

Criminalistics and Crime Scene Investigation in Microgravity Space

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Addresses the challenges and considerations of criminalistics and crime scene investigation in extraterrestrial gravitational environments. Future space exploration may require the development of protocols for extraterrestrial crime scene investigations. Challenges in microgravity effects, confined space environments, forensic techniques, communication, coordination, and legal jurisdiction are highlighted in this brief. Microgravity effects create difficulties in displacing evidence, such as blood spatter patterns, which make interpretation of events difficult. Restricted areas such as spacecraft and stations require special techniques and equipment. Storing and securing evidence in microgravity makes traditional methods impractical. The lack of gravity affects fingerprint development and preservation, requiring the use of alternative methods. Compact and specialized equipment is required to analyze DNA in space. Communication delays hinder real-time collaboration between researchers on Earth and those in space. Guidance can be provided to personnel in space with remote technologies and autonomous systems. Determining legal jurisdiction for crimes committed in space or on spacecraft requires complex international cooperation and agreements. The development of space law, technology and international agreements is important to meet the challenges of extraterrestrial crime scene investigations. Future discussions and research will provide a basis for establishing protocols for extraterrestrial crime scene investigations to ensure effective and fair forensic practices. As space exploration progresses, advances need to be made in these areas. As space exploration advances, the development of space law, technology, and international

agreements is crucial to meeting the unique challenges of extraterrestrial crime scene investigations. This summary provides a basis for future discussions and research regarding the establishment of protocols to ensure effective and fair forensic practices off Earth.

Keywords: Criminalistics; Microgravity; Crime Scene Investigation; Space; Gravity.

Formulation of Research Problem

The disciplines of criminalistics and crime scene investigation, forensic science and space research in space are developing by merging and progressing in the future. However, it should be taken into consideration that crimes are committed in space and due to the micro-levels of gravity, and even due to the human factor that will increase with the increasing astronomy and space science in space where there is no gravity. It should be known how criminalistic and crime scene investigations should be carried out due to the possibility of any incident occurring in space as people are included in space and mission periods are extended. It is necessary to express the problem of uncertainty in the processes of crime scene investigation and criminalistic techniques in space, collecting, examining and analyzing scientific evidence for the purpose of solving the causes or qualities that can be considered forensic in any criminal activity or accident ¹. In order to understand the investigation of crime scenes of different types and sizes in space, it is necessary to

first know enough information about space and understand what kind of challenges the potential risks pose from a criminalistic perspective. The basis of these risks is living in space, working in an environment with microgravity, exposure to radiation and working in a closed environment, that is, in space vehicles, are some of the inherent dangers ². In addition, some of the other dangerous situations that may occur inside and outside spacecraft are equipment malfunctions, medical emergencies and even intentional sabotage. Another problem in space is the knowledge of space researchers in criminalistics and crime scene investigation. It is important that forensic astronauts are trained to be able to conduct crime scene investigations in space, collect valuable evidence, and reconstruct the incident sequence to determine the cause or identify the people involved ³. Unlike Earth, 90 percent of gravity in space is reduced to microgravity. Microgravity, which begins in Earth orbit and continues in space, may vary depending on environmental conditions, that is, according to research conducted in space geology. In this case, microgravity brings

- 1 Chowdhury M. Why CSI: Space will be a far greater challenge than forensic science on Earth / The Conversation. November 14, 2016. URL: <https://theconversation.com/why-csi-space-will-be-a-far-greater-challenge-than-forensic-science-on-earth-68549> (date accessed: 22.01.2024).
- 2 Lampkin J., White R. Space Crime / Space Criminology. Analysing Human Relationships with Outer Space. Palgrave Macmillan, 2023. Pp. 10–15. URL: <https://link.springer.com/book/9783031399114> (date accessed: 22.01.2024).
- 3 Rengert G., Wasilchick J. Space, Time, and Crime: Ethnographic Insights into Residential Burglary. Department of Criminal Justice, Temple University, Philadelphia, PA, 1989. Pp. 78–90. URL: <https://www.ncjrs.gov/pdffiles1/Digitization/127124NCJRS.pdf> (date accessed: 22.01.2024).

differences from standard environmental conditions in the evaluation of physical events by astronauts or forensic astronauts and criminal crime scene investigators. For example, blood spatter patterns may differ in microgravity conditions. This presents special challenges that must be taken into account in scientific and forensic analyzes of events occurring in space ⁴. With all this, examining crime scenes in space poses different challenges and risks compared to some traditional crime scenes, as well as physical, chemical, biological and geological conditions on Earth. For example, the absence of gravity and its presence at micro levels affects the movement and interaction of objects, making it difficult to determine the exact trajectory of bullets or the location of evidence or evidence at the time of the incident. Additionally, the absence or limited availability of vehicles and supplies in space may hinder the collection and preservation of evidence due to limited equipment and equipment. Astronaut forensic investigators must develop new techniques and adapt their practices to the environment, using new methods to effectively secure and analyze evidence. Overcoming such challenges is crucial to the successful investigation of emerging criminal activity or accident-related investigations ⁵.

