dictated by ground teams and pre-organized timelines became the dominant way of how labor is performed by astronauts in outer space (see also, Brooker, 2023). Mirmalek (2020) attributes phenomena like this to the ‘organizational memory’ of NASA, a point that is strengthened by looking into the Skylab program. This view is supported by looking both into the past and the future of the program, with Skylab being the predecessor of the Apollo program, performing under the logic to produce as many results as possible in the shortest amount of time (Hutchinson, 2000), as well as the future predecessors of Skylab, like the ISS (Bunch, 2025). Comparing Skylab with ethnographical research on the ISS creates a direct line between the first space research station and contemporary management of space stations.

Skylab IV takes a special position in this history as a space station where social relations are informed by previous American spaceflight operations but is also an experimental laboratory in which astronauts’ bodies’ roles were not only to produce medical data but also explicitly to inform decisions on how to live in outer space.

As Bunch (2025) describes, although astronauts nowadays have bodily sovereignty in the form of a potential to refuse, this potential is compromised. This was also true for the Skylab program, where refusal was compromised by the relationship between the institution, the scientific community, and the astronauts. While protest of the way time is managed aboard Skylab was indeed actualized in this case, the crew negotiated and even surrendered to the temporal regime in allowing the final decision to be made by planners and controllers, subordinating to the hierarchical decision-making structure. We see this in the discussion around physical exercise and hygiene, where cycles of medical experiments are privileged to the bodily cycles of digestion through the temporal regime of 'science per unit time.’ While the astronauts could, in theory, disobey orders and practice physicals and hygiene as they wished, protests were actualized through categories of the temporal regime, like arguing through measurements and quantitative data in the case of Gibson or retaining control over timeframes that were necessary for multiple purposes, such as the medical tests.

The standardization techniques in which PIs develop "technology operators" for experiments (Bunch, 2025) with directions on-orbit, extensive basic training, and in-flight communication resemble Skylab's daily teleprompter instructions, training program, and real-time planning, with the exception of ESA's training regime being designed to level the skills between astronauts (ibid., p. 33). Instead, the Skylab IV team received specialized training for experiments and education for scientific expertise in the needed respective fields, not estranging astronauts during their training from the scientific basis of their work as they would at the ESA today (ibid.). This may be attributed to forging trust between the community of scientists and fighter pilots, as Hutchinson (2000) put it, but also to an understanding of scientific inquiry that favors in situ interpretations and decision-making for gathering data. Still, the tendency is there; when Skylab's astronauts perform proceduralized tasks and are put under rigid micromanagement, as was the case on Skylab IV, we see the beginning of these tendencies to put astronauts in the role of scientific executors that are puppeteered by the ground, only that in the 1970s, the sociotechnical makeup of the station would not allow for the same type of surveillance or frequent contact that the ISS infrastructure is capable of due to technological and budgetary (in that sense, institutional) limitations in the organization of astronauts' work. In a sense, Pogue, Carr, and Gibson represent more the values associated with astronauts (cf., Bunch, 2025), as they performed and embodied the role of working as scientists in outer space. Gibson's cutting time on 31.12.1973 is only due to his technological as well as scientific knowledge about the ATM 'getting ahead' of the schedule only because of the extensive training in both operating the gear. The findings show how the timeline and plan are assumed to be following the maximization of output more than Gibson's technoscientific prowess. Proposed changes during the OPS meeting and its aftermath, like the opening of the 'shopping list' to scientific tasks or practices like breaking up tasks and the accompanying agency for astronauts, also are undermined and are only possible if astronauts do know in which ways they would potentially influence data.

The conceptual frame of 'Space Normal' (Olson, 2010) takes an interesting turn when looking into the past of astronautics of Skylab. As the potential of damaging effects on bodies in outer space is still a 'known unknown' (Nielsen and Sørenson, 2017), a different category for astronaut health is not yet established. Still, Skylab IV was treated by the standards of Skylab III and with little to no timeframe to physically adapt to their new environment. Data was privileged in the concerns for medical health, as concerns of the astronauts to stay 'healthy and alert' (NASA, 1973-74c) were always weighed against the problems of planners imposing new deadlines. The astronauts were already established as medical data points, and they would have experiments that would strain their well-being and workloads that would give them little time to rest. Ultimately, the OPs conference was also a medical intervention. This relation between rhythms and health is rarely recognized during Skylab and only understood in terms of clock-time, i.e., the recommended 1-hour uninterrupted, activity-low period before sleep (NASA, 1974g). The formation of the positionality as a medical test subject and space normal in outer space medicine can, therefore, be put in line with Skylab's focus on quantitative data for the measurement of health.

The endurant desire in space culture for a refusal of the estranged labor and the production of a “novel kind of politics that exceeded both their microscale estranged labor and the non-specific metavalues associated with human spaceflight” (Bunch, 2025, p. 36) that Bunch attributes to the myth of the labor strike in the discourse of space labor certainly can take some roots in understanding the construction of time in the Skylab IV case. The time-science-work triangular relationship is truly unique in spaceflight due to the mega-infrastructures and organizational principles of institutions that execute them, such as NASA or the ESA, being dominant factors for these experiences. With experiences like ‘chasing the red line’ resembling ‘racing the clock’ of the Skylab program. ‘Chasing the red line’ as a phenomenon is also enabled and established by the predecessor of the same software first introduced to schedule and manage astronautic activities in the APS (Hughes, 2013). The APS, being developed in the organizational logic of the Apollo program, materializes the hierarchical ordering of temporalities into a timeline by allowing planners to re-/order tasks detached from their context or embedded rhythms.

One can suspect the ISS and Skylab share qualities that affect the way work is delineated and organized as well as how the work-time relationship affects how science is valued in outer space networks in which the primary organizational logic of time is the abstraction of scientific data to the principles of 'science per unit time.’ While this comparison needs further research and attention, it speaks to the importance of historical research in understanding the rich history of why space research is constructed in this specific way, what changed over the last fifty years, and how we may produce different trajectories in valuing outer space work and research.

