Brief information about the project

Name of the project	AP19676900 "New methodology for calculating radio wave propagation for terrestrial communications"
Relevance	Nowadays, network operators need to provide high-quality communications anytime, anywhere. This requires careful planning and design of a telecommunications system, the performance of which is highly dependent on the attenuation of transmitted power as it propagates through space. The difficulty of accurately determining path loss poses a significant challenge for operators who struggle with approximate solutions to optimize performance. Path losses depend on both the geometry of the environment and the electrical characteristics of the transmission medium. Thus, a tool that considers all the important parameters affecting the propagation of electromagnetic waves will greatly help in network design and timely delivery of improved connectivity services to the market.
Purpose	a) Develop network planning software to efficiently calculate path losses (e.g. urban, suburban, rural) over a wide range of frequencies. b) Obtain a more accurate asymptotic solution (Sommerfeld problem) of the propagation of electromagnetic waves over the interface between two media, possibly in plasma and more complex structures.
Objectives	1. Expand the theoretical model of the propagation of electromagnetic waves with data from well-known empirical and analytical models applicable to complex non-planar media. 2. Improve the solution to the Sommerfeld radiation problem in the spectral region and expand it to all possible parameters that influence the location of the reflection coefficient pole, including the case of plasma media and the THz frequency range. 3. Develop a time-optimal and reliable software tool for calculating losses in external radio communication lines. 4. Develop an improved empirical model for calculating path loss for use in urban, suburban, and rural conditions. 5. Case study of real network design using NOVELPATH simulator. 6. Solve the Sommerfeld radiation problem for additional cases of practical importance.
Expected and achieved results	A new theoretical model of electromagnetic wave propagation for terrestrial communications has been developed, taking into account data from well-known empirical and analytical models that are directly applicable

	to urban, suburban and rural areas; detailed comparison of the results of the analytical method with numerical solutions in the spectral domain, as well as determination of the limits of applicability of the analytical method. A time-optimal and reliable software tool for calculating losses in outdoor radio links (NOVEPATH simulator), a software package for radio visibility network design that provides "real" data with minimal need for field measurements; use of the exact solution of the Sommerfeld radiation problem in mathematical modeling as a simulation platform for obtaining empirical models; open space monitoring activities - urban, suburban, rural and open space scenarios from hectometer to centimeter waves, data approximation and alignment of path loss correction factors. Comparison of accuracy and convergence time of alternative solutions with NOVEPATH in a real scenario; short-wave asymptotic solution of the Somerfeld problem in the GT wave range for various media.
Research team members with their identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and links to relevant profiles	1. Саутбеков Сеил Сейтенович, доктор физико-математических наук, Индекс Хирша – 7, Researcher ID AAH-5891-2021, ORCID: 0000-0001-9198-4524, Scopus author ID: 24725586300. 2. Саутбекова Мерей Сеиловна, PhD, Индекс Хирша – 2; Researcher ID, ORCID: 0000-0003-2367-6022, Scopus Author ID: 55452136900. 3. Алькина Гульнар Каирбековна, Индекс Хирша – 1; Researcher ID, ORCID, Scopus Author ID: 53983789400 1. Байсалова Куралай Несипбековна, PhD-студент, Индекс Хирша – 1; Researcher ID, ORCID: 0000-0001-8576-3514, Scopus Author ID: 57296508000
List of publications with links to them	1. Sautbekov, S., Sautbekova, M., Baisalova, K., Pshikov, M. Calculation of Sommerfeld Integrals in Dipole Radiation Problems. *Mathematics*, 2024, (12), 298 https://doi.org/10.3390/math12020298 2. Bimurzaev, S., Sautbekov, S., Sautbekova, Z. Calculation of the Electrostatic Field of a Circular Cylinder with a Slot by the Wiener–Hopf Method. *Mathematics*, 2023, 11(13), 2933 https://doi.org/10.3390/math11132933 3. Sautbekov, S., Baisalova, K. Radiation of a Point Magnetic Dipole Moving in a Medium with Superluminal Speed. *Journal of Nuclear Energy Science and Power Generation Technology*. 2023, Vol.12, #3, 1000334 4. S. Sautbekov, P. Frangos, S. Bourgiotis and M. Pshikov, Radiation by a nano – ring. *Journal of Applied Electromagnetism (JAE)*, National Technical University of Athens (NTUA), School of Electrical and Computer

	Engineering, Athens, Greece, July 2023, http://jae.ece.ntua.gr/ 5. Саутбеков С.С., Пшиков М.И., Башаров Н.Е. Излучение магнитного диполя, движущегося со сверхсветовой скоростью в среде. Ашық жүйелер эволюциясының мәселелері журналы. №1-2 (25). 2023. с. 30-34. DOI. 10.26577/JPEOS.2023.v25.i1-2.i4 6. Baisalova K.N., Lombardi G., Sautbekov S.S. Classification of analogies as a methodological framework for use in instruction in physics. Recent Contributions to Physics. №2 (85). 2023. P. 59– 73. DOI. 10.26577/RCPh.2023.v85.i2.09 7. Sautbekov, S. Vavilov-Cherenkov Dipole Radiation. Third Annual Meeting of Kazakhstan Physical Society: Abstracts (June 7–11) Kurchatov: RSE NNC RK, 2023, 126 p. 8. Sautbekov, S., Alkina, G. Sommerfeld integrals asymptotics in dipole radiation problems. 2023 International Conference on Electromagnetics in Advanced Applications (ICEAA), pp. 654-658. IEEE, 2023 DOI: 10.1109/ICEAA57318.2023.10297628
Patents	-