In case investigation in space, it is important that astronauts, who are space officers, are competent in examining, researching and investigating crimes, even though they are not members of a special profession such as “forensic astronaut”. As life search activities increase in microgravity space, it is noteworthy that astronauts can apply criminalistic techniques at crime scenes in accordance with the environmental conditions ⁶. In recent years, with increasing space exploration and scientific research, criminalistic and forensic sciences have expanded their scope beyond Earth and into space. Increasing investments in colonization are indicators that crimes may occur as the number of people in space increases ⁷. A potential new area for future research to examine in forensic science, criminalistics, and crime scenes appears to be the microgravity of outer space ⁸. Of course, it is not possible to focus only on areas where colonization will occur. Space forensic officers will investigate accidents and crimes that may occur on celestial bodies within space geology. In addition to all these, there is a need to develop new forensic and criminal investigation techniques that can be applied in microgravity environments in cases of increased commercial tourism in space and events that occur or may occur during long-term

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- 4 What is Microgravity? / NASA. February 13, 2009. URL: <https://www.nasa.gov/centers-and-facilities/glenn/what-is-microgravity/> (date accessed: 22.01.2024).
 - 5 Hart S. V. Crime Scene Investigation: A Reference for Law Enforcement Training. U. S. Department of Justice, Office of Justice Programs, National Institute of Justice, June 2004. Pp. 21–54. URL: <https://www.ojp.gov/pdffiles1/nij/200160.pdf> (date accessed: 22.01.2024).
 - 6 Ireland-Piper D., Freeland S. Star Laws: Criminal Jurisdiction in Outer Space. *Journal of Space Law*. 2020. Vol. 44 (1). Pp. 45–69. URL: <https://hdl.handle.net/1959.7/uws:57229> (date accessed: 22.01.2024).
 - 7 Scharmen F. Space Forces: A Critical History of Life in Outer Space. New York, 2021. 272 p.
 - 8 Trombka J. I., Schweitzer J., Selavka C., Dale M., Gahn N., Floyd S., Marie J., Hobson M., Zeosky J., Martin K., McClannahan T., Solomon P., Gottschang E. Crime scene investigations using portable, non-destructive space exploration technology. *Forensic Science International*. 2002. Vol. 129 (1). Pp. 2–5. DOI: [10.1016/S0379-0738\(02\)00079-8](https://doi.org/10.1016/S0379-0738(02)00079-8) (date accessed: 22.01.2024).

space flights ⁹. The applicability of criminalistic techniques and space crime scene investigation techniques to extraterrestrial samples and evidence will vary. Criminalistics and crime scene investigation involve many uncertainties due to new life forms, astrophysics and astrochemistry, and differences in conditions. Forensic scientists will play an important role in investigating crimes with autonomous astronomy systems, both on-site and remotely ¹⁰. Therefore, within astronomy, microgravity also has tremendous potential for crime scene investigations, criminalistic scientific discovery, and advancing our understanding of the cosmos. Space criminalists will be able to analyze artifacts or evidence in case of any crime or trace scientific research that may occur during their missions and other astronomical research.

Article Purpose

This study uses a literature review and conceptual analysis to understand hypothetical challenges associated with criminalistic and crime scene investigations in gravitational environments beyond Earth, specifically microgravity scenarios. This study conducted a literature review covering the existing literature regarding space forensic investigations and crime scene investigations. Published articles, books and scientific reports on criminalistics in space, microgravity effects, limited space environments and forensic science techniques were scanned and the knowledge on these subjects was summarized. The resulting literature was put through a conceptual analysis process. Potential challenges of crime

scene investigations under microgravity conditions in space were identified and proposed solutions to deal with these challenges were examined. Conceptual depth is provided on forensic techniques, communication and coordination, crime scene investigations in limited areas, and legal jurisdiction. Additionally, the research includes suggestions and discussions on how criminalistic or forensic science investigations and crime scene investigations in space can be improved, providing a basis for future research. Suggested methods and explanations are presented to provide guidance for future researchers. This method and methodology aims to understand the information in the literature on criminalistics and crime scene investigations in extraterrestrial microgravitational environments and to create a framework for future research in this field.