6.4. Reflections on Methodology and Theoretical Concepts

For understanding how and to what end time was constructed during the Skylab IV labor dispute, ANT, post-ANT, and Adam’ social analysis of time, especially the concept of timescapes, served well as a theoretical underpinning and guided the document-driven and practice-oriented methodology of this thesis. The focus on materiality in the ANT tradition and a practice-oriented document analysis allowed for looking at non-human actors like spreadsheets that perform tasks of homogenization in order to draw things together (Asdal, 2008). For example, 'shopping list,' allowed the crew to sequence and take on certain 'low-priority' tasks to their own judgment. This non-human actor was enrolled and mobilized as a solution for time management issues between air and ground, an interesting aspect of the mission that may be missed without ANT's sensibilities. To understand the Skylab program both as an actor-network and a unique assemblage that would coproduce a diverse and technically mediated timescape allowed for understanding the Skylab IV labor dispute as a sociotechnical phenomenon rather than just an organizational field site. While practice-oriented document analysis highlighted the role of documents within this field. In terms of understanding how time was constructed at Skylab, findings depict a complex landscape of different categories of rhythms and temporalities, intertwined in a processual interplay with and coproduced by standardizations, epistemic values, and institutional decision-making structures, as well as individual actors' (both human and non-human) agency. Those were made visible by the temporal experiences described and problematized by actors as well as practices to handle frictions between different categories of time. In combination with ANT, this theoretical and methodological perspective allowed one to understand to what end time was constructed by means of describing the sociotechnically mediated relations and diverse arrangements of actors, both in the larger framework of NASA and the AAP and in the rationales and practices of Skylab IV that would take action in order to produce a specific end.

Post-ANT concepts were helpful in understanding the labor conflict as a complex negotiation between a multiplicity of goals and values within a program emerging from a strained actor-network by a timescape that would position clock time as one of its supreme ordering principles while also being in exchange with temporalities present in contemporary academia, such as the presence of 'development' (Iparraguirre, 2021) as a temporal organization principle of past, present, and future.

7. Conclusion

This master’s thesis presented the case of Skylab IV from the perspective of the construction of time and its role in the labor conflict, emerging in the last week of 1973. I presented previous research on the case and outlined the unique position of Skylab IV in the larger discussion of labor conflicts in outer space and as a historic case. My research questions aimed to understand the timescape during this period, under which temporal logic Skylab operated, and what practices supported and/or intervened in the specific constellation of time-shaping that would co-produce the temporal experiences of the crew, scientific outcomes, and social life aboard the space station. I positioned my approach more into a relational, semiotic-material, and practice-oriented perspective, differentiating this thesis from more discourse-oriented and interpretive perspectives on time, acquired my material through web-based archival research, and went for a practice- and time-oriented document analysis. Summarizing the findings and discussion from the previous chapters, I will address my research questions in a direct fashion in order to present the conclusions of my investigation.

What logics of time can be identified that constitute the co-production of Skylab’s Timescape during the Skylab IV mission?

For my first subquestion, I found how, through intertwining economics with scientific rationales in labor organization and management, Skylab was constructed to value scientific output in terms of quantity, with the institutionalization of 'science per unit time,’ privileging clock time, valorizing speed, and employing Taylorist principles that all equate time with measurable, quantitative output and construct time as a scarce and calculable resource to be optimized. Further, temporal principles were materialized in instruments and infrastructure, enabling the Skylab IV mission to serve the governing principles established by NASA. These temporal logics were inherited from previous Apollo missions and did not map onto a prolonged work relation of multiple months, pushing astronauts to their physical and mental limits by neglecting embodied and situational temporalities such as the intricacies of the circadian rhythms, causing situated expertise to be neglected or marginalized, and creating frequent de-harmonization and instability in the actor-network. In contrast, the astronauts were not fully subscribed to this operational logic, protesting the network for a more feasible scientific workload that would be based on endurance instead of maximal performance, arguing for data of higher quality through agency in their own time management and sensibility to their own rhythms, cycles, and routines.

How did management, labor, and knowledge-making practices during the Skylab program – particularly during the labor conflict on Skylab IV – enact, constitute, or reconfigure the program's timescape, and how did these practices shape astronauts' temporal experiences?

Management, labor, and knowledge-making practices enacted and reconfigured Skylab's timescape by continuously negotiating how time should be organized, controlled, and valued. Management using calculative tools, practicing rigid scheduling and instructing astronauts on a daily basis would reinforce a clock-time regime that framed astronauts as scientific executors, narrowing scientific work to moments of data extraction and marginalizing preparatory, interpretive, and bodily practices. Astronauts enacted time and time again an alternative temporal logic through practices of resistance and adaptation. They were keen in negotiating for changes to sequencing and ordering principles of timeframes and would even surrender prolonged timeframes for less imposition's of work during specific timeframes that were important for the astronauts circadian rhythm or other temporal needs. Practices to produce more harmonized schedules between the different lived rhythms and temporalities of astronauts included a wide range of practices that are also deployed in the academic sector, but were constructed in the unique alignment and conditions of dwelling and working in outer space. Especially interesting in this case were practices such as trading time across activities, restructuring task sequences, and asserting the necessity of uninterrupted periods for exercise, hygiene, and rest. Temporal practices that would co-construct Skylab's timescape were also unique to the sociotechnical configuration of the space station such as delayed communication in reporting to ground or the rhythmic alignment or attunement strategies to the outer space infrastructure and instruments enabling temporal management and knowledge-making aboard Skylab. Astronauts also had to come up with timecuts and different work constellations in order to cope with the demanding time schedule.

The labor conflict would have flight controllers and higher-ups negotiate with the crew of astronauts, making flight controllers reflect on their set standards by the abstraction of the previous crew's work in numerical data and allow through the enrollment of documents and changes in communication strategies more agency in sequencing practices to the astronauts. Although this allocation of agency was limited and still in the operational temporal logic emerging from the hierarchical positioning of the temporality of clock time and the valorization of speed, these changes were enough to have the astronauts go the full length of the mission. The tension between these approaches shaped astronauts' temporal experiences as marked by stress, interruption, and sociotechnical torque, while also opening moments in which autonomy led to improved scientific outcomes.

What specific moments led to the labor dispute between Astronauts and Mission Control on the Skylab program?

