research summary report

A MULTIDISCIPLINARY ANALYSIS OF PLANETARY DEFENCE FROM ASTEROIDS

AS THE KEY NATIONAL POLICY ENSURING FURTHER FLOURISHING AND PROSPERITY OF HUMANKIND BOTH ON EARTH AND IN SPACE

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This research was supported by the Technological Agency of the Czech Republic. Particularly through a scientific grant TACR TL01000181: *"A multidisciplinary analysis of planetary defence from asteroids as the key national policy ensuring further flourishing and prosperity of humankind both on Earth and in Space."*

HOMΞ

The following summary report is the requested result of the applied research project, summarises the results of the project and comments on the fulfilment of the project objectives. Attached is the protocol of acceptance of the result by the client, i.e. the application guarantor of the Ministry of Transport.

The purpose of this report is to summarize the project in a concise and clear manner, not to discuss it comprehensively. The document serves to provide a basic quick orientation to the project architecture, its results, achieved objectives and societal change as a key qualitative indicator of the applied social science research of the TAČR ÉTA programme.

The project had two thematic areas at its inception, which have expanded to three (*planetary defence*, *space mining* and a third new *breakthrough project*) during the design and change management process. The thematic areas, or key themes, are always represented by one or more binding outcomes with a set of bonus outcomes.

The project was conceived as a multidisciplinary project with an emphasis on a social science approach in the discipline of international relations, which is why it was submitted to the ÉTA competition. The final outputs with an emphasis on societal change, albeit brief but based on previous extensive research, are *policy papers* on each of the three key themes proposing a specific policy strategy with an emphasis on a multidisciplinary approach, i.e. with an emphasis on science development, industry promotion and policy change. All the results are theoretically anchored in cosmopolitan theory based on a realist concept of a cosmopolitan responsible state primarily formulating the foreign policy of the state, but also e.g. the form of national legislation.

The report is further developed by the project website www.planetary-defense.eu, which is an integral part of the report.

Note 1: The numbering of the results uses our internal #xx series. The Vxx series denotes the results according to the ISTA system of the Czech Technology Agency, which contained the binding results from the beginning of the project. However, bonus results will only receive the Vxx code when they are entered into this information system in the following year. Therefore, the Vxx series cannot be used if the results are only in the process of being created and are marked as such, e.g. at the time of handover to the application sponsor. For better orientation, we use the #xx/Vxx combination only for binding results that have the Vxx code from the ISTA system since the beginning of the project.

Note 2: Result #13a/V13 is reported as a manuscript, but will appear as a peer-reviewed article in Space Policy in 2022. Similarly, the manuscript of V16 will appear under a new title as an edited monograph.

** Note 3: Bonus results marked with * are included in this report, although they will come out in 2022 at the time of project implementation. As the recipient of this report is the client, i.e. the Department for Transport, the results are shown as they will be delivered to the application sponsor. These results are not presented in the final project report but will be presented in subsequent implementation reports.*

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EVALUATION OF PROJECT IMPACTS

The project arose in a political situation where Luxembourg unilaterally declared its interest in 2016 to adopt national legislation allowing private companies to acquire the right to mine material in space. Planetary defence, as opposed to mining, was already well underway in preparation for demonstration missions. Our initial shared interest with the Department of Transportation (DOT) was to link the economic rationality of asteroid mining to a multilateral security regime ensuring that states participating in planetary defense missions would also have security assurances. Last but not least, it was crucial for the MoD to shape interest in mining within the Czech scientific and industrial environment.

On the question of ***planetary defence***, the task was relatively obvious, because the situation where a number of states participating with their scientific and industrial capabilities in the ESA HERA[1] mission have no security guarantees at all is certainly very unfortunate, while at the same time opening up a wide space for foreign policy. The research has focused on the study of the whole range of activities necessary for planetary defence, i.e. methods of asteroid observation, the conceptualisation of the asteroid as a threat with the potential to be seen in a positive security perspective (as a potential for human flourishing, both economically and purely pragmatically), the role of the space community in formulating the need for states to reflect on the issue towards a realistic ambition of policy making, through to concrete proposals in the form of integrating planetary defence into the R2P concept or quite specific multilateral policies. At the end of the project, the NASA DART mission[2] was launched, which has the potential to support the whole international debate, as it will make the efforts around planetary defence realistic to the layman, and a policy paper was published, proposing a concrete approach for the Czech Republic. The research has thus been moving all along towards its culmination, in which we put into the hands of the political representation a comprehensive body of knowledge and concrete proposals on how the international multilateral order can be promoted. The whole project is anchored in cosmopolitan theory, specifically in the concept of the cosmopolitan responsible state, which is nothing other than a responsible foreign policy having as a frame of reference the welfare of humanity, a central term from the Cosmic Treaty. By combining the promotion of a multilateral order with a cosmopolitan responsible foreign policy, we fulfill the central goal of the project in the flourishing of humanity by developing a planetary defense policy. In this sense, the project has achieved its goal. Further discussion of the emergence of a multilateral regime is directly dependent on political will and international diplomatic efforts.

On the issue of ***space mining***, the activity in the project was much more dynamic, as it was necessary to respond to current international developments. The project focused on two main areas: technology and the legal regime for mining. In the case of technology, the results of the project ranged from experimental research on the PALS laser and recommendations for further technological development, to an analysis of current Czech capacities capable of participating in mining. The result of the efforts is the approved SLAVIA mission, which combines the scientific and technological

[1] DART' s sister mission, which will measure the effects of the kinetic impactor impact in the DART mission.

[2] A kinetic impactor that will demonstrate the possibility of deflecting an asteroid by simply impacting and transferring kinetic energy.