Main Content Presentation

Procedures for Conducting Crime Scene Investigations in Space

Crime scene and criminalistic investigation in space and astronomy is a relatively unexplored area of forensic science compared to other areas. As space scientific research increases, there is a need for appropriate procedures for crime scene investigation in space, and the standards of criminalistic investigation techniques need to be determined. Different conditions need to be taken into account when determining such principles. When a crime occurs within space stations or on spacecraft, it is necessary to have systematic approaches

9 Goh G. M. Keeping the peace in outer space: a legal framework for the prohibition of the use of force. *Space policy*. 2004. Vol. 20 (4). Pp. 8–15. DOI: 10.1016/j.spacepol.2004.08.002 (date accessed: 22.01.2024).

10 Freitas Jr. R. A., Valdes F. The search for extraterrestrial artifacts (SETA). *Acta Astronautica*. 1985. Vol. 12 (12). Pp. 1027–1034. DOI: 10.1016/0094-5765(85)90031-1 (date accessed: 22.01.2024).

and procedures to ensure that evidence is collected, classified, protected and analyzed correctly. It is necessary to determine forensic space criminalistic and crime scene investigation procedures externally, outside of spacecraft, that is, in the conditions of planets in celestial bodies, geological structures in stars and in the cosmos, including the universe space¹¹. The main risk and difficulty of crime scene investigations in space for astronauts who will be able to conduct criminal investigations will be microgravity¹². For this reason, the first stage of the research should be to ensure the safety of the area examined by the astronauts and the protection of the crime scene. It is inevitable to use special tools designed for fixing evidence in the air gap, establishing boundaries, for example, for evidence in liquid form¹³.

Once crime and accident crime scenes are secured, the next step is to document them. Astronauts' investigations into and around the station require continuous photographic and video recording to document the location of detailed evidence. In cases where it is very difficult to retrieve evidence that will be thrown into the void due to lack of gravity due to an accident-related explosion in space, these documents will provide the opportunity to examine the remarkable evidence quality. In addition,

researchers must prevent contamination (darkening) of evidence due to restricted air circulation in spacecraft or stations¹⁴.

While examining crime scenes in space at all these stages, the use of robotic autonomous vehicles that can act against microgravity and ensure the safety of astronauts will allow the technical development of criminalistics. Thanks to autonomous vehicles, researchers will be able to carefully document evidence, given the fragile nature of evidence in space. Additionally, appropriate surveillance procedures should be followed to ensure the security of the integrity of the evidence. An on-site examination should be carried out depending on the circumstances of the evidence and the equipment at the technical vehicle or station. Depending on the evidence, safe transportation to Earth should be provided for analysis when necessary¹⁵.

Evidence Collection and Preservation in Microgravity Field

Collecting and preserving evidence in a low-gravity environment requires special methods, techniques, and equipment to ensure the integrity of the evidence. One of the main challenges is that evidence is susceptible to contamination due to its low mass. For similar reasons, astronauts must know and be able to apply special

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- 11 Hart S. V. Op. cit. Pp. 35–43. URL: <https://www.ojp.gov/pdffiles1/nij/200160.pdf> (date accessed: 22.01.2024).
 - 12 White R. Plugging the Leaks in Outer Space Criminal Jurisdiction: Advocacy for the Creation of a Universal Outer Space Criminal Statute. *Emory Int'l L. Rev.* 2021. Vol. 35 (2). Pp. 333–336. URL: <https://scholarlycommons.law.emory.edu/eilr/vol35/iss2/5> (date accessed: 22.01.2024).
 - 13 Montesinos C. A., Khalid R., Cristea O., Greenberger J. S., Epperly M. W., Lemon J. A., Boreham D. R., Popov D., Gorthi G., Ramkumar N., et al. Space Radiation Protection Countermeasures in Microgravity and Planetary Exploration. *Life*. 2021. Vol. 11(8):829. Pp. 20–33. DOI: [10.3390/life11080829](https://doi.org/10.3390/life11080829) (date accessed: 22.01.2024).
 - 14 Burney I., Pemberton N. Making space for criminalistics: Hans Gross and fin-de-siècle CSI. *Studies in history and philosophy of science part C: studies in history and philosophy of biological and biomedical sciences*. 2013. Vol. 44 (1). Pp. 16–19. DOI: [10.1016/j.shpsc.2012.09.002](https://doi.org/10.1016/j.shpsc.2012.09.002) (date accessed: 22.01.2024).
 - 15 Trombka J. I., et al. Op. cit. Pp. 3–5. DOI: [10.1016/S0379-0738\(02\)00079-8](https://doi.org/10.1016/S0379-0738(02)00079-8) (date accessed: 22.01.2024).

methods for collecting and preserving evidence¹⁶. To collect evidence in low-gravity space, astronauts or researchers may use special equipment different from that used on Earth. Because the possibility of radiation on the evidence from outside the station requires attention and similar situations are possible. For this reason, radiation tests are required while securing the evidence. It should not be forgotten that if not performed, it may also damage the evidence. Evidence collection kits and storage containers and similar tools are designed to secure evidence, preventing it from being lost or corrupted. As an example, a specially designed evidence immobilization collection kit consists of adhesive strips or lidded containers that can be sealed to prevent movement of evidence¹⁷. In addition, astronauts need to be careful about evidence whose components may change and deteriorate due to movements that may occur due to contact with the evidence. The portable laboratory must be protected within the station, and gloves and protective equipment are required to prevent deterioration in the examination of evidence¹⁸. Crime scene investigation in microgravity requires planned implementation. Contrary to popular belief, the use of refrigeration and leak-proof containers must be designed appropriately for space. Preferably, researchers may need to rely on alternative techniques and methods.