The labor dispute on Skylab IV emerged from specific moments where conflicting temporal regimes produced dissidence. Key moments include the imposition of densely packed schedules derived from short-duration Apollo missions onto an 84-day flight, the frequent interruptions from Mission Control during ongoing tasks and leisure periods, and the pressure from PIs to adhere to rigid experimental timelines despite in situ difficulties. Moments such as the daily transmission of ever-increasing task instructions, frequent interruptions of essential bodily routines, leisure time, observations, and experiments, as well as preparatory and subsequent scientific work. With sequencing as a major issue, task transitions and transitory phases between work, housekeeping and leisure became revealing moments for how the astronauts experienced Skylab's timescape. Further, handling of technological constraints by management led to issues in communication timing, data recording procedures, and instrument demands, further increasing these tensions by forcing repeated task disruptions and resynchronization efforts by astronauts, while privileging the ground team. The OPs conference and subsequent negotiations were a key moment in which these issues surfaced, as astronauts articulated the need for temporal restructuring. These moments produced the conditions for the labor conflict, not as an isolated breakdown but as the culmination of sustained temporal misalignment.

How and to what end is time constructed in the management and labor practices that influenced the Skylab IV labor dispute between astronauts and Mission Control?

Time in the Skylab IV program was constructed as an instrument of governance, optimization, and accountability, serving the goal of maximizing the amount of data output measured by quantity within an economic-operational framework. Through scheduling systems, management software, and institutional protocols, time was abstracted, measured, and reconfigured independent of context, enabling centralized time-control over labor, if not all aspects of life, and knowledge-making aboard Skylab. This construction allowed management to compare and trade activities against their contribution to 'science per unit time.' However, this same abstraction produced alienation and experiences of 'racing against the clock' by disregarding the qualitative dimensions of work, such as continuity, recovery, and in situ application of expertise in observations and experimental knowledge-making. The imaginary of 'urgency' would dominate the mission. In response, astronauts' interventions were constructed from the friction with time as lived, rhythmic, and relational, oriented toward sustaining both human well-being and scientific quality over a prolonged duration. The labor dispute thus exposes that time was not merely managed but actively contested, with its construction determining not only productivity but also authority, expertise, and the conditions under which scientific knowledge in space could be produced.

Skylab IV, in this sense, can be understood as a case full of insights for collaborative research in modern academic settings, in which academics are subjected to market-oriented or mission-oriented timescapes. Further, Skylab seems to share an unbroken line of history with today's Euro-American spaceflight programs. The organization of time mattered for the way science was practiced. More than the organizational principle of 'science per unit time,' scientific data production was interwoven with Skylab's sociotechnical timescape, as the qualities of the relationship between scientists on the ground and astronauts would shape the design of instruments and the temporal work experience of astronauts. During the OPS conference, astronauts would stress their own agency in conducting scientific experiments and time management to benefit their mental and physical health, which in return would enhance the quality of data through in situ decision-making.

Unique to outer space were the highly technologically mediated relations between human actors and their influence on the timescape, the economic underpinnings of mobilizing a supersized infrastructure, and the unique constellation of concerns for control and care when it comes to the bodily sovereignty of human actors in outer space.

7.1. Limitations

The results depicted here are only the results from a fraction of the material from the Skylab IV case, with a focus on just an eventful week of a multiple-month operation. Further, the case is embedded in the Skylab program, which in turn is an offspring of the Apollo program. Inquiry into both programs may solidify the discussed findings and interpretations or bring more nuance into the discussion, as some of the findings are referring to insights from an engagement with Skylab IV when understanding NASA as an institution, while the data referenced in this master's thesis excluded other oral histories, transcripts, and documents from other missions and programs. For example, the Skylab II mission's data may show us more of the formation of the Skylab program and its temporal dimensions.

The ANT-style analysis present in the findings pictured a rather rigid interpretation of the network. An analysis of the simulation stage or the earlier mission's formation may enrich the analysis of Skylab IV's actor network with more complexity, such as how power is distributed, actors are enrolled or displaced, etc. For example, in the actor-network of NASA, employees who were astronauts on one mission would take on multiple roles during other missions, like CC or query in press conferences. This means the positionality of one actor in the network may change drastically with far-reaching consequences for their biographies.

The aspect of individual actors' biographies was also only touched briefly. A worthwhile look from this perspective might be cases like Gibson modifying his biography to get a seat at one of the rockets. Here, practices of tailoring one's biography in order to suit certain roles hint at a temporal practice of taking agency in one’s individual construction of a self-representing timeline. Astronauts and academics share this practice of non-linear reinterpretations of their own past in the present to reorient one's biography for future scientific endeavors (e.g, Vostal, 2015; 2021). More focus on the past may enrich this case study not only in a temporal, practice-oriented context but also in a discursive understanding of narratives and imaginaries around spacefaring.

More generally, working with a historic case like Skylab IV is making one’s qualitative research prone to constructive and performative effects due to being mediated reports from the field, such as the historic interviews with the astronauts in the 2000s. As discussed before, interpretations of ‘what happened’ at Skylab are numerous (see, Brooker 2019-20; Uri, 2020), and there will always be aspects reliant on the interpretations of the material. Further inquiry therefore may produce more complexities and/or subtleties to the case. By comparing transcripts with re-interpretations from interview situations, though, I found myself strengthening arguments while also highlighting contradictions. To reduce contradictions to mere products of time can be tempting, but inquiry into these aspects of documents may produce unique insights. As in biographic-interview situations, an actor reconfigures its biography. For example, Gerald Carr working in human applications after the Skylab program might have influenced him to reconfigure Skylab as a turning point for his life. These insights, only briefly discussed, may also add to future inquiry into the Skylab case.

As I touched upon the temporality of development during the discussion (6.1.), the historic context was fairly marginalized within this thesis. As referenced before, the Apollo program has an unbroken history with the rocketry of the Nazi regime, with actors like Von Braun still working in prominent roles for NASA at the time. Further, the transcripts of Skylab IV start with a speech of former U.S. president Nixon, contextualizing Skylab as an endeavor of progress. As do many of the astronauts in their interviews. This temporality, also present in other (often Western) research settings (Iparraguirre, 2021), was only briefly discussed in this context due to this thesis's more practice-oriented approach. The temporal logic of Skylab, though, is intertwined with an understanding of progress, such as shown in the aforementioned discussion subchapter, and would add to the already complex and interesting findings of Skylab's timescape(s). In the light of the historic presence of Skylab, the interviews of the JSC can be understood as NASA's attempt to collect some of the tacit insights of Skylab for the ISS program. Both JSC interviewers and interviewees often position Skylab in direct line with the ISS, so the relation between both projects and their organization may highlight unquestioned or unexamined inherited features from earlier programs to their predecessors.