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capabilities of the Czech Republic and proposes a specific demonstration satellite. In addition to this success, mining technological capabilities will continue to be developed at a new facility at HiLase that is looking for new space applications of laser technologies, not including mining. In the case of the legal regime, the research dynamic has been considerably more vibrant. The project team participated in official international meetings, such as the Hague Working Group, where they not only advocated the convenience and appropriateness of promoting a multilateral solution to the legality of space mining, but also analysed specific options for developing national legislation that would not provide exclusive advantages to the state adopting its own laws regulating mining, but instead ensure inclusive rights for all in the spirit of the policy of a cosmopolitan responsible state. In addition to a number of publications and conference papers, a set of results addressing the possible form of national legislation that, instead of creating exclusive rights for extractive companies, creates the potential to initiate the emergence of an international regime by pushing from a position of inclusive national legislation that supports, among other things, UN programmes and other transnational development initiatives, can be considered a significant research breakthrough in thinking about the legality of space mining. The issue is discussed in the chapters of the final edited monograph and in two scholarly articles beyond the binding outcomes to be published in 2022. Moreover, a draft model reflecting the concept of Social License to Operate has resonated in professional international circles to the extent that a developed version will appear in the Palgrave Handbook. In summary, the dilemma of whether it is worthwhile for the Czech Republic to unilaterally approve internationally problematic national legislation is solved very elegantly by the project. However, this elegance is again based on a simple concrete application of the concept of a cosmopolitan responsible state. On the issue of mining, the project reaches the goal of proposing a very specific policy for the development of national and international legislation applying the concept of a cosmopolitan responsible state. A policy that clearly fulfils the cosmopolitan principles of human flourishing by introducing non-conflicting inclusive legislation, as the project set out to do in its beginnings. As in the case of planetary defence, the full realisation of these ideas needs to be taken up by political authority.

In terms of ***breakthrough projects,*** the project focused on the identification of key scientific and technological capabilities in the Czech environment capable of participating in the Starshot Breakthrough Intiatives (BI) project, but also in other, mainly laser space applications, e.g. in the field of cometary splinter removal. The initial conference and workshop Prague Laser SpaceApps Workshop 2019 served primarily for this purpose, where Czech capacities presented themselves and communication between the project team, the Czech industry and BI started. In the field of political science, the project focused on developing the argument of the constitutive effects of Large Technical Systems (LTS) as vehicles for political change already inherent in the dual-use technology. Among the clear achievements confirming the right direction of our efforts is the emergence of the PULS initiative and its support by Nobel Laureate Gérard Mourou. Finally, our efforts have translated into the planned creation of a new scientific department at HiLase in Dolní Břežany focused on space applications of laser technology. The use of high-energy systems in space for peaceful applications will undoubtedly require the establishment of a safety regime to ensure the predictable use of sensitive technology. On this issue, the results of the project are reflected in the concrete discussions between the expert community and the UN, which are being developed within the PULS initiative even after the end of the project, as well as in the very concrete political programme of the Pirate Party for the European elections and the elections to the Parliament of the Czech Republic. In this sense, the whole argumentation of the LTS as agents of political change, including concrete policy proposals, is

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translated into practical politics and, as in the previous cases, the prepared body of knowledge will be translated into social change with political will.

The project was perceived as too ambitious in the beginning. By the end of its implementation, it was clear that translating the highly ambitious vision into concrete form would not be problematic by developing the expert discussion that the project had undoubtedly developed beyond the initial plans, but above all by finding the political will to ensure change. However, in all three cases, real events are taking place on a global scale that will sooner or later force the political representation to take action. In this sense, the project has fulfilled its objectives completely and brings to these days a comprehensive body of knowledge that fulfils cosmopolitan ideas through responsible politics, new workplaces and a motivated scientific and industrial community in the Czech Republic and worldwide.

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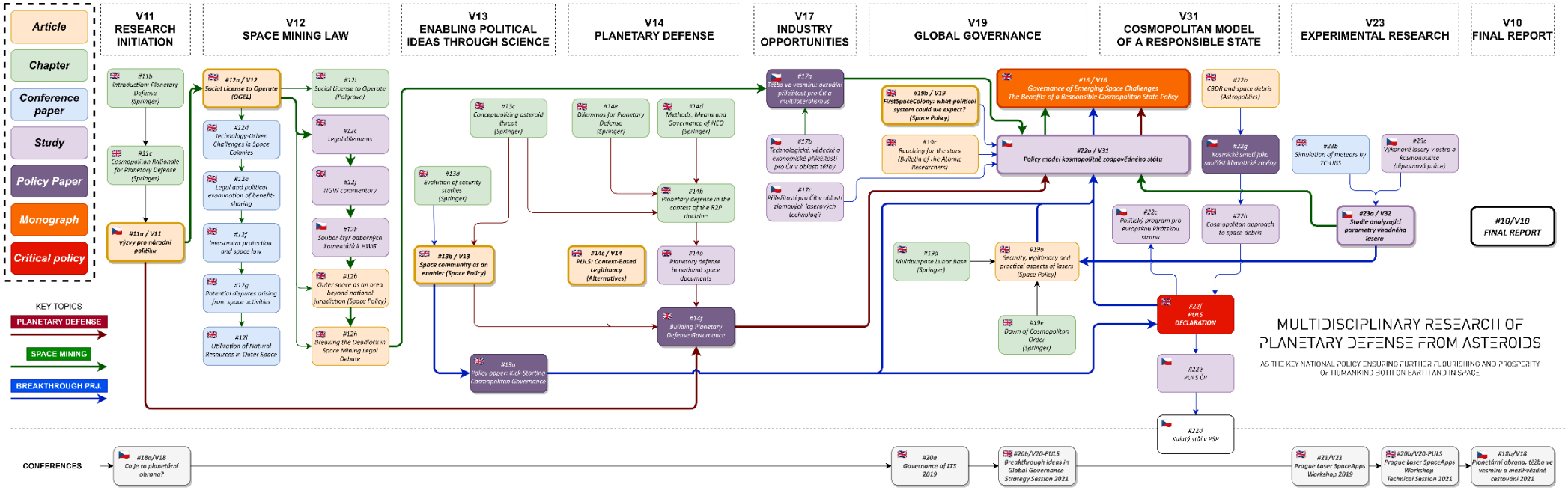
PROJECT STRUCTURE

The structure of the project is clickable on the website with the ability to navigate to the detail of individual results, which is more detailed than in this printed version of the report.
For quick reference, we recommend following the three coloured lines representing the three key themes of the project from the initial results to the final monograph.
The chapters of the final monograph are not entered in the structure but listed below in the results listing.
The different coloured cells represent different types of results.



