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Outside the Earth: Translating and Exploring with Tsiolkovsky

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1. Introduction

This article describes a study that grew out of research and translation work completed within the framework of a series of innovative interdisciplinary courses called "Russian for Rockets." While there are currently no language study requirements in most science, technology, engineering, and mathematics (STEM) disciplines, there is a high demand among STEM majors in U.S. universities for language courses with a strong technical component. In particular, a poll at the Purdue School of Aeronautics and Astronautics conducted in 2018 showed that over 90% of respondents were interested in taking a course in technical Russian.[1] This finding resulted in the development of unique language courses in the Russian Program at Purdue University that explore science and engineering from linguistic and cultural perspectives. These courses target students with different levels of proficiency in Russian (from elementary through intermediate to advanced) and with various majors, interests, and backgrounds. The courses are part of the Purdue School of Languages and Cultures LSP (Languages for Specific Purposes) initiative, in which we address the needs of a versatile community of students in our language classes focusing on their specialized professional areas.

Recent course offerings within the series include "Russian for Scientists and Engineers," "Russian, Rockets and Space," and the grant-winning course "Technical Russian."[2] Co-taught in collaboration with

[1] The poll was designed and conducted by Dr. Alina Alexeenko (Aeronautics and Astronautics, College of Engineering, Purdue University) and Dr. Olga Lyanda-Geller (School of Languages and Cultures, College of Liberal Arts, Purdue University) in October 2018. The survey was completed by Purdue Aeronautics and Astronautics majors.

[2] The course Russian, Rockets and Space (offered in Fall 2019) was taught by Dr. Alina Alexeenko and Dr. Olga Lyanda-Geller for the Purdue Honors College. The courses Russian for Scientists and Engineers (offered in Summer 2019) and Technical Russian (offered in Spring 2021) were designed and taught by Olga Lyanda-Geller for the Purdue Russian Program. The Technical Russian course was awarded a course development stipend from Indiana University in March 2020.

Language and Engineering faculty, and including speakers from a variety of disciplines, these unique courses have seen a steep increase in popularity among STEM and non-STEM students alike. While continuing to work on their proficiency in Russian, students taking these multidisciplinary courses learn about the history of science and current scientific and engineering technologies in the Russian-speaking world. The ability to foster collaboration with Russian-speaking partners[3] and to have direct access to authentic materials in Russian can spur significant scientific and technological breakthroughs. An illustration of this need in fostering the collaboration is NASA's requirement of knowledge of the Russian language for many jobs in the U.S. space program. Students who took these interdisciplinary courses enjoyed working on interesting and challenging projects, including but not limited to translation studies.[4] This faculty-student collaboration resulted in two conference panels and a book project that stemmed from the translation work.

In these specialized Russian courses designed for scientists and engineers, which attract students from the entire Purdue campus, we work with authentic Russian and English texts and corpora themed around space. In this paper, we focus on our translation and commentary on Konstantin Tsiolkovsky's *Вне Земли* [*Outside the Earth*], a science fiction novel that was started in 1896, finished and partially published in 1916, and fully published in 1920 (Tsiolkovsky, 1920).

2. Scholarly and educational contributions

The annotated translation project we discuss here stemmed from our classes dedicated to the Russian language, rockets, and space that targeted students with different language skills. The courses' objectives included learning about the history of space exploration and current space technologies. The courses' learning outcomes consisted of building basic translating and interpreting skills to work with specialized English and Russian texts, as well as developing an understanding of key scientific discoveries.

[3] This includes professionals, researchers, scholars, industry, business and government representatives in the US and abroad with whom students will be able to collaborate now and in the future.

[4] Other projects included presentations about the animals used by space programs, astronaut fatalities, and other space-related presentations. There were also interdisciplinary projects involving using different software, for example, to explore the possibilities of applying coding for studying space vocabulary and corpus design.

Space remains only partially explored so far. To enable future Elon Musks, we need to constantly reevaluate the ideas of space pioneers and explorers. Interest in space is reflected not only in aerospace scientific and engineering papers but also in children's literature, literature for young adults, and popular science. Students who took these interdisciplinary courses, regardless of their major areas of specialization, reported that they were inspired by the possibility of getting acquainted with these diverse scholarly and artistic texts in their original language.