For example, in biological evidence, cryo-preservation may be preferred to prevent contamination in space and for reliable analysis. Additionally, digital imaging and recording devices should be used to detect visual evidence and ensure that important information is properly protected¹⁹.

Criminalistic Challenges in Microgravity Field

Criminalistics in space is the technical field that combines the principles of forensic science with unique challenges in a microgravity environment. The main difficulties here are the physical conditions in examining the crime scene as well as the preservation and collection of evidence. Due to the absence of gravity or being at micro levels, objects tend to move freely due to their mass. This is a situation that puts evidence at risk in the event of a crime or accident²⁰. Lack of gravity in space can also cause evidence to be dispersed, corrupted or contaminated, negatively affecting investigations. Another challenge is the effects of the lack of gravity on the human anatomy that criminalists can examine in microgravity space, and this should be taken into consideration for both fatal cases and the investigator. Astronauts or cosmonauts in space experience physical changes similar to muscle atrophy and loss of bone density due to low gravity²¹. This situation creates a complicating effect on investigating

- 16 Montesinos C. A., et al. Op. cit. Pp. 6—14. DOI: [10.3390/life11080829](https://doi.org/10.3390/life11080829) (date accessed: 22.01.2024).
- 17 Livesey A. K., Brochon J. C. Analyzing the Distribution of Decay Constants in Pulse-Fluorimetry Using the Maximum Entropy Method. *Biophysical Journal*. 1987. Vol. 52 (5). Pp. 698—702. DOI: [10.1016/s0006-3495\(87\)83264-2](https://doi.org/10.1016/s0006-3495(87)83264-2) (date accessed 01. 22. 2024).
- 18 Ruffell A., McKinley J. Forensic geoscience: applications of geology, geomorphology and geophysics to criminal investigations. *Earth-Science Reviews*. 2005. Vol. 69 (3—4). Pp. 236—238. DOI: [10.1016/j.earscirev.2004.08.002](https://doi.org/10.1016/j.earscirev.2004.08.002) (date accessed: 22.01.2024).
- 19 Burney I., Pemberton N. Op. cit. Pp. 16—23. DOI: [10.1016/j.shpsc.2012.09.002](https://doi.org/10.1016/j.shpsc.2012.09.002) (date accessed: 22.01.2024).
- 20 Vandeviver C., Bernasco W. The geography of crime and crime control. *Applied geography*. 2017. Vol. 86. Pp. 220—225. DOI: [10.1016/j.apgeog.2017.08.012](https://doi.org/10.1016/j.apgeog.2017.08.012) (date accessed: 22.01.2024).
- 21 Feinzeig S. D. How Does Spaceflight Affect the Human Body? *The Science Journal of the Lander College of Arts and Sciences*. 2014. Vol. 8 (1). Pp. 24—27. URL: <https://touro scholar.touro.edu/sjlcas/vol8/iss1/5> (date accessed: 22.01.2024).

crime scenes and applying criminalistic methods and forensic procedures²². Cosmonauts and astronauts can generally examine crime scenes in isolation, on or off various spacecraft, simultaneously in the same environment or in different locations. Any lack of communication or cooperation inside and outside spacecraft will present additional challenges in criminalistics²³. Criminalistic investigations and forensic investigations often require team collaboration and information transfer. Space criminal and forensic investigators need to improve their communication systems to avoid fraud, and establishing assignment protocols is essential. Also mentioned here is the importance of communication with the world, as it is possible that the need for various guidance and expertise may arise²⁴. When all is observed, crime scenes are only found on the earth's surface, and criminalistic investigations can also be carried out in space, although they involve difficulties²⁵. At this point, the importance of criminalists in space and astronomy sciences emerges. Because, in the face of the difficulties of crime scenes in the sky and on earth, investigating and solving the trace and crime path requires the unique application of special techniques and methods. Unlike on Earth, it requires special equipment and training processes to ensure the

integrity and security of evidence in the face of microgravity. Only forensic scientists and criminalistic experts should use or apply alternative criminalistic methods for crime scenes in space. All of these are important for the development and future of the search and investigation of crime scenes outside the Earth's atmosphere²⁶.