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SUMMARY OF KEY THEMES AND LISTING OF RELATED RESULTS

In the structure of the project, the process of working on the key themes is highlighted by coloured lines: dark red represents planetary defence, green represents space mining, blue represents breakthrough projects. The stronger line represents the main progression through the project, the weaker one the complementary. Bold and thickened cells are binding results. The following list of deliverables reflects the project solution flow in the project structure diagram by key themes.

Important for all topics is the study of the policy model of a cosmopolitan responsible state #22a proposing concrete principles of cosmopolitan responsible politics. All the findings then culminate in an edited monograph with an emphasis on small states and their scientific, technological, and policy capabilities in the topics we study.

Code	Name	Result type
#22a	Policy model of a cosmopolitan responsible state	O - studies
#16	Small States as drivers for cosmopolitan responsibility in space Governance of Emerging Space Challenges - The Benefits of a Responsible Cosmopolitan State Policy	About - book manuscript

In the course of the research, the project team organized several conferences, which can be divided into the following three categories: summarizing the whole project (#18), technical solutions to fracture projects (#20b+#21), and the issue of global governance of fracture projects (#20a+20b).

Code	Name	Result type
#18m/V18	What is planetary defence? (popular 2019, professional 2021)	M - conferences
#20a	Global Governance of Large Technical Systems (within PLSAW2019)	M - conferences
#20b/V20	PULS Technical Session (2021) PULS Strategy Session - Brekthrough Ideas in Global Governance (2021)	M - conferences
#21/V21	Prague Laser SpaceApps Workshop (2019)	W - workshop

Planetary Defence

In the context of planetary defence, the project was based on a publication in progress for Springer, which was greatly expanded thanks to the acquisition of this project. The chapters that were added to the publication are the starting ideas for the project. At the beginning of the project, the political challenges for the implementation of planetary defence policy were defined in the context of the development of security studies in political science, the methods for asteroid observation were developed in the technical part of the project, and the dilemmas arising from international space law were defined in the legal part.

Another part of the research looked at potential policy approaches, and such results certainly include a chapter applying the R2P concept to planetary defense, a rationalization of cosmopolitan theory for planetary defense policy, an argument for why the space science community is well suited to initiate planetary defense policy when extended to include characteristics of the security

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community, or the potential of using lasers as instruments of contextually oriented legitimacy in the question of global governance of large technical systems. For the purpose of developing the policy paper, but also for inspiration in the case of the development of a national planetary defence strategy, a study summarizing the references to planetary defence in the national strategies of major countries of the world with an emphasis on normative orientation has been conducted. Finally, a policy paper proposing the creation of a security community based on the principles of multilateralism was developed.

Note: A dedicated technological study mapping the usable Czech capabilities has not been developed for planetary defence because of the ongoing DART and HERA demonstration missions in which the Czech Republic is participating. Due to this situation, nothing would immediately (as opposed to mining, see below) realistically come out of it. Capacities for planetary defence have been mapped, however. A presentation of Czech capabilities was made to the UN COPUOS SMPAG working group, where possible future technological concepts for asteroid deflection are being discussed. During the implementation of the project, the SMPAG team will continue to participate in the project, so this topic remains open for the next years.

Code	Name	Result type
#11b	Introduction: Planetary Defence	C - chapter
#11c	Cosmopolitan Rationale for Planetary Defense	C - chapter
#11a/V11	Challenges for national policy on planetary defence and asteroid mining	J - reviewed article
#13c	Conceptualizing the Asteroid Threat and Searching for a Balanced Answer Between Effectiveness and Desirability	C - chapter
#13d	Evolution of security studies and the Resulting Perspectives of an Asteroid Threat	C - chapter
#14e	Dilemmas for Planetary Defense Posed by the Current International Law Framework	C - chapter
#14d	Methods, Means and Governance of NEO Observation	C - chapter
#14b	Planetary defense in the context of the R2P doctrine	C - chapter
#14a	Planetary defence in national space documents	O - studies
#13b/V13	Space community as an enabler of cosmopolitan ideas through Large Technical Systems	About - manuscript of the article
#14c/V14	Peaceful Use of Lasers in Space: Context-Based Legitimacy in Global Governance of Large Technical Systems	J - reviewed article
#14f	**Building planetary defense governance: A Proposal for Multigenerational, Financially Sustainable and Scientifically Beneficial Planetary Defense**	**O - policy paper**

Mining in space

The topic of space mining has been studied as a separate topic, also as a topic with the potential to provide funding for inherently global problems - planetary defence or orbital debris (studied as a peripheral topic extending the argumentation of the cosmopolitically responsible state and creating pressure on states not to think in terms of their own borders with regard to the orbital nature of the problem).

The topic of mining began with an article defining the challenges of mining in space for the nation-state (along with the topic of planetary defense). Subsequently, the research was very much oriented towards the international law perspective on space mining, which began with the elaboration of legal dilemmas in the matter of space mining. The conclusions and partial reflections were presented at a series of international expert conferences and a peer-reviewed article was

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produced proposing a model based on the concept of Social License to Operate. This idea has resonated with the professional community to the extent that it will be published in the Palgrave Handbook after the end of the project.

As part of the research into the dilemmas of international law on space mining, the project team was part of the international expert Hague Working Group, which produced two studies commenting on its proposals, both for the Department of Transport in Czech and for the international community in English. The primary professional output of space mining is two peer-reviewed articles addressing first the whole issue of regulating space beyond the jurisdiction of nation states in a technical manner and a very specific proposal on how states can think to find a way out of the current impasse debating the legality of space mining. On this basis, a policy paper proposing specific actions for the Czech Republic was drafted, which opened the discussion on the creation of a substantive law. However, its creation awaits a political decision. Expert support for this policy paper and the actions of the nation state can be found in the final monograph.

On the issue of mining, a study has been carried out on the Czech scientific and industrial capacities available for mining in space. The work on this study has also led to the proposal for the SLAVIA project of the Academy of Sciences, which has been approved within the financial framework of ambitious projects and is now (end of 2021) under implementation. In addition to this project, this study initiated a number of projects in collaboration with HiLase and the creation of a new department for space applications of lasers at Hilas (see more in the societal impact section of the project).