Students with mixed STEM and liberal arts backgrounds and different levels of language proficiency enrolled in these specialized space-oriented Russian classes. Multiple research and translation projects stemmed from the partnership between aerospace engineering and Russian faculty and students. We confirm that productive work with authentic sources and documents is possible for students of all levels, including students with little or no background in the language. We chose primary and secondary reading sources that would provide the maximum benefit to students. After just one semester of Russian, the beginners were able to work with original texts, such as technical manuals and excerpts from newspapers and memoirs. Students with more advanced language skills, including those from STEM departments and those with no aerospace background, reported enjoying reading and translating literary sources, in particular, space-based science fiction, such as Konstantin Tsiolkovsky's *Outside the Earth* (1920) and Aleksei Leonov's children's book *Солнечный ветер* [*Solar wind*] (1977).

This paper, however, describes a collaborative project between a Russian faculty member and an undergraduate heritage student of Russian who is an Aerospace major and a Russian minor. The collaboration resulted in a book-length scholarly contribution containing both translation and extensive scientific, engineering, and linguistic commentary.[5] This project contributes to broadening the language, literature, and engineering horizon of students' education via implementing inspiring research and translation work.

[5] The next stage of our collaborative work is a book proposal with a subsequent publication of the book.

3. Methods

Due to the interdisciplinarity of our project, we combined different methods in the study, bearing in mind the following target audiences:

(i) Speakers of English with interest in aerospace engineering working toward improving their Russian reading proficiency

(ii) Heritage speakers of Russian both with and without special aerospace background working toward expanding their literary and scientific vocabulary and improving their syntax, grammar, and style

In our translation work, we primarily used two methods: source text analysis and translation with commentary (Williams & Chesterman, 2015). Source text analysis with a prior examination of semantic, syntactic, and stylistic characteristics of the original text prepared the student translator to find better translation solutions. As Tsiolkovsky's text is an original science fiction novel with highly specialized technical components, the result of our work is a cross-genre translation.[6]

While working on the translation, we also provided cultural, historical, linguistic, scientific, and engineering commentaries on various aspects of the text. Translation with commentary required language, literature, and engineering research from both authors of the paper. We focused on collaborative product-oriented research with a descriptive and explanatory approach to the source text (Saldanha & O'Brien, 2015).

This combination of methods allowed us to pursue our research and educational purposes, which were different from providing yet another artistic translation.[7] Our purpose was to prepare an annotated bilingual edition of a novel with scientific and linguistic commentaries,

[6] Our cross-genre translation project brings together elements of science fiction and scientific and technical literature.

[7] In 1979, Adam Starchild translated *Outside the Earth* as part of his edited collection of Tsiolkovsky's science fiction (Tsiolkovsky, 1979/2000). In the introduction to his collection of translations, Adam Starchild professed to being "an avid science fiction reader" to whom the translation was "a labor of love" (Tsiolkovsky, 1979/2000, p. 4). Our new translation combines both the artistic and engineering perspectives, with an emphasis on the science component. Adding the engineering perspective has resulted in changes in the language made to better suit the target demographics: people with an interest in science, language, and space travel, rather than just science fiction fans. Furthermore, in the more than 40 years since the publication of Starchild's collection of Tsiolkovsky's works, technical lexicon has significantly evolved, which further justifies the need for a retranslation. For example, Starchild translates the word *шар* as "globule," while our translation renders it as "sphere," as it is commonly used in modern aerospace science.

thus making a science fiction masterpiece available for reading in the original language to a broad audience—from high school and college students to independent learners of Russian.

4. Work on the project

4.1. Choice of the source text: The importance of translating Tsiolkovsky's science fiction

In the engineering program at Purdue University, students begin in a common curriculum before applying to a specific program. When Michael Pilipchuk was accepted into the Aerospace program, one of the first classes he took was Introduction to Aerospace Design. Students in the class were passionate about different aspects of aviation or space travel and conducted research on its history before the class began. However, when the students started learning the fundamental rocket equations, instructors noticed a gap in their collective knowledge: most of the students were not familiar with Russian rocket scientist and author Konstantin Tsiolkovsky. Some students recognized the Ideal Rocket Equation he had derived, but his name was a mystery. The reason that Tsiolkovsky was unknown was not that he was one of the first rocket scientists in the world, because, for example, his contemporary, Robert Goddard, is well recognized, even among people who do not specifically know his work. Konstantin Tsiolkovsky's contributions to rocket science are just as vital, but his name remains, undeservedly, largely unknown to the Western world, despite his renown in Russia.