Material Evidence in Microgravity

So far, there have been no criminal cases in space for criminalistics and crime scene investigation. Although committing a crime in space and carrying out judicial investigations is an idea that is not yet foreseen in international law systems, it does not mean that it will not happen²⁷. It is clear why we will see concrete steps on this issue in the future. Astronauts, cosmonauts and space agencies sent to space and operating in space conduct research and work for peaceful goals. However, if crimes are committed in space in the future, how these events will be handled and possible issues of examining crime scenes should be subject to the legal framework or laws. Providing evidence or searching for evidence at crime scenes, as well as criminal investigations, is only possible if the crime is determined by law. The necessity of regulating and establishing universal and international space laws is likely due to these reasons.

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- 22 Sarıtaş S., Tarlacı S. Uzay Ortamının Astronotların Duyusal Ve Motor Sistemleri Üzerine Etkisi Ve Uzay Hareket Hastalığı. *Samsun Sağlık Bilimleri Dergisi*. 2022. Vol. 7 (1). Pp 58. DOI: [10.47115/jshs.1084034](https://doi.org/10.47115/jshs.1084034) (date accessed: 22.01.2024).
- 23 Townsley M. Visualising Space Time Patterns in Crime: The Hotspot Plot. *Crime Patterns and Analysis*. 2008. Vol. 1. Pp. 62–66. URL: <http://hdl.handle.net/10072/25749> (date accessed: 22.01.2024).
- 24 Arshad I., Ferré E. R. Cognition in zero gravity: Effects of non-terrestrial gravity on human behaviour. *Quarterly journal of experimental psychology*. 2023. Vol. 76 (5). Pp. 980–986. DOI: [10.1177/17470218221113935](https://doi.org/10.1177/17470218221113935) (date accessed: 22.01.2024).
- 25 Adli Bilimlerde Örnek Alınması ve Delil / ed. O. Celbiş. Ankara, 2019. DOI: [10.37609/akya.1428](https://doi.org/10.37609/akya.1428) (date accessed: 06. 02. 2024).
- 26 Burney I., Pemberton N. Op. cit. Pp. 16–23. DOI: [10.1016/j.shpsc.2012.09.002](https://doi.org/10.1016/j.shpsc.2012.09.002) (date accessed: 22.01.2024).
- 27 Gorove S. Criminal Jurisdiction in Outer Space. *The International Lawyer*. 1972. Vol. 6. Pp. 313–318. URL: <https://scholar.smu.edu/til/vol6/iss2/7> (date accessed: 22.01.2024).

Since the staff at space stations, such as the current International Space Station, are responsible for teams with joint working and security protocols and legal protocols, they can provide material evidence under the same conditions and manage criminal investigations²⁸. However, due to the increasing private sector in space, tourism, scientific research activities and the possibility of active projects such as settlement projects in space in the future, necessary precautions will need to be taken. The issues of committing crimes in microgravity space and examining related crime scenes and judging them with concrete material evidence should be based on a common scientific idea with legal regulations that increase in importance with colonization and space field research²⁹.

It is not always possible to conduct a crime scene investigation in remote control spacecraft and in any environmental conditions in space. The way to deal with this situation can be prevented by the development of space technology and forensic technology³⁰. For example, negative situations resulting from the accident of the station or vehicle in space may also activate new crime scene reconnaissance tools with autonomous control tools. With visual and audio analysis, studies can be developed to identify the causes of the incident, identify problems in the system and prevent similar

problems in the future. Crime scenes and criminal investigations in space activities are too sensitive to be left to space companies and independent experts³¹.

For this purpose, criminalistic investigations should be carried out by joint or autonomous space forces of states and scientists. Of course, it should be noted at this point that space vehicles and equipment are in use and a confidentiality principle is required for access to the criminal laboratories to be established within the stations³². In the scientific crime laboratories to be established, not only crime scenes will be examined with spectrometers, probes, swabs and other measuring devices³³. It should be considered that it can contribute to research for signs of life on planets. Because the atmospheric conditions examined, the components in rock or soil and similar samples can be evaluated as scientific data in subsequent cases or accidents. The main reason for this situation is the formation of colonies as a result of life-search discoveries that will be opened to space in the future³⁴. Crime scene investigations with spacecraft allow us to learn more about planets, satellites, asteroids and other celestial objects. This information helps us deepen our understanding of the formation and development of the universe and provides important data for future space exploration and colonization

28 White R. Op. cit. Pp. 336–356. URL: <https://scholarlycommons.law.emory.edu/eilr/vol35/iss2/5> (date accessed: 22.01.2024).

29 Spektor B. The World's First Space Crime May Have Occurred on the International Space Station Last Year / Live Science. August 27, 2019. URL: <https://www.livescience.com/anne-mcclain-space-crime.html> (date accessed: 22.01.2024).