Code	Name	Result type
#11a/V11	Challenges for national policy on planetary defence and asteroid mining	J - reviewed article
#12a/V12	Utilization of Natural Resources in Outer Space: Social License to Operate as an Alternative Source of Both Legality and Legitimacy	J - reviewed article
#12i	Social license to operate (handbook version)	C - chapter*
#12d	Technology-Driven Challenges in the Governance of Future Space Colonies	D - conference paper
#12e	Legal and political examination of benefit-sharing: Between interest of all countries and province of all mankind	D - conference paper
#12f	Investment protection provisions in national legislation	D - conference paper
#12g	Potential disputes arising from space activities: opportunities for investment arbitration	D - conference paper
#12l	Utilization of Natural Resources in Outer Space	D - conference paper
#12c	Space Resource Activities: Legal Dilemmas and Brief Possible Policy Positions	O - studies
#12j	Comments on Draft Building Blocks for the Development of an International Framework on Space Resource Activities	O - report
#12k	A set of four expert commentaries on Building Blocks for the Development of an International Framework on Space Resource Activities	O - report
#12b	Outer Space, an Area Recognized as Res Communis Omnium: Limits of National Space Mining Law	J - reviewed article*
#12h	Breaking the deadlock in space mining legal debate	J - reviewed article
#17b	Technological, scientific and economic opportunities for the Czech Republic in the field of space mining	O - studies
#17a	**Space mining: a current opportunity for the Czech Republic to promote multilateral international order**	**O - policy paper**

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Breakthrough projects

The third theme of the project is closely linked to the collaboration with Breakthrough Initiatives, who have several programmes for the search for life in space. The best known is certainly the SETI programme, which has been running for more than half a century. The cooperation was mainly on the Starshot project, because it is in this project that the laser capabilities of the Czech Republic can be used. The theoretical assumption was that building large technical systems infused with the ideas of the space community could have the potential to constitute a more inclusive cosmopolitan model of global governance. The fundamental driver of such a process is then the inevitable dual-use nature of high-energy, and thus security-sensitive, systems. The scholarly debate around this theoretical model is the manuscript of a technical paper and a potential policy approach in a key policy paper produced early in the collaboration with Breakthrough Initiatives.

Subsequently, experiments were carried out at the Institute of Plasma Physics to study what lasers could be used for space applications. The resulting knowledge served as the basis for a critical evaluation of the role of laser technology in practical applications in space. The chapters of the initial book dealing with global governance issues with an emphasis on cosmopolitan theory also served to critically evaluate laser technology.

A major line of activity in this third theme was the launch of the PULS (Peaceful Use of Lasers in Space) initiative and the creation of its declaration, endorsed by Nobel laureate Gérard Mourou. The ideas from the declaration were developed as recommendations for the Czech Republic and a round table was organised in the Chamber of Deputies. The PULS Declaration inspired the political programme of the Pirate Party for the European elections (eventually also for the elections to the Czech Parliament). In addition to the political dynamics of high-energy systems for the Starshot project, a study mapping the scientific technological capacities of the Czech Republic usable for ambitious laser-oriented projects was carried out, resulting in the opening of an intensive cooperation with HiLase and the establishment of a new department for space applications of laser technologies.

Within the theme of breakthrough projects, the team focused on one sub-theme where space debris was studied, its perception as a global problem and the possibility of removal by large engineering systems. Thematically, orbital debris fits into the third key theme. In the context of orbital debris, a technical paper discussing the concept of CBDR - Common But Differentiated Responsibility, and a policy paper based on it, including a related study, were produced.

Code	Name	Result type
#13b/V13	Space community as an enabler of cosmopolitan ideas through Large Technical Systems	About - manuscript of the article
#13a	**Kick-Starting Cosmopolitan Governance Through Science: The Case of and Giant Laser System**	**O - policy paper**
#23b	Simulation of meteors by TC-LIBS	D - conference paper
#23c	Power lasers in astro and aerospace	O - thesis
#23a/V32	Studies analysing the parameters of a suitable laser	O - studies
#19d	The Multipurpose Lunar Base as a First-Line Biosphere Defense and as a Gateway to the Universe	C - chapter
#19e	Dawn of Cosmopolitan Order? The New Norm of Responsibility to Defend Earth and the Planetary Council	C - chapter
#19a	Security, legitimacy and practical aspects of lasers	J - reviewed article*
#22b	Common But Differentiated Responsibilities for Space Debris Removal	J - reviewed article

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#22g	Space debris as part of climate change: a cosmopolitan responsible approach	P - policy paper
#22h	Cosmopolitan Approach to the Issue of Space Debris	O - studies
#22c	Space program of EU Pirate Party	O - political programme
#22f	PULS Declaration - Peaceful Use of Lasers in Space	O - other
#22e	PULS for the Czech Republic	O - other
#22d	Round table in the Chamber of Deputies	O - other
#19b/V19	First Space Colony: what political system could we expect?	J - reviewed article
#19c	Reaching for the stars: The case for cooperative governance of directed energy technologies	J - reviewed article
#17c	Opportunities for the Czech Republic in the field of breakthrough laser technologies	O - studies

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LIST OF RESULTS AND BRIEF DESCRIPTION

The following list of results is divided according to the professional focus of the project based on the mandatory results in all three key themes. The mandatory results are highlighted in orange. Key policy papers are highlighted in purple.