For the course Russian, Rockets and Science, students were assigned to read the first few chapters of Tsiolkovsky's fictional work *Outside the Earth*. One student, Michael, was surprised to realize that the man behind one of the most fundamental equations of rocket science turned out to be a science fiction author as well. Reading the first four assigned chapters of the novel was not enough for Michael, and he continued working on translating other chapters of the book, which ended up turning into his main assignment for that class. When the semester ended, the translation was not yet complete, so the project and the faculty-student collaboration expanded beyond the class. The goal became to make a coauthored, guided book-size reader that would include side-by-side translations and commentary both on the language (Olga Lyanda-Geller) and on the science aspects of the work (Michael Pilipchuk).

4.1.1. Tsiolkovsky as a scientist

Now considered one of the three founders of rocket science,[8] Konstantin Eduardovich Tsiolkovsky (1857–1935)[9] came from humble beginnings. After an illness left him almost deaf at the age of 10, he was forced to quit school and resort to studying at home. Having overcome illness and adversity to get an education, Tsiolkovsky used his mostly self-taught knowledge to design airplanes and dirigibles. To test them, he built the first wind tunnel in Russia, where he conducted research on drag and aerodynamics. Tsiolkovsky's interests then gradually shifted to space, leading to his most ground-breaking work. His passion for space encouraged him to explore life beyond Earth and write about the possibility of life in space.

The crown jewel of Tsiolkovsky's research was in chemical propulsion. Tsiolkovsky was one of three rocket scientists to independently derive the ideal rocket equation, forming the foundation of the field of rocketry at the beginning of the 20th century. Tsiolkovsky was the first of the three to publish the equation, in 1903. The relationship outlined in the Ideal Rocket equation relates the change in velocity provided by an engine of a given efficiency (specific impulse), gravity, and the change in mass, which accounts for the quantity of burned fuel. In short, it is the idealized version of the equation comparing a rocket's change in speed to fuel burn in the absence of external forces.

Tsiolkovsky's work has been widely recognized by space explorers. His legacy has been revered not only in Russia, where he was born, but also in Western nations. This point of view has been shared, in particular, by Wernher von Braun, who laid the foundation of practical rocket science and engineering (Braun et al., 1985). In the former Soviet Union and in modern Russia, though, Tsiolkovsky has been the subject of apologetics, and his achievements have at times been exaggerated. In general, there was a tendency in the Soviet Union to create a cult of a Russian scholar, at the expense of silencing the contributions of the rest of the world. For instance, Tsiolkovsky could have been represented as the only founding father of modern rocketry and astronautics, while he actually was one of the few, together with the

[8] Together with Hermann Oberth (1894–1989) and Robert H. Goddard (1882– 1945).

[9] The amount of biographical, critical, and scholarly literature dedicated to Tsiolkovsky in different languages is immense. To start acquaintance with Tsiolkovsky's biography, one might consider Andrews (2009); Golovanov (1970); Demin (2005); and Vorob'iev (1940).

Frenchman Robert Esnault-Pelterie, the Germans Hermann Oberth and Fritz von Opel, and the American Robert H. Goddard. Or Tsiolkovsky could have been credited with being the first to suggest the idea of a multi-step rocket in 1929, while in reality Goddard had patented this idea six years earlier, in 1914 (Mars [2021] and Dunbar [2013]). This tendency continues today, and traces of "Tsiolkovsky's myth" can still be found in literature (see, e.g., Alekseeva [2007]; Demin [2005]; and Majsova [2018]).

However, had nothing to do with creating this myth, just as he had nothing to do with creating the "Tsiolkovsky anti-myth" that exists in modern criticism. This anti-myth, which appeared after the dissolution of the Soviet Union, exaggerates Tsiolkovsky's weaker points (see, e.g., Hagemeister [2012] and Salakhutdinov [2003]), and is also not justified. In this regard, Tsiolkovsky's books stand by themselves, and an unbiased study is necessary to discover the true scale of this visionary.