Before writing this thesis, I would have planned to also go into detail about one of the studies that were produced by the Skylab program, such as the M151 habitation study (Kubis and McLaughlin, 1975). Looking into the future towards Brooker's publication and a findings chapter already filled to the brim, I was not able to discuss the details of the research that was a direct outcome of the Skylab program. An inquiry into such research may draw a more complex and thorough understanding to the claims to the mode data production and the relationship of Skylab's research to future studies situated in low-earth orbit and outer space. With the sheer complexity of Skylab's technoscientific network in dozens of instruments, I further could only look at a few instruments discussed by the astronauts. The socio-political context in which scientific results of Skylab may also inform the U.S. imperialist policy was also only touched upon briefly (2.2) due to the focus of this thesis.

What came extraordinarily short for this thesis was a focus beyond an actor-network understanding of power relations in the Skylab program. Feminist technoscience previously would look at the Skylab case in order to show that actors of different genders were neglected in the narratives of 'man making history' and the dominant male ethos at NASA (Gál et al., 2023). This study has little contribution to this, with its focus on the all-male crew and their direct relationship to other male actors in the management teams. A focus on female or queer time(s) at NASA during this time period, for example, would certainly be a rich case that would show the more complex underpinnings of Skylab's form of organization. Most prominently, I highlighted how transcription work and editorial writing were practiced by an all-female-presenting team. Their work would not only allow the transparency of the mission to the public, but also this thesis would not be possible without this work. Their unique positionality in doing labor categorized and institutionalized as female labor would make for a good topic of inquiry in this direction and is one shortcoming of this thesis.

Time surely is a complex topic for investigation, and Adam (2021) was right in stating that it changes to some extent every aspect of research. The relational quality of time to any and every topic, be it scientific data production, bodily experience, work relations, power distribution, governance, or infrastructure, is all interwoven with societies and social life when it comes to time. Work, as demonstrated here, is only one angle in which this relation might be explored. The Skylab IV mission, in that sense, shows how a unique corpus of research may be the outcome of temporal social inquiry. With our view directed to the future of space programs intertwining state actors and the private sector, both actualizing life, dwelling, and research in low-earth orbit in ever-new constellations, the case of Skylab IV serves as a critical point of reflection for how temporal regimes are constructed, negotiated, and contested.

References

Adam, B. (1995) *Timewatch : the social analysis of time*. 1. publ. Cambridge: Polity Press.

Adam, B. (1998) *Timescapes of modernity : the environment and invisible hazards*. London ; New York : Routledge.

Adam, B. (2004) *Time.* Boston, MA: Polity Press.

Adam, B. (2021) 'Preface: Academic Timescapes in Focus', in *Inquiring into Academic Timescapes*. United Kingdom: Emerald Publishing Limited.

Alhadeff-Jones, M. (2021) 'Time and the Rhythms of Academia: A Rhythmanalytical Perspective', in *Inquiring into Academic Timescapes*. United Kingdom: Emerald Publishing Limited, pp. 21–37. Available at: https://doi.org/10.1108/978-1-78973-911-420211004.

Asdal, K. (2008) 'On Politics and the Little Tools of Democracy: A Down-to-Earth Approach', *Distinktion (Aarhus)*, (16), pp. 11–26.

Asdal, K. and Reinertsen, H. (2021) *Doing Document Analysis : A Practice-Oriented Method*. First edition. London: SAGE Publications, Ltd. (UK).

Araújo, E., Oliveira C.S., Castañeda-Rentería, L., Chagas, K. (2021) 'Academic Times, Shortcuts, and Styles – Exploring the Case of Time for a PhD from a Gender Perspective', in *Inquiring into Academic Timescapes*. United Kingdom: Emerald Publishing Limited, pp. 103–122. Available at: https://doi.org/10.1108/978-1-78973-911-420211010.

Bass, D.S., Wales, R.C. and Shalin, V.L. (2005) 'Choosing Mars time: analysis of the Mars Exploration Rover experience', in *2005 IEEE Aerospace Conference*. IEEE, pp. 4174–4185. Available at: https://doi.org/10.1109/AERO.2005.1559722.

Buchli, V. (2020) 'Extraterrestrial methods: Towards an ethnography of the ISS', in *Lineages and Advancements in Material Culture Studies*. 1st edn. United Kingdom: Routledge, pp. 17–32. Available at: https://doi.org/10.4324/9781003085867-2.

Bunch, G. (2025) 'Transcendence, bodies, and estranged labour in outer space: The astronaut's contribution to a general theory of hierarchy', in *Exploring Ethnography of Outer Space*. 1st edn. United Kingdom: Routledge, pp. 21–42. Available at: https://doi.org/10.4324/9781003437956-2.

Burneva, P. (2021) 'Trading Time: A Hauntological Investigation', in *Inquiring into Academic Timescapes*. United Kingdom: Emerald Publishing Limited, pp. 157–164. Available at: https://doi.org/10.1108/978-1-78973-911-420211014.

Brooker, P. (Forthcoming) 'Living and Working in Space: An Ethnomethodological Study of Skylab'. Manchester: Manchester University Press.

Brooker, P., Sharrock, W. (2023) 'Living and Working in "The Great Outdoors": Astronautics as Everyday Work in NASA's Skylab Programme', in *The Routledge Handbook of Social Studies of Outer Space*. 1st edn. Routledge, pp. 388–399. Available at: https://doi.org/10.4324/9781003280507-36.

Brooker, P. (2019-2020) 'Skylab: ASOS...IN SPAAAAACCCEEEE!!!!! (podcast mini-series). Skylab: Living and Working in Space'. June 2019–February 2020. Available at: https://open.spotify.com/show/6n4XL8KH1atmkwclbr9CWy?si=f00111425a1f46f7 (Accessed 5 April 2026).