30 Ireland-Piper D., Freeland S. Op. cit. URL: <https://hdl.handle.net/1959.7/uws:57229> (date accessed: 22.01.2024).

31 Houck M. M., Siegel J. A. Fundamentals of forensic science. 2nd ed. Istanbul, 2009.

32 Ruffell A., McKinley J. Op. cit. Pp. 235–239. DOI: 10.1016/j.earscirev.2004.08.002 (date accessed: 22.01.2024).

33 Adli Bilimlerde DOI: 10.37609/akya.1428 (date accessed: 06. 02. 2024).

34 Hardenstein T. S. In Space, No One Can Hear You Contest Jurisdiction: Establishing Criminal Jurisdiction on the Outer Space Colonies of Tomorrow. *Journal of Air Law and Commerce*. 2016. Vol. 81. Pp. 255–283. URL: <https://scholar.smu.edu/jalc/vol81/iss2/4> (date accessed: 22.01.2024).

attempts. The task here is space forces, astronaut forensic scientists will only be able to conduct such examinations in low gravity areas³⁵. Some of the duties of the Space Force in investigating crimes can be listed as follows: Management of space activities, space security and defense, space communication and exploration, determination of space attack capacity, provision of space intelligence, investigation of crimes and conducting forensic investigations for their recovery³⁶. The missions of space forces may vary depending on the country's policies and strategies, the purposes of space activities and military requirements. Countries' space forces often work in cooperation with other military forces and civilian space agencies³⁷. The branch of ballistics has the biggest impact on space research today and in the future. In this respect, as a different similarity, the importance given to ballistic science in criminalistic and crime scene investigation applications is different³⁸. Currently, the possession of firearms in space is prohibited for defensive purposes under the 1967 bilateral International Out-

er Space Treaty with the United States and the Soviet Union and is considered a weapon-free zone. However, there is no law preventing space forces from carrying a small weapon³⁹. However, firearms cannot be used as a criminal element in space. The reasons for this are gravity at micro levels as well as the lack of oxygen to react with during ignition. However, considering that modernized weapons that may be used in the future have oxidizers, they will have an ignition effect thanks to the chemical that reacts instantly⁴⁰. However, if it is considered according to criminalistics and astronomy, when the gun is fired, the effect will be equal to the reaction force according to Newton's 3rd law, and the result will be a reversal due to microgravity⁴¹. The bullet of a gun fired in micro-level gravity in space may not stop until it hits a fixed object in space because the universe is growing faster than the moving object. Considering that the scene of the incident is a fixed or moving object and its mass is calculated, it can be measured how much impact the object it hits will suffer due to the ballistic

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- 35 Sparavigna A. C. Astronomy and Tidal Analysis Applied to the Study of Julius Caesar's Commentarii. SSRN Electronic Journal. 2016. Pp. 1–10. DOI: [10.2139/ssrn.2817327](https://doi.org/10.2139/ssrn.2817327) (date accessed: 22.01.2024).
- 36 Brownsberger S. Seeing the Invisible: A Short History of Scientific Evidence for Dark Matter / Science in the News. March 5, 2018. URL: <https://sitn.hms.harvard.edu/flash/2018/seeing-invisible-short-history-scientific-evidence-dark-matter/> (date accessed: 22.01.2024).
- 37 Barbier R. The Purpose and Mission of the Space Force / American University. July 23, 2020. URL: <https://www.american.edu/sis/centers/security-technology/the-purpose-and-mission-of-the-space-force.cfm> (date accessed: 22.01.2024).
- 38 Wright D., Grego L., Gronlund L. The Physics of Space Security: A Reference Manual. Cambridge, 2005. Pp. 1–18. URL: <https://www.amacad.org/publication/physics-space-security-reference-manual> (date accessed: 22.01.2024).
- 39 Bourbonnière M., Lee R. J. Legality of the deployment of conventional weapons in earth orbit: balancing space law and the law of armed conflict. *European Journal of International Law*. 2007. Vol. 18 (5). Pp. 874–876. DOI: [10.1016/j.spacepol.2004.08.002](https://doi.org/10.1016/j.spacepol.2004.08.002) (date accessed: 06.02.2024).
- 40 Hitchens T., Katz-Hyman M., Lewis J. US Space Weapons: Big Intentions, Little Focus. *Nonproliferation Review*. 2006. Vol. 13 (1). Pp. 36–42. DOI: [10.1080/107367006000861350](https://doi.org/10.1080/107367006000861350) (date accessed: 22.01.2024).
- 41 Classical Mechanics: A professor-student collaboration / ed. M. Campanelli. Bristol, 2020. 376 p. URL: <https://www.tandfonline.com/doi/abs/10.1080/00107514.2021.1959648> (date accessed: 06.02.2024).