V11 - Research initiation and topic definition

Code	Name	Result type
#11a/V11	Challenges for national policy on planetary defence and asteroid mining	J - reviewed article
	The article discusses the issue of planetary defense from the perspective of four disciplines: astronomy observing asteroids, engineering designing methods of deflection, international law framing the legal space for potential deflection, and political science examining the normative side of the entire planetary defense effort. Furthermore, the text explores the potential of linking the themes of mining and defense as contemplated in the initial project brief, with particular emphasis on the legality of mining. The paper links the themes through the Welsh School of Security Studies' concept of human flourishing, that is, by emphasising positive security standing on the promotion of scientific and industrial capabilities and the resulting potential for human flourishing. The article concludes by introducing a theoretical-epistemological framework for further research in the spirit of a humanistic and globally responsible policy in response to the threat of asteroid collision and outlines directions for a future cosmopolitan responsible foreign policy.	
#11b	Introduction: Planetary Defence	C - chapter
	The introductory chapter to the book, work on which began before this project was acquired but which, because of its acquisition, extended into the first year of its solution, presents the very basic starting ideas of viewing planetary defense as a problem of global responsibility rather than a threat. Thus the chapter should immediately take the reader untouched by the topic out of the question of how likely it is that the Earth will collide with an asteroid, because the whole (unlikely, but with huge consequences) problem is not about the likelihood of a collision, but about the role of knowledge (astronomy and orbital orbit) and the resulting responsibility to act. All the initial ideas had a rather philosophical dimension when the chapters of this first book were written, whereas the final moments of the project transform them into concrete policy proposals.	
#11c	Cosmopolitan Rationale for Planetary Defense	C - chapter
	Within this chapter we develop an argument for why ideas in cosmopolitan theory are essentially the only rational approach, and a strategic necessity, in dealing with the global problem of the nature of the asteroid conflict. The basic argument for the development and application of cosmopolitan theory is the assumption that planetary defense is not an ephemeral initiative, but an evolved scientific and technological program that will have some form of political control in any case. The considerations in this chapter, though entirely initial, are translated into a concrete proposal for a multilateral security community at the end of the project. In this way, idealistic cosmopolitanism becomes a fully realistic multilateralism, or rather, this approach demonstrates how cosmopolitanism can be seen as a normative surface on which realistic political actions can still take place, but which will already have a clear normative direction and boundaries.	

V12 - Space mining law

Code	Name	Result type
#12a/V12	Utilization of Natural Resources in Outer Space: Social License to Operate as an Alternative Source of Both Legality and Legitimacy	J - reviewed article
	The paper posits that the lackluster motivation of mining companies to mine in space is due, among other things, to legal uncertainty stemming from the vague regulation of space mining in international law. Although mining has been addressed at UN COPUOS, or dealt with in the Hague Working Group, yet some states have chosen to enact their own national legislation that assigns rights at the national level to companies for the material they mine. This approach has caused considerable international uproar. The	

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	paper thus studies whether the concept of a Social License to Operate could serve as a legitimizing instrument after mining, when the company, and hence the sending state, will be confronted with the illegality of mining in space based on the Space Treaty, an interpretation that most of the world community is inclined towards.

#12b	Outer Space, an Area Recognized as Res Communis Omnium: Limits of National Space Mining Law	J - reviewed article*
	One avenue that has been studied in a number of results is the adoption of national legislation that allows for mining in space but reflects the international legal regime set primarily by the space treaty. This article focuses on an analysis of the regulation of space mining by international law and draws practical implications for national-level lawmakers. The final monograph, #16, then develops Chapter 8, which directly discusses the specific legislative levels of space-oriented national law regulating space mining.	

#12c	Space Resource Activities: Legal Dilemmas and Brief Possible Policy Positions	O - studies
	An initial study of the dilemmas of space mining regulation, oriented towards both international and national law, serving to further scholarly work on the topic. The study also addresses the problematization of benefit sharing as required by the Space Treaty or the Moon Treaty, a central theme running through all other results addressing the application of cosmopolitan ideas to the regime of space mining.	

#12d	Technology-Driven Challenges in the Governance of Future Space Colonies	D - conference paper
	A conference paper that problematizes the topic of colonization of other bodies and the associated emergence of local and interplanetary political regimes, especially emphasizing their potential for emergence through the specific design of technological elements or central activities of colonies (mining). From this conference paper comes First Space Colonies #19/V19, which discusses the emerging political regimes in detail. Here the question of whether the design of technology can enhance the potential for the emergence of different political regimes is highlighted.	

#12e	Legal and political examination of benefit-sharing: Between interest of all countries and province of all mankind	D - conference paper
	International space law emphasizes that activities in outer space should be carried out for the benefit of all states and that outer space is the province of humanity. Vague as this formulation is, it is precisely on the issue of space mining that the cosmopolitan nature of the current regime comes to the surface. This conference paper analyses the motivations for inserting this clause and offers three: conflict prevention, globally beneficial to humanity, to provide a predictable and stable legal framework ensuring attractiveness to investors enabling the development of the necessary technology and activities.	

#12f	Investment protection provisions in national legislation	D - conference paper
	Another conference paper discusses in detail investor protection regimes, which appear to be essential to ensure the financing of business activities directly dependent on legal regimes set by public institutions, including international ones, so that a change of government at the national level cannot thwart huge investments in key infrastructure, for example. But the international system is not the only instrument for investment protection. Some standing states for which FDI is crucial have introduced their own specific national legislation protecting foreign investors. This article focuses on studying the potential of national legislation on predictability and stability in the broader issue of investment in space projects.	

#12g	Potential disputes arising from space activities: opportunities for investment arbitration	D - conference paper
	The poster focuses on potential disputes arising from the emergence of contentious national legislation that, if it ultimately motivates investors towards space mining, comes into conflict with international law. The poster discusses what potential arbitration options investors have if the state does not adequately protect their investment.	

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#12h	Breaking the deadlock in space mining legal debate	J - reviewed article
	One of the final articles intertwines cosmopolitan thinking with the possibilities of national legislation and confronts them with the current debate on the legality of space mining at an impasse. Among the key arguments is the inherently cosmopolitan nature of international law, which in turn creates the scope for us to adopt cosmopolitan national legislation if we accept the principle that all states in the world should benefit from mining. The conclusion of the article offers benefits not necessarily in a global tax, but primarily in non-financial benefits such as a funded planetary defence as a global security system partly financed by mining leading to human flourishing. The paper is one of the key contributions concluding the initial objectives of the project.	
#12i	Social license to operate (handbook version)	C - chapter*
	Significantly developed result #12/V12 for the purposes of the Palgrave publisher's handbook.	
#12j	Comments on Draft Building Blocks for the Development of an International Framework on Space Resource Activities	O - report
	A commentary for the Ministry of Transport, confronting the Czech position and the activities of the Hague Group. The text deals with all the building blocks developed by the Hague Group and analyses them from the perspective of the known position of the Czech Republic.	
#12k	A set of four expert commentaries on Building Blocks for the Development of an International Framework on Space Resource Activities	O - report
	A significantly more detailed commentary for the purposes of the Hague Group, which explains in detail the four selected building blocks, their legal foundations and the alternatives discussed. In particular, the document serves to provide a more detailed insight into the substance of the working group's work and creates greater insight into activities outside the project, interaction with it, and potential starting points for the future international regime.	
#12l	Utilization of Natural Resources in Outer Space	D - conference paper
	The paper analyses two national laws legalizing space mining (USA and Lux) and proposes how these laws should be amended to comply with the basic principles of international space law, with which the vast majority of the international community believes they are in conflict, although it is directly emphasized that the activities regulated by them must comply with international law. In this context, the paper assesses whether it is even possible to develop national legislation that would ensure general socio-economic stability and thus provide certainty for investors.	