Callon, M. (1984) 'Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay', *The Sociological review (Keele)*, 32(1_suppl), pp. 196–233. Available at: https://doi.org/10.1111/j.1467-954X.1984.tb00113.x.

Contella, D. *et al.* (2018) 'The International Space Station: Operating an Outpost in the New Frontier.', Houston, TX: National Aeronautics and Space Administration. Available at: www.nasa.gov/sites/default/files/atoms/files/iss-operating_an_outpost-tagged.pdf (Accessed 5 April 2026).

Castaño, P., Salazar, J.F. and Gorman, A. (2023) ‘Plant Biologists and the International Space Station: Institutionalising a Scientific Community’, in *The Routledge Handbook of Social Studies of Outer Space*. 1st edn. Routledge, pp. 427–440. Available at: https://doi.org/10.4324/9781003280507-39.

Dakka, F. (2021) ‘Rhythm and the Possible: Moments, Anticipation and Dwelling in the Contemporary University’, in *Inquiring into Academic Timescapes*. United Kingdom: Emerald Publishing Limited, pp. 39–57. Available at: https://doi.org/10.1108/978-1-78973-911-420211005.

Darrin, A., O’Leary B. (2009) ‘Introduction’, in *Handbook of Space Engineering, Archaeology, and Heritage*, pp. 3–15. Boca Raton, FL: CRC Taylor & Francis.

Damjanov, K., Salazar, J.F. and Gorman, A. (2023) ‘Space Infrastructures and Networks of Control and Care’, in *The Routledge Handbook of Social Studies of Outer Space*. 1st edn. Routledge, pp. 328–338. Available at: https://doi.org/10.4324/9781003280507-30.

Eshun, K. (2003) ‘Further Considerations on Afrofuturism’, *CR (East Lansing, Mich.)*, 3(2), pp. 287–302. Available at: https://doi.org/10.1353/ncr.2003.0021.

Etzkowitz, H. (2013) ‘Anatomy of the entrepreneurial university’, *Social Science Information*, 52(3), pp. 486–511. Available at: https://doi.org/10.1177/0539018413485832.

Felt, U. (2015) ‘Keeping Technologies Out’, in *Dreamscapes of Modernity*. University of Chicago Press. Available at: https://doi.org/10.7208/chicago/9780226276663.003.0005.

Felt, U. (2025) *Academic Times : Contesting the Chronopolitics of Research*. 1st ed. 2025. Singapore : Springer Nature Singapore : Imprint: Palgrave Macmillan.

Gál, R.P. and Armstrong, E.S. (2023) ‘Feminist Approaches to Outer Space: Engagements with Technology, labor, and Environment’, in *The Routledge Handbook of Social Studies of Outer Space*, p. 158. Available at: https://doi.org/10.4324/9781003280507-15.

Girard, M. and Stark, D. (2003) ‘Heterarchies of Value in Manhattan-Based New Media Firms’, *Theory, culture & society*, 20(3), pp. 77–105. Available at: https://doi.org/10.1177/02632764030203006.

Goffman, E. (1961) *Asylums : essays on the social situation of mental patients and other inmates*. 1. publ. New York, NY [u.a.]: Doubleday.

Gorman, A. (2005) ‘The cultural landscape of interplanetary space’, *Journal of social archaeology*, 5(1), pp. 85–107. Available at: https://doi.org/10.1177/1469605305050148.

Gorman, A. (2007) ‘La Terre et l’Espace: Rockets, Prisons, Protests and Heritage in Australia and French Guiana’, *Archaeologies*, 3(2), pp. 153–168. Available at: https://doi.org/10.1007/s11759-007-9017-9.

Gorman, A. and Salazar, J.F. (2023) ‘Space and Time through Material Culture: An Account of Space Archaeology’, in *The Routledge Handbook of Social Studies of Outer Space*. 1st edn. Routledge, pp. 44–56. Available at: https://doi.org/10.4324/9781003280507-5.

Heckscher, C.C. (1994) ‘Defining the Post-bureaucratic Type’, in *The Post-bureaucratic Organization: New Perspectives on Organizational Change*, pp. 14–62. Thousand Oaks, CA: Sage.

Hitt, D., Garriott, O.K. and Kerwin, J. (2008) *Homesteading space : the Skylab story*. Lincoln : University of Nebraska Press.

Innerarity, D. (2012) ‘Chronopolitics: A Theory of Social Rhythm’, in *The Future and Its Enemies*. United States: Stanford University Press.

Iparraguirre, G. (2021) ‘Cultural Rhythmics Inside Academic Temporalities’, in *Inquiring into Academic Timescapes*. United Kingdom: Emerald Publishing Limited, pp. 59–72. Available at: https://doi.org/10.1108/978-1-78973-911-420211006.

Jasanoff, S. (2004) ‘Ordering Knowledge, Ordering Society’, in *States of Knowledge.* 1st edn. Routledge, pp. 13–45. Available at: https://doi.org/10.4324/9780203413845-2.

Jasanoff, S. and Kim, S.-H. (2015) *Dreamscapes of modernity : sociotechnical imaginaries and the fabrication of power*. Chicago ; London : The University of Chicago Press.

Jeevendrampillai, D., Kozel, A. and Gorbanenko, J. (2025) *Exploring Ethnography of Outer Space: Methods and Perspectives*. Taylor & Francis. Available at: https://doi.org/10.4324/9781003437956.

Klimburg-Witjes, N. (2024) 'A Rocket to Protect? Sociotechnical Imaginaries of Strategic Autonomy in Controversies About the European Rocket Program', *Geopolitics*, 29(3), pp. 821–848. Available at: https://doi.org/10.1080/14650045.2023.2177157.

Klimburg-Witjes, N. and Kuerten, P. (2025) 'Pacing space: futuring practices and temporal ownership in the European space sector', *Science & public policy* [Preprint]. Available at: https://doi.org/10.1093/scipol/scaf067.

Knorr-Cetina, K. (1999) *Epistemic cultures : how the sciences make knowledge*. Cambridge, Mass. : Harvard University Press.