properties created by the bullet or low gravity⁴². Although there is no concrete example of crimes committed with firearms in space so far, it seems theoretically possible to conduct a crime scene investigation regarding crimes committed with weapons in space⁴³. In 2021, Russia deliberately tested weapons to destroy one of its own satellites, Cosmos 1408, and thousands of pieces were thrown into space. Similar tests The United States, China, India and Russia have tested anti-satellite weapons in space. However, the United States became the first state to ban anti-satellite weapons in 2021⁴⁴. Microgravity effects should be handled in different ways in criminalistic investigations in the space field, which should be understood from the symptoms. It is possible to observe that material evidence exhibits variable trace evidence, unlike in the world due to the lack of gravitational force⁴⁵. As understood especially from ballistic studies, the main reason for this is that the laws of physics work differently than in the world. Differences will inevitably be observed in chemical and biological evidence. Displacement of Evidence: Objects can float freely as soon as the effect of motion due to a standard force due to microgravity is observed. In this case, deterioration in the evidence may

cause location changes, making it difficult to identify the actual crime scene⁴⁶. Blood Spatter Models: Another aspect of crime scene investigation that may require criminalistic examination for crimes that may be committed in space, although not currently, is blood spatter-related analyzes and tests. Traces of blood, which can be found in liquid or dry form due to the lack of gravity, behave differently in the space environment and may affect the investigation of criminal investigation differently⁴⁷.

Forensic Techniques

Fingerprint: This type of trace evidence can be inside spacecraft or in the environment where humans may live, where a colony may have been created. The reason is to wear protective clothing in open remote areas. Therefore, microgravity has little effect on fingerprints. The same applies to footprints.

DNA Analysis: Necessary DNA analyzes in space can be performed with compact and special equipment. However, it is difficult to detect this type of evidence at crime scenes in microgravity, because this evidence, which may be quite small, may be overlooked and lost in the air space⁴⁸.

Crimes are actually being committed in space, even now, with technological tools.

42 Wright D., Grego L., Gronlund L. Op. cit. Pp. 52–65. URL: <https://www.amacad.org/publication/physics-space-security-reference-manual> (date accessed: 22.01.2024).

43 Rosa-Aquino P. What happens if you break the law in space — and 3 times people or governments have tested the rules / Business Insider. Nov 12, 2022. URL: <https://www.businessinsider.com/what-happens-if-you-break-the-law-in-space> (date accessed: 22.01.2024).

44 Reiss R. Have There Been Any Crimes Committed In Space? / Space-facts.co.uk. Mar 27, 2023. URL: <https://www.space-facts.co.uk/have-there-been-any-crimes-committed-in-space> (date accessed: 22.01.2024).

45 Hermida J. Crimes in Space: A Legal and Criminological Approach to Criminal Acts in Outer Space. *Annals of Air and Space Law*. 2006. Vol. 31. Pp. 17–19. URL: <https://www.julianhermida.com/dossier/dossiercrimmcgill.pdf> (date accessed: 22.01.2024).

46 Lampkin J., White R. Op. cit. Pp. 150–165. URL: <https://link.springer.com/book/9783031399114> (date accessed: 22.01.2024).

47 Karakuş O., Ünal B. Biyolojik İncelemeler. Olay Yeri İnceleme / Kriminalistik ; ed. O. Karakuş. 2nd ed. Ankara, 2009.

48 Sander E. Olay yerinde kriminalistik. Ankara, 1997. 416 p.

Because this is because internet networks surround the world from space. For this reason, there are concepts of “Cyber Space, Cyber Space and Cyber World”⁴⁹. When considered from a criminalistic perspective, all areas where cyber crimes occur are considered crime scenes. To give an example of the reason, disrupting, damaging or destroying an internet network and the technological tools connected to it, that is, the system of satellites, is considered a crime. Any change or touch made remotely in any system will cause many problems such as drifting in the microgravity field in space or a satellite falling to the earth in the near-earth area. If external cyber crimes are committed in outer space, the destruction of the defense systems of states will result in serious risky consequences⁵⁰. In addition to cyber security and informatics tools, the increase in artificial intelligence studies means that crimes can be committed through AI in space. Since artificial intelligence and technological devices can be used in a microgravity environment, it can be considered as a crime scene investigation, concretely or abstractly. It is necessary to collect evidence in case artificial intelligence remote sensing devices or autonomous vehicles are attacked in space where gravity is low. It is only possible to access the causes and consequences through recording systems. In addition, obtaining data mines safely will help shed light on the events⁵¹.