4.1.2. Tsiolkovsky as a science fiction writer

Books helped Tsiolkovsky continue his education after his hearing loss and were his life-long passion. Tsiolkovsky appreciated the works of Jules Verne— in particular, his novels *From the Earth to the Moon* (1865) and *Around the Moon* (1869). Verne's works unlocked Tsiolkovsky's interest in science and exploration and also served as a source of ideas. Tsiolkovsky's literary interests directly fed into his scientific inquiries and vice versa, and writing provided a way for him to express scientific ideas in a manner comprehensible by the lay reader. To this end, Tsiolkovsky's first notable work was *На Луне* [On the Moon], written in 1887, first published in 1893. *Outside the Earth*, the work translated for this project, was his third book, initially published in 1916.

As we learn from Tsiolkovsky's preface to the first edition of the novel *Outside the Earth*, in 1896 he contemplated writing a detailed scientific work that would theoretically justify in a literary form his proposals for creating a rocket-propelled spacecraft (Vorob'iev, 1958). Tsiolkovsky started working on the novel, wrote the first few chapters, and then postponed his work. In 1916, the journal *Природа и люди* [Nature and people] suggested that he should return to the book. Tsiolkovsky finished the novel and started publishing it in the journal. However, only approximately a half of *Outside the Earth* was published

because the journal ceased to exist. The entire novel was first published as a book four years later (Tsiolkovsky, 1920). Despite its fictional style and format, the novel actually outlines a well-reasoned, strict scientific program of future human exploration of space and interplanetary travel. Tsiolkovsky artistically expressed his scholarly idea that humankind could explore space if an international team of scientists, engineers, and inventors were provided with the necessary working conditions. In *Outside the Earth*, Tsiolkovsky assembled an imaginary international team of real and fictional scholars from the past and present who worked on creating rocket-propelled spacecraft, and he sent them on their first space adventures.

Tsiolkovsky realized that his scientific treatises were unlikely to be read by the average person, so he included extensive explanations of his scientific ideas and theories in his science fiction works. In *Outside the Earth*, the characters with no special scholarly background ask the scientists to explain scientific phenomena. For example, in nearly every scene, a character says, "But I thought . . ." or "But isn't. . ." and then the scientists, named after the greatest luminaries of mankind, including Newton, Galileo, and Helmholtz, correct the errant ideas, as in the following exchange:

> – Какой это эфир? Неужели тот, который имеется у нас в аптеке? – спросил, улыбаясь, другой из рабочих.
> – О нет! Это подобие воздуха, но только поразительно упругого и крайне разреженного, – заметил Гельмгольц. – Сущность эфира довольно загадочна.
>
> "What is this ether? Is it the same one that we keep in the medicine cabinet?" asked another of the workers with a smile on his face.
> "Oh, not at all! Its essence is similar to that of the air, but amazingly firm and very sparse," noted Helmholtz. "The essence of ether is rather mysterious." (Tsiolkovsky, 1920, p. 20)

Tsiolkovsky made it possible for readers to learn about the realities and potential future of science without the need for a textbook. In fact, Tsiolkovsky provided an uncanny explanation of space flight in his novel. Cosmonaut Yuri Gagarin (1961) reported that during his first space journey, he experienced exactly the same conditions he had read

about as a child in Tsiolkovsky's *Outside the Earth* and in other science fiction works written for children and adults. Such was the power of Tsiolkovsky's artistically expressed scholarly works, which continue to inspire generations of space explorers.

4.2. Book translation

4.2.1. Class project

Although the class Russian, Rockets and Science, with its individualized approach, welcomed students with different levels of proficiency in Russian, it was primarily aimed at students with no prior knowledge of the language. Thus, students needed practice reading materials that would accommodate an elementary-level vocabulary but do so without relying on overly simplistic stories that may not appeal to college students. Translated readers, which juxtapose the text and translation, are a good solution for language learners, because they offer the definitions of unfamiliar words.

With this idea in mind, the Aerospace and Russian professors who taught the course translated the first four chapters of *Outside the Earth* and assigned it as homework. Having grown up in a Russian-speaking household, Michael Pilipchuk already had a near-native language proficiency and took the class more for the history and policy of the Space Race rather than for the language fundamentals. Therefore, he needed an assignment that would better align with his needs. Because the first few chapters of the book piqued his interest, he continued to translate the work, creating the opportunity for his classmates to keep reading and learning.