Moore, S.K. and Gast, M.A. (2010) '21st Century extravehicular activities: Synergizing past and present training methods for future spacewalking success', *Acta astronautica*, 67(7), pp. 739–752. Available at: https://doi.org/10.1016/j.actaastro.2010.06.016.

Kubis, J. F., and McLaughlin, E. J.(1975). 'Skylab Task and Work Performance (Experiment M151—Time and Motion Study)', *Acta astronautica* 2(3–4), pp. 337–349. https://doi.org/10.1016/00945765(75)90100-9.

Latour, B. (2005) *Reassembling the social : an introduction to actor-network-theory*. Oxford : Oxford University Press.

Latour, B. (2008). 'On Technical Mediation. Philosophy, Sociology, Genealogy.', in *Common Knowledge*. Available at: http://www.bruno-latour.fr/node/234, pp. 29-64 (Accessed 5 April 2026).

Law, J. and George Routledge & Sons (2004) *After method : mess in social science research*. London New York: Routledge, Taylor & Francis Group.

Lefebvre, H. (2004) *Rhythmanalysis : space, time, and everyday life*. London New York: Continuum.

Lynch, M. (1993) *Scientific practice and ordinary action : ethnomethodology and social studies of science*. Cambridge : Cambridge University Press.

Michael, M. (2017) '"Classical" Actor-Network Theory', in *Actor-Network Theory: Trials, Trails and Translations*. 55 City Road London: SAGE Publications Ltd, pp. 28–51. Available at: https://doi.org/10.4135/9781473983045.n3.

Maile, D.U. (2021) 'On Being Late: Cruising Mauna Kea and Unsettling Technoscientific Conquest in Hawai'i', *American Indian culture and research journal*, 45(1), pp. 95–122. Available at: https://doi.org/10.17953/AICRJ.45.1.MAILE.

Mazzucato, M. (2018) 'Mission-Oriented Research and Innovation. A problem-solving approach to fuel innovation-led growth.' Brussels: European Commission, DG Research and Innovation.

McCurdy, H. E. (1994) 'Inside NASA: High Technology and Organizational Change in the U.S. Space Program. Baltimore, MD: Johns Hopkins University Press.

Mesmer-Magnus, J. *et al.* (2021) 'Working in Space: Managing Transitions between Tasks', in *Psychology and Human Performance in Space Programs*. 1st edn. United Kingdom: CRC Press, pp. 179–203. Available at: https://doi.org/10.1201/9780429440854-10.

Mirmalek, Z. (2020) *Making Time on Mars*. 1st edn. Cambridge: The MIT Press. Available at: https://doi.org/10.7551/mitpress/11553.001.0001.

Mitterle, A. (2021) 'Time, the University, and Stratification: The Historical Making of Institutional Time as a Strategic Resource', in *Inquiring into Academic Timescapes*. United Kingdom: Emerald Publishing Limited, pp. 211–229. Available at: https://doi.org/10.1108/978-1-78973-911-420211019.

Mol, A., Smith A., and Weintraub, E.R. (2005). *The Body Multiple : Ontology in Medical Practice* (2. print.). Durham, NC [u.a.]: Duke Univ. Press.

Nielsen, K.H. and Sørensen, M.P. (2017) 'How to take non-knowledge seriously, or "the unexpected virtue of ignorance"', *Public understanding of science (Bristol, England)*, 26(3), pp. 385–392. Available at: https://doi.org/10.1177/0963662515600967.

Ojani, C. (2024) ‘Reindeer, rockets and space infrastructures: Enacting oligoptic-satellitarian environments in Northern Sweden’, *Environment and planning. E, Nature and space (Print)*, 7(5), pp. 1957–1974. Available at: https://doi.org/10.1177/25148486241262621.

Olson, V.A. (2010) ‘The Ecobiopolitics of Space Biomedicine’, *Medical anthropology*, 29(2), pp. 170–193. Available at: https://doi.org/10.1080/01459741003715409.

Olson, V. A. (2018) *Into the Extreme: U.S. Environmental Systems and Politics Beyond Earth.* Minneapolis: University of Minnesota Press.

Phillips, R. (2019). *The Nowness of Black Chronopolitical Imaginaries in the Afro/ Retrofuture,* Available at: The Funambulist (24), 19 June. https://thefunambulist.net/magazine/24-futurisms/nowness-black-chronopolitical-imaginaries-afro-retrofuture-rasheedah-phillips (Accessed: 05.04.2026).

Pinch, T.J. and Bijker, W.E. (1984) ‘The Social Construction of Facts and Artefacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other’, *Social studies of science*, 14(3), pp. 399–441. Available at: https://doi.org/10.1177/030631284014003004.

Popper, J. (2021) *Fragmenting a Monolith: Exploring and Disrupting an Outer Space Imaginary.* Available at: https://phaidra.kunstuni-linz.at/detail/o:2792.

Richardson, I. *et al.* (2017) ‘Careful Surveillance at Play: Human-Animal Relations and Mobile Media in the Home’, in *Refiguring Techniques in Digital Visual Research*. Switzerland: Springer International Publishing AG, pp. 105–116. Available at: https://doi.org/10.1007/978-3-319-61222-5_9.

Salazar, J.F. and Gorman, A. (2023) ‘A Chronopolitics of Outer Space: A Poetics of Tomorrowing’, in *The Routledge Handbook of Social Studies of Outer Space*. 1st edn. Routledge, pp. 142–157. Available at: https://doi.org/10.4324/9781003280507-14.

Saperstein, J.D. (2021) ‘Opening the Black Box of Outer Space: The Case of Jason-3’, *Geopolitics*, 26(3), pp. 729–746. Available at: https://doi.org/10.1080/14650045.2020.1806241.

Rossiter, N. (2016) *Software, infrastructure, labor : a media theory of logistical nightmares*. New York: Routledge Taylor & Francis Group.

Rosner, D. (2018) *Critical fabulations : reworking the methods and margins of design*. Cambridge, Massachusetts : The MIT Press.

Sammler, K.G. and Lynch, C.R. (2021) ‘Apparatuses of observation and occupation: Settler colonialism and space science in Hawai’i’, *Environment and planning. D, Society & space*, 39(5), pp. 945–965. Available at: https://doi.org/10.1177/02637758211042374.