Conclusions

Although criminal investigations are not currently common in space, forensic

investigations will increasingly be conducted in the future because gravity is low. Its main source is the increasing speed of space and astronomy research. There is no doubt that space exploration research, including the idea of searching for life and establishing colonies, will gain differences in criminal crime scene investigations in the microgravity environment in the future. Forensic research and the examination of criminal trace evidence or crime scenes concern not only the space area where the human factor is located, as it is thought, but also all kinds of material evidence of criminal elements originating from human-dependent autonomous vehicles or technological means.

Space incident investigation is an important field that combines forensic science or criminalistics and space exploration. This discipline has become increasingly critical with the increase in space missions. In the event of a crime in space, collecting and analyzing evidence is vital to astronaut safety and the success of space missions. However, difficulties such as this low-gravity environment and limited resources make crime scene investigation in space different from the gravitational world. Increasing crime scene investigation experiments and research in space can increase the safety of future space missions and contribute to more effective space exploration. Additionally, it will be valid for colonization in space and space tourism. Advances in this field could accelerate scientific discoveries about crimes in space and analysis of extraterrestrial samples. Thus, not only criminal research and development is limited, but also leads to scientific discoveries

49 Cyberspace and National Security: Threats, Opportunities, and Power in a Virtual World / ed. D. S. Reveron. Georgetown University Press, 2012. URL: <https://www.jstor.org/stable/j.ctt2tt6rz> (date accessed: 22.01.2024).

50 Reiss R. Op. cit. URL: <https://www.space-facts.co.uk/have-there-been-any-crimes-committed-in-space> (date accessed: 22.01.2024).

51 Trombka J. I., et al. Op. cit. Pp. 1–9. DOI: 10.1016/S0379-0738(02)00079-8 (date accessed: 22.01.2024).

about the universe that are waiting to be discovered.

Depending on all these, it is inevitable to create relevant legal laws in order to prevent crimes committed in space and those that may be committed in the future. This situation has become even more critical with the increase in the exploration and use of space. Existing similar instruments, such as the International Outer Space Treaty, support the use of outer space for peaceful purposes, but do not contain detailed provisions regarding crimes. For this reason, it is obvious that there is a need for regulation in order to prevent and address the problems and risks that will be encountered in future space and astronomy activities. Establishing an effective legal framework to combat crimes in space will require international cooperation and the active participation of states with a presence in space. With the creation of the necessary laws, criminalistic and forensic science research will also increase.

Collaboration between space agencies, legal experts, and scientists is critical to identifying crimes, defining penalties, and establishing trial processes. It provides concrete evidence of scientific findings and research results, which are also mentioned in criminalistic and crime scene investigations in microgravity space. With the research conducted, it is possible to determine that it will gain more importance in the coming years in order to ensure security and order in space.

**Криміналістика
та розслідування місця злочину
в мікрогравітаційному просторі
Горкем Ардакан Тан**

Розглянуто проблеми криміналістики щодо розслідування місця злочину в позаземних гравітаційних середовищах. Майбутнє дослідження космосу може потребувати розроблення протоколів для розслідувань позаземних місць злочину.

Висвітлено проблеми, пов'язані з впливом мікрогравітації, замкнутим космічним середовищем, криміналістичними методами, комунікацією, координацією та юридичною юрисдикцією. Ефект мікрогравітації створює труднощі, пов'язані з переміщенням доказів (наприклад, крапель крові), що ускладнює інтерпретацію подій. Зони обмеженого доступу (такі, як космічні кораблі та станції) потребують спеціальних методів і обладнання. Зберігання та захист доказів в умовах мікрогравітації робить традиційні методи непрактичними. Відсутність гравітації впливає на розвиток і збереження відбитків пальців, що потребує використання альтернативних методів. Для аналізу ДНК у космосі потрібне компактне та спеціалізоване обладнання. Затримки зв'язку перешкоджають співпраці в реальному часі між дослідниками на Землі та в космосі. Визначення юридичної юрисдикції для злочинів, скоєних у космосі або на космічних кораблях, потребує складної міжнародної співпраці та відповідних угод. Розвиток космічного права, технологій і міжнародних угод важливий для розв'язання завдань позаземних розслідувань. Майбутні обговорення та дослідження стануть підґрунтям для створення протоколів позаземних розслідувань місця злочину, щоб забезпечити ефективну та справедливую судово-експертну практику. Оскільки дослідження космосу прогресує, то розвиток космічного права, технологій і міжнародних угод має вирішальне значення для розв'язання унікальних завдань розслідування на позаземному місці злочину. Це дослідження забезпечує основу для майбутніх обговорень створення протоколів для забезпечення ефективної та справедливої судово-експертної практики поза межами Землі.

Ключові слова: криміналістика; мікрогравітація; розслідування на місці злочину; космос; гравітація.

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Declaration of Competing Interest

Author declares that there are no conflict of interest.

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