4.2.2. Questions, difficulties, and unexpected surprises of translation

Difficulties with translation can be split into lexicographical complications and technical or engineering-adjacent complications. On a literary level, three main factors make translation difficult. The first factor is the age of the language. When Tsiolkovsky wrote a century ago, the technology involved in air travel was in its infancy, and the language associated with it was undeveloped. An example of this is demonstrated in the word *аэростат* [aerostat], which is the "generic" version of the term "zeppelin," a class of airships named for their inventor. The English *Dictionary of Aviation* has a similarly obscure word—"aerostat"—with the same meaning since

both words derive from Greek roots (Crocker, 2007,). Although "zeppelin" is a better-known term, we used "aerostat" in the translation to convey the older feel of the language.

Obscure non-technical language proved to be the second complicating factor. A more extreme example of this is the word *балахонщик* [balakhonshchik]. According to Vladimir Dal's (1863) *Explanatory Dictionary of the Living Great Russian Language*, *балахонщик* is defined as "кто шьет балахоны, торгует ими, носит их" ["he who sews sacks (shapeless garments), sells them, or wears them"] (p. 37), resulting in a vague meaning. To find this definition, it is necessary to reference a dictionary that was published in 1863 because the word is not currently in use. Since the word is derived from the word *балахон* [balakhon], meaning "loose overalls" or "robe," the translated text has it as "the person wearing the robe." This phrase, however, is inconveniently long, and the term is used frequently, making for tedious reading. As a work-around, we changed the word to "robed figure" and later to "spacewalker." Although the later version is not an accurate translation, it causes less confusion for the reader, particularly since the term is used well after the robes are no longer worn.

The third factor is the very long sentences used in Russian. English allows for that as well, but they are less frequently used, creating a contrast in style. Translators solve this problem in different ways: some choose to follow the author's style, while others change the wording to something more apt in the receiving language. In our case, we attempted to preserve Tsiolkovsky's writing style, adding explanatory notes when necessary. As previously stated, this has forced us to make the long sentences work in English rather than splitting some of them into shorter, more manageable sentences.

In addition to the aforementioned linguistic difficulties, there are those that result from the technical aspect. Of these, the biggest challenge is dealing with the mix of shockingly accurate predictions with beliefs that have long since been proven wrong. On one hand, retaining the inaccurate information highlights how amazing Tsiolkovsky's correct predictions and calculations are. However, on the other hand, it leaves the door open for misinforming the reader, who may not know what is accurate and what is not. An example of this challenge is the notion of where the atmosphere ends and space begins. Tsiolkovsky (1920),

through one of his characters, states that the atmosphere extends only 300 kilometers above the surface of the Earth. In another instance, when a character is in orbit at an altitude of 1,000 kilometers, Tsiolkovsky states that the nearest gas molecules are 800 kilometers away, implying that the atmosphere extends 200 kilometers above the Earth. Aside from the discrepancy between the figures, both are incorrect. The uppermost layer of the atmosphere is considered to end about 10,000 kilometers above the Earth, and the international consensus for the beginning of space is the Kármán line, at 100 kilometers (National Environmental Satellite Data and Information Service, 2016).

Less-blatant errors come in the form of statements that are scientifically correct but potentially misleading to a reader with less in-depth knowledge. Providing a rotating rocket as a solution for weightlessness, while accurate, for example, is nowhere near as simple as Tsiolkovsky makes it seem. Rotating a rocket around too small a radius would cause problems due to a disparity between the acceleration at the wall and closer to the center. Specifically, a person standing on the wall would experience higher acceleration at their feet than head. While a large rotation diameter resolves this problem and prevents dizziness, Tsiolkovsky glosses over the difficulties of constructing the massive structures needed for such an endeavor. As with some of the literary difficulties, the technical issues were kept in the text to preserve the original work.

4.2.3. Commentary work

Because we were pursuing both research and educational purposes, namely, to transform the text from a purely literary work into a study aid and to guide the reader through the novel's complexities, we added informative commentary to the translation. We included annotations on both the scientific/aerospace and the Russian components of the text. In addition to introducing corrections to scientific ideas from a modern perspective, we also commented on various aspects of Russian culture, providing the reader with a better understanding of both topics.