Uri, J. (2020) *The Real Story of the Skylab 4 “Strike”’in Space*. Johnson Space Center, NASA. Available at https://www.nasa.gov/history/the-real-story-of-the-skylab-4-strike-in-space/ (Accessed 5 April 2026).

Uri, J. (2024) *45 Years Ago: Skylab Reenters Earth’s Atmosphere.* Johnson Space Center, NASA. Available at https://www.nasa.gov/history/45-years-ago-skylab-reenters-earths-atmosphere/ (Accessed 5 April 2026).

Vertesi, J. (2020) *Shaping Science: Organizations, Decisions, and Culture on NASA’s Teams.* Chicago, IL: Chicago University Press.

Valentine, D. (2012) ‘Exit Strategy: Profit, Cosmology, and the Future of Humans in Space. in *Anthropological Quarterly*, vol. 85, pp. 1045-1067. Project MUSE. Available at: https://dx.doi.org/10.1353/anq.2012.0073.

Vostal, F. (2015) ‘Academic life in the fast lane: The experience of time and speed in British academia’, *Time & society*, 24(1), pp. 71–95. Available at: https://doi.org/10.1177/0961463X13517537.

Vostal, F. (2021) ‘Introduction: On Times, Scapes and Chronosolidarity in Academia’, in *Inquiring into Academic Timescapes*. United Kingdom: Emerald Publishing Limited.

Weibel, D. L. (2019) ‘Astronauts vs. Mortals: Space Workers, Jain Ascetics, and NASA’s Transcendent Few’. in *Space Review* Available at: https://www.thespacereview.com/article/3690/1 (Accessed 5 April 2026).

Yaden, *et al.*(2016) 'The overview effect: Awe and self-transcendent experience in space flight'. In *Psychology of Consciousness: Theory, Research, and Practice*. **3** (1): 1–11. doi:10.1037/cns0000086. ISSN 2326-5531.

Ylijoki, O.-H. (2021) 'Temporal Navigation in Academic Work: Experiences of Early Career Academics', in *Inquiring into Academic Timescapes*. United Kingdom: Emerald Publishing Limited, pp. 87–102. Available at: https://doi.org/10.1108/978-1-78973-911-420211009.

Sources

Burns, L., and Gibson, E. G. (2021) 'The 'Strike' in Space" (podcast episode)'. *Witness History (podcast)*. Available at https://www.bbc.co.uk/sounds/play/w3cszmsv (Accessed 30 December 2025).

Carr, G. P. (2000). *NASA Johnson Space Center Oral History Project: Oral History Transcript.* Interviewed by Kevin M. Rusnak, 25 October 2000. Available at https://www.nasa.gov/history/history-publications-and-resources/oral-histories/johnson-space-center/ (Accessed 30 December 2025).

Gibson, E. G. (2000). *NASA Johnson Space Center Oral History Project: Oral History Transcript.* Interviewed by Carol Butler, 1 December 2000. Available at https://www.nasa.gov/history/history-publications-and-resources/oral-histories/johnson-space-center/ (Accessed 30 December 2025).

Gibson, E. G. (1973) *The Quiet Sun.* Washington, National Aeronautics and Space Administration (NASA SP-303).

Compton, D. W., and Benson, C. D. (1983) *Living and Working in Space. A History of Skylab.* Available at https://sma.nasa.gov/SignificantIncidents/assets/living-and-working-in-space.pdf (Accessed 30 December 2025).

Hitt, D., Garriott, O., and Kerwin J. (2008). *Homesteading Space: The Skylab Story.* London: University of Nebraska Press.

Hughes, F. E. (2000) *NASA Johnson Space Center Oral History Project: Oral History Transcript.* Interviewed by Rebecca Wright, 25 September 2013. Available at https://www.nasa.gov/history/history-publications-and-resources/oral-histories/johnson-space-center/ (Accessed 30 December 2025).

Hutchinson, N. B. (2000) *NASA Johnson Space Center Oral History Project: Oral History Transcript.* Interviewed by Kevin M. Rusnak, 5 June 2000. Available at https://www.nasa.gov/history/history-publications-and-resources/oral-histories/johnson-space-center/ (Accessed 30 December 2025).

NASA (Pomeroy, B.), (1973a). *NASA Press Kit. Project: SKYLAB 4. Third Manned Mission.* Available at: https://web.archive.org/web/20090321042316/http://www-lib.ksc.nasa.gov/lib/public/archives/apollo/pk/SKYLAB4PK.PDF (Accessed 30 December 2025).

NASA, (1973-74b) *NASA Johnson Space Center. Pc-Transcript.* Uploaded by John Stoll, 9 December 2010. Available at: https://dn721608.ca.archive.org/0/items/Skylab4/Sl4PcTranscript_text.pdf (Accessed 30 December 2025).

NASA, (1973-74c) *NASA Johnson Space Center. Air-to-Ground-Transcript.* Uploaded by John Stoll, 9 December 2010. Available at: https://ia801708.us.archive.org/30/items/Skylab4/Sl4A-gTranscript_text.pdf. (Accessed 30 December 2025).

NASA, (1973-74d) *NASA Johnson Space Center. Voice Dump.* Shared by P. Brooker.

NASA, (1973-74e) *NASA Johnson Space Center. Onboard Communication.* Shared by P. Brooker.

NASA, (1973-74f) *NASA Johnson Space Center. Skylab IV. Flight Plan as Flown.* Available at: https://forum.nasaspaceflight.com/index.php?topic=5838.0 (Accessed 30 December 2025).

NASA, (1974g) Lessons learned from the Skylab program. Available at: https://ntrs.nasa.gov/api/citations/19760004100/downloads/19760004100.pdf (Accessed 30 December 2025).

NASA, (2025). Muscle and Exercise Studies to Maintain Crew Health in Space. Available at: https://www.nasa.gov/missions/station/iss-research/astronaut-exercise/ (Accessed 30 December 2025).

Pogue, W. R. (2000) *NASA Johnson Space Center Oral History Project: Oral History Transcript.* Interviewed by Kevin M. Rusnak, 17 July 2000. Available at: https://www.nasa.gov/history/history-publications-and-resources/oral-histories/johnson-space-center/ (Accessed 30 December 2025).