V13 - Technologies enabling political ideas through science

Code	Name	Result type
#13a	Kick-Starting Cosmopolitan Governance Through Science: The Case of and Giant Laser System	O - policy paper
	One of the key policy papers that describes how large technical systems could give rise to new forms of global governance. The paper emphasises the emergence of science and technology centres such as CERN or ITER and argues that the constitutive process towards new forms of global governance can accelerate the dual-use nature of emerging technologies and large technical systems in/to space. It is precisely in terms of this dynamic that there is a great need for a normative framework to emerge at the very moment of the development of sensitive technologies, ensuring not only regulation, but above all maximum transparency of the final use of the technology in question. Moreover, if this normative framework can be transformed into international law, this process is already a constitutive moment. The presented assumption is demonstrated by the so-called GLS - Giant Laser System in the form of the Starshot project by Breakthrough Initiatives, which simply needs a security regime for its existence.	

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#13b/V13	Space community as an enabler of cosmopolitan ideas through Large Technical Systems	About - manuscript of the article
	The above argument in the policy paper is here multiply expanded, analysed, supported and confronted with the academic literature. Moreover, the paper develops the argument that the specific nature of the space community has the potential to set this constitutive process in motion. The key difference from the policy paper, then, is that the agents of political change are not only large technological systems that require a normative framework to be operationalised at all, but also the space community with its specific shared idealism, which carries with it a great deal of political capital and thus the potential to mobilise the whole process into a historically significant political initiative.	

#13c	Conceptualizing the Asteroid Threat and Searching for a Balanced Answer Between Effectiveness and Desirability	C - chapter
	The chapter discusses the dynamics of the securitization of the asteroid threat and demonstrates, especially to the space community, that "awarness building" alone does not necessarily lead to desirable consequences or positive interest in planetary defense issues. On the other hand, it is pointed out how the securitization process can be approached constructively by emphasizing not only the "magnitude" but the "inevitability" of the threat, by pointing out that the threat in question is a natural phenomenon, which e.g. terrorism is not; it stands and falls on human will, its randomness, and thus the questionable extent to which it is an objective or random threat.	

#13d	Evolution of security studies and the Resulting Perspectives of an Asteroid Threat	C - chapter
	The chapter on the space community presents the evolution of thinking in security studies, with an emphasis on discussing how security studies is likely to reflect the entire debate around the asteroid threat. The chapter attempts to understand rationalist and interpretive thinking in relation to each other, using a renewed discussion of normatively oriented pragmatism, or reflexive pragmatism, an approach that emphasizes objective facts leading to improved conditions of life (pragmatism) backed by a normative framework that clearly declares what the desired change is (reflexive).	

V14 - Planetary defence

Code	Name	Result type
#14a	Planetary defence in national space documents	O - studies
	A study analysing in detail the strategic documents of nation states in which it seeks elements of planetary defence. Where a planetary defense orientation is found, it examines political motives, which include global benefit, national benefit, national security, global security, advanced science, industrial support, and political leadership. The study analyzes the texts of each strategy in great detail, excerpting and referencing the original documents. In this form, the study has served very well in further work on planetary defence and may very well serve in the design of the national planetary defence strategy of the Czech Republic.	

#14b	Planetary defense in the context of the R2P doctrine	C - chapter
	The chapter discusses the possibility of applying the R2P - Responsibility to Protect concept to the issue of planetary defence. It builds on the significant advantage that the activation of R2P in this case does not undermine the sovereignty of the state, emphasizes the responsibility of each state to protect humanity as a whole and its own citizens, but opens up a number of other problematic levels, especially the risk of a unilateral mission if there is no international response plan for an asteroid in a collision orbit.	

#14c/V14	Peaceful Use of Lasers in Space: Context-Based Legitimacy in Global Governance of Large Technical Systems	J - reviewed article
	The paper studies the role of large-scale technical systems, useful for both planetary defence and interstellar travel, in the question of new forms of global governance. It focuses on the central research question of the project, namely the various sources of legitimacy for the emergence of large technical systems. Here, in particular, the perspectives of efficiency (output) and inclusiveness (input), which can answer both the meaningfulness of their existence towards the desired flourishing of humanity and whether they as technologies reflect the basic value criteria preceding potential international conflict. The conclusion	

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	discusses how these large-scale technical systems could become instrumental in the creation of global networked spaces suitable for coordinating global democratic governance.

#14d	Methods, Means and Governance of NEO Observation	C - chapter
	The chapter discusses in detail the methods of asteroid observation for non-astronomers.	

#14e	Dilemmas for Planetary Defense Posed by the Current International Law Framework	C - chapter
	The chapter deals with the analysis of the dilemmas that the current international law, untouched by planetary defence regulation, poses on this issue. This approach allows for the identification of a number of problematic moments that will need to be addressed politically, further developed, for example, in a policy paper addressing planetary defence.	

#14f	Building planetary defense governance: A Proposal for Multigenerational, Financially Sustainable and Scientifically Beneficial Planetary Defense	O - policy paper
	One of the key policy papers of the project focuses on proposing policy actions for a small state, e.g. the Czech Republic, on planetary defence not only to ensure a cooperative global model but also to prevent unilateral action by a state with a strong space programme. The policy paper is being released just in time for the launch of the DART mission to demonstrate the kinetic impactor method, which should motivate scientists to act, because in the current era of media-filled reports on the real mission, it opens up space for serious discussion of the shape of global governance of planetary defence. Central to the policy paper's discussion is the proposal for the emergence of a security community from/within the current scientific community and the emphasis on the principles of multilateralism ensuring security for all (indivisibility) and the possibility of developing scientific and industrial capabilities by participating in other demonstration missions (diffuse responsibility).	