In our commentary about the aerospace aspects of the text, we addressed several overarching themes. The first theme was erroneous information, which required a straightforward explanation according to currently accepted knowledge. As one of the founders of rocket science,

Tsiolkovsky did not have the century of research and development that today's readers have access to. To ensure that the reader learns the correct scientific information, we added annotations citing reputable sources in the footnotes.

We also provided unit conversions in our annotations. In the original text, measurements are often provided in stones and versts, terms that are now rarely used and are likely unknown to the reader. Footnotes provide measurements in commonly known units, such as kilograms and kilometers.

Additionally, some of our commentary discusses the modern uses and implications of Tsiolkovsky's writings, including notes about how a technology is currently used, for example, or the ways in which modern rocketry is trying to incorporate Tsiolkovsky's ideas.

To reinforce the literary and linguistic components of Tsiolkovsky's work, we also included notes on the language, culture, and history of Russia. Every literary work is a reflection of the time and place in which it was written, and *Outside the Earth* can be used as a backdrop to introduce the reader to the conditions in the Russian Empire at the start of the 20th century. This was an important and turbulent period in the country, eventually leading to its collapse. As such, the opinions and views of contemporary writers can provide readers with an idea of what the times were like.

Our linguistic commentary primarily targets readers with intermediate to advanced levels of proficiency in Russian and includes explanations about different language phenomena, such as complicated or unusual syntactic constructions, interesting vocabulary choices, colloquialisms, abbreviations, and ellipses. We also draw the reader's attention to Russian idioms and phrases, providing their English equivalents. Whenever beneficial, we offer our comments on the author's style.

Our annotations on scientific components are provided in both English and Russian. The language commentaries are provided in both languages, especially when a more advanced grammar topic is used, or only in Russian by providing a synonym or an antonym or by paraphrasing an expression. The number of comments per chapter is commensurate with the chapter's length and complexity. An example of an annotated paragraph is given in the Appendix.

4.2.4. The results of the projects

Broadly, students who completed the LSP (Languages for Specific Purposes) Russian, Rockets and Space courses built basic translating skills required to work with specialized English and Russian texts. They also developed an understanding of key scientific discoveries that enabled space exploration.

Due to a flexible, individualized approach to the course projects, research work that had begun during the course continued beyond the classroom. This effort resulted in two conference panels, "Russian, Rockets and Space in Translation," consisting of students' original research that was presented at the 2021 Midwest Slavic Conference, hosted virtually by Ohio State University, April 15–18, 2021,[10] and at the 2020 Central Slavic Conference, St. Louis, MO, February 28–March 1, 2020.[11]

Speaking in a narrow sense, the Tsiolkovsky project discussed in this article provides an example of a successful advanced collaboration on a complex matter that is far beyond the scope of standard undergraduate-level work.

In this multiyear, team faculty-undergraduate project to create an annotated translation of Konstantin Tsiolkovsky's *Outside the Earth*, a course project was converted into an interdisciplinary research work gathering sources about space, science, and Russian culture, history, and language. The end result, a side-by-side annotated translation, provides an educational tool for learning Russian. We are also preparing a book proposal, for which the target audience is Russian language learns with an interest in STEM, as well as aerospace researchers in general. The scientific component of the work should help create a basic foundation for a technical lexicon.

[10] The panel "Russian, Rockets and Space in Translation" included the following undergraduate and graduate students' papers:
Michael Pilipchuk, "The Importance and Experience of Translating Tsiolkovsky";
Geoffrey Andrews, "Linguistic Trajectories: Tracking Spaceflight-Driven Changes in Russian and English Lexica";
Justin Mansell, "Translating Russian Airplanes Using a Common Language: Engineering."

[11] This panel, also entitled "Russian, Rockets and Space in Translation" consisted of the following undergraduate students' presentations:
Ryan Grunsten and Christine Rodriguez, "Space Race Propaganda of the US and USSR";
Michael Pilipchuk, "The Importance of Translating Tsiolkovsky"; and
Tristan Schefke, "Translating *Solar Wind*, a Children's Book by Alexei Leonov."