Figures

Figure 1: NASA (1972) *0101536*, Available at: https://images.nasa.gov/details/0101536 (Accessed: 15 January 2026).

Figure 2: NASA (1972) *0101321*, Available at: https://images.nasa.gov/details/0101321 (Accessed: 15 January 2026).

Figure 3: NASA (1973) *0102035*. Available at: https://images.nasa.gov/details/0102035 (Accessed: 15 January 2026).

Annex

Video Essay: Science Per Unit Time: Insights into Living in Space

Creator's Statement

Science Per Unit Time: Insights into Living in Space assembles archival footage and reports of the third manned mission aboard the Skylab space station, and explores conflicts within the space mission related to time. Skylab was the United States' first space station, launched by NASA, and occupied for about 24 weeks between May 1973 and February 1974. Skylab 4 was the third and longest space mission to its date, and housed a number of tests in order to understand how people could live in outer space for an extended period of time. The crew conducted extensive scientific experiments, including solar observations and medical studies, while overcoming early challenges such as space sickness and heavy workloads. These challenges would lead to Skylab 4 becoming infamous for the first supposed strike or mutiny in space, when the astronauts stopped communications with the ground.

The opening minute of the video essay is intended to highlight the multiplicity of time by the question of "where to start" thinking about time in space. A convoluted question that is answered in multiple ways; the imaginaries of NASA, how the mission is deemed useful, and the pre-flight phase that contains dozens of plans for the mission. A synchronisation between the ticking clock in the background and the countdown to the astronauts' rocket launch is intended to bring back to the conflict that would define Skylab's legacy. From here, the essay explores the mission as an exemplary case for the conflictual potential between the Newtonian time – or clock time – and time as an embodied and experienced phenomenon. When Barbara Adam (1998, 40) describes clock time, it is in relation to technological artifacts, following the Newtonian principles of decontextualisation, fragmentation, predictability, abstract space and time; or in other words, "without concern for the life-cycle of a product, without reference to its interaction with the environment, without recognition that the created artifact forms an integral part of the world-wide web of interconnected processes". In Skylab, we follow three astronauts, engulfed in these Newtonian principles, which are not only ever-present in the technological make-up of the space station, but also in the daily scientific practice and experiments performed by the three scientists. Moreover, Skylab 4 became an experiment itself, testing what might happen when humans live for a long period of time in space. As such, as an essential feature, the clock is always in the background.

Only once does the video look into the perspective of the astronauts of what time meant for them during the mission. It goes from " as much science per unit time" – as per the directive of the mission – to feelings of hurriedness, tiredness, pressure, and an abundance of conflict in which the demarcation of time became the centre of the struggle. As such, work becomes an inevitable axis to explore this conflict. The hectic jumps between all the areas of work represent not only the working atmosphere, but also the sheer load of tasks that the astronauts were expected to fulfil day in and day out. What we find in between this mountain of material is the reasoning for needing humans in space, but also what it means to have humanity in space. Sickness, curiosity, decision-making, rebellion, and enjoyment (to name a few) need room when living in space – just as much as they are part of human life on Earth.

The archival footage and interviews with Gerald Carr and Edward Gibson form the basis of the essay. In addition, a few screenshots from the missions press conference, air-ground transcripts, and a few title cards are being used to form an investigative narrator who, along with the audience, forms questions toward the material and finds himself flipping to the pages, comparing them to the video material. Further, the text elements highlight certain aspects that are deemed important for guiding the audience toward the experiences of the crew in the space mission. This gesture intends to invoke a sense of controversy that may further spark the audience to form questions and second guess what they see. My reason for this is that Skylab 4's legacy itself is debated among the press, NASA, and the astronauts themselves, to which extent the activities on Skylab count as a true strike in space or mutiny. As Brooker (2019-20) points out in his podcast series, it can be frustrating that in a case such as Skylab, there was little attention given to these labor conflicts and far more to whether a strike actually happened, or to the quantitative measurements of living in space. This essay, as such, tries to make space for the qualitative experience of what happened at Skylab. In contrast to the arranged material, which is a collage from different kinds of NASA publications, there is one piece that is ever present in the essay; *Tick-Tock* by Hans Zimmer: a piece from the soundtrack for the science-fiction film *Interstellar*, prominently featuring a ticking clock in its foundation. The idea here is to convey a sense of urgency, felt also by the astronauts from time to time again, when the mission's design, and decision-making by planners and controllers, pushed the astronauts to the bearable limit of working hours. Further, the sound is there to remind us of the ever-present feature of time as a controlled unit and should contrast with the work environment in such a way that it feels alien at times. The video essay ends in a moment of relief from the clock, when the orchestra overshadows the ticking noise as the astronauts are seen running in circles in near zero-g, enjoying their weightless environment. However, while the image fades black, the sound of the clock creeps back in; a reminder that human moments like these—of escape from the clock—were rare but precious. As such, this video essay is a reflection on the Skylab 4 mission's struggles, and also a meditation on the intricate dance between human experience and the technological frameworks that define space missions.

References

Adam, B. (1998) *Timescapes of Modernity: The Environment and Invisible Hazards*. London: Routledge.

Brooker, P. (2019-2020) 'Skylab: ASOS…IN SPAAAAACCCEEEE!!!!! (podcast mini-series).' in *Skylab: Living and Working in Space*. Available at https://open.spotify.com/show/6n4XL8KH1atmkwclbr9CWy?si=f00111425a1f46f7. (Accessed 30 January 2024).

AI Usage Table

AI Tool	Work Phase	Prompts/How was the AI used?	Reason for Usage	Comment and Reflection on the Results
QuillBot (Grammar Check)	Grammar and spelling Check at the end of the project.	It's not a generative language model, so no prompt was used. I used the Grammar Check for additional support during my grammar checking process.	Finding grammar and spelling mistakes that I would read over.	Mostly it worked fine in finding grammatical errors. Except for STS specific terminology. It was clear that the software cannot comprehend language. Which is why I never blindly copied a correction.

This table was put together by the STS TAs based on the "Documentation Table" developed by the Writing Center of UniGraz (available here).