

Brief information about the project

Name of the project	AP26104583 Development of attitude determination and control system of a nanosatellite for remote sensing of the Earth»
Relevance	The growing demand for accurate Earth remote sensing data and the development of small satellite technologies require efficient and cost-effective 3U nanosatellites. The key factor determining their performance is the accuracy of the attitude determination and control system, which directly affects the quality of satellite imagery. The project aims to develop a high-precision and energy-efficient attitude control system using magnetorquers and reaction wheels, as well as to integrate two cameras with resolutions of 40 m and 6 m. Its implementation will improve data quality and expand the functional capabilities of nanosatellites.
Purpose	The purpose of the project is to develop a control system ensuring medium and high attitude accuracy of a 3U platform nanosatellite for Earth remote sensing tasks.
Objectives	– Development of attitude control system algorithms for a nanosatellite using magnetic coils to ensure camera pointing accuracy within 3–5 degrees at 40-meter resolution. Measurable indicators: camera pointing angular error does not exceed 3–5 degrees; camera resolution is at least 40 meters. Role: effective algorithms using magnetic coils will ensure stable nanosatellite attitude within the required limits; attitude accuracy is essential for obtaining high-quality data from the 40-meter resolution camera. Relationship to other tasks: the algorithms of this task may influence the overall nanosatellite control system, interacting with algorithms developed in other tasks. Expected results: development of effective algorithms for precise camera pointing at 40-meter resolution; demonstration of the operability of the algorithms using magnetic coils. – Development of attitude control system algorithms for a nanosatellite using reaction wheels for precise camera pointing within 1 degree at 6-meter resolution. Measurable indicators: camera pointing angular error does not exceed 1 degree; camera resolution is at least 6 meters. Role: reaction wheel control algorithms will provide high attitude accuracy, which is critical for the high-resolution camera. Relationship to other tasks: integration of algorithms with magnetic coils and reaction wheels of the control system to ensure coordinated operation. Expected results: development of effective algorithms for precise camera pointing at 6-meter resolution; successful tests using reaction wheels for attitude control. – Design of an attitude control system for a small spacecraft equipped with two cameras of different resolutions (40 and 6 meters), followed by integration

	into the nanosatellite service platform. Measurable indicators: successful integration of the control system into the service platform; synchronization of the operation of the two cameras with different resolutions. Role: designing a unified attitude control system that accounts for the differences between cameras will ensure effective use of data from both cameras. Relationship to other tasks: use of attitude algorithms developed in previous tasks for optimal coordination between cameras. Expected results: a control system ready for integration, capable of operating effectively in space conditions; successful integration of the developed control system with the service platform, ensuring coordinated operation and collection of high-quality data. Technology Readiness Level (TRL) at the time of application submission – 2, and it is planned to be brought to level – 4 upon project completion.
Expected and achieved results	A nanosatellite attitude control system with medium accuracy based on frequency-domain quality criteria, using the Ziegler–Nichols, Chien–Hrones–Reswick, and T-sum methods for tuning controller gains; A nanosatellite attitude control system with high accuracy using active attitude and stabilization systems based on linear control algorithms such as PID controller, pole placement method, LQR controller aimed at minimizing the integral quality performance functional, and robust control algorithms such as μ and H_∞ controllers, Extended Kalman Filter (EKF), etc. for stochastic processes; A technology for developing a combined attitude control system for an Earth Remote Sensing nanosatellite based on Bdot damping algorithms, Model Predictive Control, sliding mode control (for dynamically symmetric bodies), and adaptive control; Training of at least 1 (one) Doctor of Philosophy (PhD) or Doctor of Sciences, with the dissertation defended no later than 2 (two) years after project completion. – At least 2 (two) articles and/or reviews in peer-reviewed scientific journals indexed in Science Citation Index Expanded, ranked in the 1st and/or 2nd quartile by impact factor in Web of Science and/or with a CiteScore percentile in Scopus of at least 65 (sixty-five); – At least 2 (two) articles or reviews in a peer-reviewed foreign or domestic journal recommended by KOKSNVO; One of the articles must be in the category "multidisciplinary" (of multidisciplinary or interdisciplinary practical application) addressing tasks of enterprises from the real sector of the Kazakhstan economy; furthermore, the project results must include design and engineering documentation prepared in accordance with ESKD standards.

	For domestic journals from KOKSNVO List 1 that do not fall under the "multidisciplinary" category, journals from KOKSNVO Lists 1 and 2 that are indexed in two or more categories are accepted. 2) Publication of monographs: a monograph is planned to be published by the "Kazakh University" publishing house; 3) Obtaining patents: not planned. 4) Development of scientific-technical and engineering documentation: development of design and engineering documentation is planned. 5) Dissemination of results: dissemination will be carried out through the publication of scientific articles and reports at international scientific symposia and conferences and in the open press. 6) Other measurable results: algorithms for controlling the angular motion of a 3U platform nanosatellite for Earth Remote Sensing will be developed, and applications for copyright registration will be filed.
Research team members with their identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and links to relevant profiles	Rakisheva Zauze Bayanovna (Candidate of Physical and Mathematical Sciences, Professor, Project Leader) h-index = 4 Scopus Author ID: 56449239900 ORCID: 0000-0003-2745-7775 Shinichi Nakasuka (PhD, Professor) h-index = 22 Scopus Author ID: 35401647800 ORCID: 0000-0003-4479-1951 Kalieva Nazgul Bolatovna (PhD, Acting Associate Professor, Al-Farabi Kazakh National University) h-index = 1 Scopus Author ID: 57191632932 ORCID: 0000-0002-8629-0023 Ibraev Gulama-Garip Alisher Erikzhanovich (PhD) h-index = 4 Scopus Author ID: 57190969416 ORCID: 0000-0001-5000-0023 Doszhan Nursultan Sagynaiuly (PhD, Acting Associate Professor, Al-Farabi Kazakh National University) h-index = 1 Scopus Author ID: 57212867470 ORCID: 0000-0001-6178-8389 Lyazat Zhanbolat Tulendyuly

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Usage	The developed control algorithms for small spacecraft with medium and high accuracy can be applied to the design of attitude determination and control systems and navigation systems for 3U nanosatellite platforms for various purposes. They may be of interest to target audiences such as universities (L.N. Gumilyov Eurasian National University, Satbayev University, AUES), research institutes (JSC “National Center for Space Research and Technology”, Institute of Space Engineering and Technology, Institute of Ionosphere, Fesenkov Astrophysical Institute), National Company “Kazakhstan Gharysh Sapary”, GHALAM LLP, and laboratories (e.g., Intelligent Space Systems Laboratory at the University of Tokyo).
Priority compared to real-world alternatives	-
List of publications with links to them	-
Patents	-