5. Conclusion and perspectives

Our faculty-undergraduate collaboration has resulted in a successful translation study and research. Combining the methods of source text analysis and translation with commentary, we achieved our research and pedagogical purposes of providing a broad audience with an annotated bilingual reader.

Our work has also demonstrated the feasibility of similar projects in various areas on the boundary of science, engineering, and humanities. In particular, we have shown that translation projects are viable for learners with different language proficiencies. Even after just one semester of Russian, students with no previous background in the language were able to work with authentic documents in the original Russian and enjoy the possibility of applying their newly acquired language skills to their other professional areas of study. Students with more advanced language proficiency were able to pursue more ambitious research endeavors. This article describes one such project as an example. Research done for the Russian for Rockets courses primarily focused on intersections of Russian and mathematics, physics, aerospace engineering, computer science, history, and political science. Projects on intersections of other fields of knowledge await their exploration. In future work, it would be of interest to enhance digital and computational components of such projects.

Appendix

Sample paragraph with engineering and Russian comments

— Если бы вы и были правы, считая тяжесть необходимой, — возразил бывший тут учитель физики, — то ведь ничего нет легче, как• ее произвести искусственно, вращением жилища. Там это вращение вечно, ничего не стоит, поэтому и тяжесть также вечна и ничего не стоит; кроме того, величина ее	"If you were correct in considering gravity necessary," objected a present physics teacher, "then there's nothing easier than to artificially recreate it by rotating the home.* There, that rotation will be permanent and require nothing, so gravity is also permanent and at no cost;

совершенно зависит от нас; она может быть и меньше земной и больше, пределы ее изменения безграничны… Вот в том-то и преимущество ••: на Земле тяжесть неизменная, а тут какой угодно ••• силы, начиная с нуля. Кстати, о температуре: при очень близком расстоянии от Земли ее нельзя очень сильно понижать: мешает теплое лучеиспускание планеты; но по мере удаления от нее это понижение может становиться все значительней и значительней ••••. На расстоянии Луны, где находятся теперь наши мировые скитальцы, температуру можно понизить чуть не до абсолютного нуля, т. е. ••••• до 273° ниже точки замерзания воды. (Tsiolkovsky, 1920, p. 72)	besides, its magnitude will be completely up to you—it can be less than Earth's or greater, and there's no end to possible changes . . . That's the advantage—on Earth, gravity is constant, but here—of any magnitude, starting at zero. Also, about temperature: near Earth you can't lower it too much—the planet's heat radiation interferes—but as you move away from it, this decrease can be more and more substantial. At the same distance as the Moon, where our cosmic wanderers were now located, the temperature can be lowered almost to absolute zero, meaning 273 degrees below water's freezing point."**

* scientific and engineering comments
• language and style comments

* This is theoretically possible but requires either massive sizes or incredible rotational speeds for practical results.

Это теоретически возможно, но требует либо гигантских размеров, либо очень быстрого вращения для практического применения.

** Regarding the temperature estimate, Tsiolkovsky did not consider the role of the presence of atmosphere on Earth and its almost nonexistence on the Moon, as well as its nonexistence in open space. As we now know, the Moon's temperatures at night are indeed low, -183 degrees C (although this is much warmer than -273 C). However, during

the day, the absence of screening of sunlight radiation by the atmosphere results in temperatures as high as 106 C.

** По поводу оценки температур: Циолковский не рассматривал роль присутствия атмосферы на Земле и её практическое отсутствие на Луне, а также её отсутствие в открытом космосе. Например, как мы знаем теперь, температура на Луне ночью действительно низкая, -183° Цельсия (хотя это намного больше, чем -273° Ц). Однако днём отсутствие экранирования солнечной радиации атмосферой приводит к температурам до 106° Ц.

• "Нет ничего проще, как..." A more conventional way of introducing the subordinate clause here would be "нет ничего проще, чем..."

•• "Вот в том-то и преимущество, что..." = "Преимущество именно в том, что..."

••• "Какой угодно" = "любой"

•••• "всё значительнее и значительнее": Inn constructions with repetitions, Russian can repeat the comparative form of the used adjective or adverb, although the form "всё более и более значительно" is also common.

••••• "т.е." = "то есть"

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