V17 - Capacity utilisation of the Czech Republic (industry opportunities)

Code	Name	Result type
#17a	Space mining: a current opportunity for the Czech Republic to promote multilateral international order	O - policy paper
	One of the key policy papers focusing on the proposal of a multilateral model for space mining that respects international law and its interpretation by a broad section of the international community, while supporting the development of national industry and science. Among the keys is an emphasis on the dissemination of benefits from mining through the implementation of already established and approved UN global agendas, including in a non-financial form. This policy paper is a key outcome for further policy actions of the Czech representation if it wants to support the Czech industry built on current scientific projects developing technologies for mining and at the same time ensure that Czech law does not clash with the divergent views of the international community. It also includes an extensive annex for orientation in international law. To illustrate, both the series of publications in #12 and Chapter 8 of the final monograph #16 can be added, portraying a possible approach to the development of national space mining legislation based on a cosmopolitically responsible approach respecting contemporary international space law.	
#17b	Technological, scientific and economic opportunities for the Czech Republic in the field of space mining	O - studies
	A study that was quite crucial in motivating a number of companies in the Czech Republic towards space mining and contributed to the creation of the SLAVIA project from the financial framework of ambitious ESA projects. The study proposes what current scientific and technological capabilities in the Czech Republic are suitable for a practical demonstration mission in space and defines specific requirements for desirable technological skills, especially in the field of materials prospecting.	
#17c	Opportunities for the Czech Republic in the field of breakthrough laser technologies	O - studies

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The Czech Republic has a huge potential and legacy in the field of laser technologies and their use in space, from light sailing to celestial body prospection to space traffic security. However, in order to maintain the existing capabilities and fulfil their potential, stable systematic support from the state is needed. The study identifies several potential breakthrough space projects based on current Czech capabilities. An effective and simple step that can respond to the growth of new sectors is the development of a laser instrument for spacecraft with applications for tracking objects in orbit, space debris ablation and remote ablation prospection of laser-excited plasma.

V19 - Global governance

Code	Name	Result type
#19a	Security, legitimacy and practical aspects of lasers	J - reviewed article*
	A direct publication based on the PLSAW 2019 workshop discussing practical, safety and legitimization aspects of the development, construction and operation of large technical systems with emphasis on laser technologies for space applications. The paper proposes three approaches: a) the construction of a networked governance model transcending traditional dynamics around national sovereignty, b) a context-driven legitimation of trade-ins and trade-offs, and c) a multi-stakeholder model responding to the complexity and multipolarity of the contemporary space policy space.	
#19b/V19	First Space Colony: what political system could we expect?	J - reviewed article
	The relationship between a particular design of technology and a form of governance is demonstrated through the example of the first space colony. The normative argument for cosmopolitan ordering as a response to the controversies of the politics of national exceptionalism, libertarianism, or a purely scientific expert system of governance is elaborated. The normative argument demonstrates how cosmopolitan ideas should be part of future political arrangements by cementing the advantages of other approaches into a sustainable model in which colonies (or any other technology-dependent space project) can flourish. The paper develops a range of arguments that are then reflected in the policy model of a cosmopolitan responsible state that is being built.	
#19c	Reaching for the stars: The case for cooperative governance of directed energy technologies	J - reviewed article
	In collaboration with Joan Johnson Freese, this paper is a follow-up to PLSAW 2019, specifically the policy session Governance of Large Technical Systems. The paper does not discuss, but rather introduces the whole issue of governance of laser LTSs and highlights the need to open international discussions on their regulation.	
#19d	The Multipurpose Lunar Base as a First-Line Biosphere Defense and as a Gateway to the Universe	C - chapter
	The final chapter develops a number of even rather wild considerations, but they have a completely rational basis in the perception of political dynamics. In the event of the failure of the emergence of a security regime regulating high-energy systems for space applications, we have here considered the option of installing lasers on the far side of the Moon, which would thus be unable to threaten the Earth. Technically, such a solution is very problematic for many reasons (cost, cooling without a medium, etc.), but it has nevertheless served as a contrasting model to the efforts to establish a global safety regime.	
#19e	Dawn of Cosmopolitan Order? The New Norm of Responsibility to Defend Earth and the Planetary Council	C - chapter
	The chapter develops a reflection on a new R2P-based standard called R2DE - Responsibility to Defend Earth. The standard was not developed further in the project, but as a normative orientation it is certainly applicable to the building of a security community based on multilateralism proposed in policy paper #14f.	

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V31 - Model cosmopolitan model of a responsible state

Code	Name	Result type
#22a	Policy model of a cosmopolitan responsible state	O - studies
	A key result that builds on a number of publications. The study presents cosmopolitan ideas as the basis for the principles of action of a cosmopolitan responsible state. This concept responds to the criticism of excessive idealism in cosmopolitan theory; thus, theorists have responded with a concept standing quite realistically on the current global political order. Thus, the study should make it clear to all skeptics that the proposed political change is not a matter of rearranging the world, but a vector of (primarily) foreign policy or national legislation with cosmopolitan features, addressing the range of problems that the project opens up.	
#22b	Common But Differentiated Responsibilities for Space Debris Removal	J - reviewed article
	In the context of the elaboration of the concept of a cosmopolitan responsible state, an article has been written that takes a slightly different perspective on this issue. The concept of CBDR - Common But Differentiated Responsibilities, on the basis of which it points to the growing weight of responsibility of those actors who make up the orbital garbage. He then develops the interaction of CBDR and the dynamics of orbital litter into a concrete discussion around the consolidation of international cooperation underpinned by the current international legal system.	
#22c	Space program of EU Pirate Party	O - political programme
	The team developed the space part of the political programme for a pan-European Pirate Party.	
#22d	Round table in the Chamber of Deputies	O - other
	During the organization of PSLAW 2019, a roundtable was organized for the Subcommittee on Aeronautics and Space Programme of the Chamber of Deputies of the Czech Republic.	
#22e	PULS for the Czech Republic	O - other
	A strategic one-page vision for the Czech Republic was developed for the next meeting of the Ministry of Transport.	
#22f	PULS Declaration - Peaceful Use of Lasers in Space	O - other
	The PULS Declaration is a fundamental document describing the goals of the scientific community in establishing a safety regime to enable the development, construction and operation of high-energy systems for civil applications. The Declaration was endorsed by Nobel Laureate Gérard Mourou.	
#22g	Space debris as part of climate change: a cosmopolitan responsible approach	P - policy paper
	The policy paper, which is not the culmination of one of the three key themes of the project, but builds on the developed paper #22b. It develops the concept of a cosmopolitan responsible state through the CBDR concept and develops orbital trash through an environmental perspective. A key argument is the consideration of the potential extension of the international legal perception of the environment to include orbit, which would allow for a more rapid development of a regulatory regime that avoids the potential unusability of orbit due to chained collisions.	
#22h	Cosmopolitan Approach to the Issue of Space Debris	O - studies
	A study developing the discussion in policy paper #22g into a theoretical and philosophical argument.	

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V32 - Experimental research

Code	Name	Result type
#23a/V32	Studies analysing the parameters of a suitable laser	O - studies
	The study explores the possibilities of enhancing the ablation effect on existing laser technologies for the purpose of potential asteroid mining or deflection. A list of potential subjects for their development has been developed in all three applications considered: interplanetary and interstellar flight, prospecting for raw materials or asteroid diversion from collision orbit, and space debris cleanup.	
#23b	Simulation of meteors by TC-LIBS	D - conference paper
	Conference paper from part of the experimental research that led to study #23a/V32. This research used real meteorites on which the LIBS technology, i.e. laser excited plasma spectroscopy, was demonstrated.	
#23c	Power lasers in astro and aerospace	O - thesis
	A thesis that built on the experimental research leading up to study #23a/V32.	

V16 - Final monograph

The monograph is listed in the project as a binding deliverable in the form of O - book manuscript. It will be published by Springer in 2022. Below is a list of chapter titles.

#16	Small States as drivers for cosmopolitan responsibility in space	About - book manuscript
	Governance of Emerging Space Challenges: The Benefits of a Responsible Space State Policy	Title of published monograph in Springer
	The monograph summarizes and expands on the research findings and does not contain duplicate information, e.g. at the level of policy recommendations, which are more focused in terms of their literary genre. Instead, the monograph develops the theoretical basis of the concept of the cosmopolitan responsible state (1), aligns it with regime theory (2), and puts it in the light of realist-geopolitical critique (3). In the next section, it builds an argument on a cosmopolitan-oriented interpretation of contemporary cosmic law (4), which, together with the chapter conceptualizing the cosmopolitan responsible state (5), are the theoretical-conceptual core of the publication and the theoretical-epistemological anchor of the whole research. In the next part, the monograph applies this framework to our three key themes: planetary defense (6), space mining (7), and fracture projects (8), complemented by the issue of orbital debris developing the concept of responsibility in a cosmopolitan spirit (9). The final part of the book then deals with the technical feasibility of each of the key topics: planetary defence covering astronomy to deflection methods (11), mining (12) and the use of lasers in space (13).	

1	Reconciling cosmopolitan theory and policy practice? Responsible states as a transitional category
2	International security regimes, space, and responsible cosmopolitan states
3	Cosmopolitan visions under the critical sight of realist(ic) geopolitics
4	International Space law as the transiting path to cosmopolitan order
5	Cosmopolitan responsible state in space politics
6	Addressing Global Governance Gaps in Planetary Defence
7	Space mining: Attempts to materialize cosmopolitan ideas enshrined in international space law
8	Peaceful Use of Lasers in Space: Challenges and Pathways Forward
9	Cosmopolitan Approach to the Issue of Orbital Debris
10	Addressing Global Governance Gaps in Planetary Defence
11	Technology readiness and small states contributions in planetary defence
12	Asteroid prospecting and space mining

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13	High-energy systems today and tomorrow

Key conferences organised

#18m/V18	What is planetary defence? (popular 2019, professional 2021)	M - conferences
	This result consists of two conferences. The first one, which is listed as a popularization conference, presented a number of original scientific results, but also introduced the project and the issues it deals with to the professional and general public. The final conference was divided into a professional and a public conference, where both the scientific results and the whole issue were presented to the public.	

#20a	Global Governance of Large Technical Systems (within PLSAW2019)	M - conferences
	Policy session following PLSAW 2019 at HiLase. Implications for further development at the policy level were divided into practical, security and legitimisation, and several publications were developed over the next two years. A key outcome of this workshop and conference was the establishment of the PULS initiative with the support of a Nobel Laureate.	

#20b/V20	PULS Technical and Strategy Sessions (2021)	M - conferences
	Follow-up conference to the #21 Prague Laser SpaceApps Workshop (2019) reported as one outcome, but consisting of two thematically distinct days: the PLSAW Technical session and the PLSAW Strategy session - Breakthrough Ideas in Global Governance 2021. In the technical part, the presentations of the outcomes discussed specific possible levels of collaboration between HiLase and Breakthrough Initiatives. The strategy session mainly discussed ideas for the development of PULS based on the commentary for the UNSC, available at www.lasers4space.com.	

#21	Prague Laser SpaceApps Workshop (2019)	W - workshop
	The first laser workshop was the central event in the development of the cooperation with Breakthrough Initiatives and an important prerequisite for the future development of the cooperation with HiLase.	

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EVALUATION OF THE ACHIEVEMENT OF THE PROJECT OBJECTIVES

A. THE OBJECTIVE OF THE PROJECT WAS ACHIEVED.

The recommended position on planetary defence permeates all publications.
The scope and vision of the other secondary ambitious impacts of the project was very broad and as a result many of these visions have come to fruition. The only vision that the project cannot fulfil is the actual behaviour of the state according to the recommendations that emerged.

B. WE HAVE ACHIEVED ALL THE MANDATORY RESULTS.

Changed results/objectives:

- Feasibility study: if we evaluate the successive change procedures, the feasibility study was transformed into a study of the technological and scientific capabilities of the Czech Republic for mining, which was directly followed by the SLAVIA project from the financial framework of ambitious ESA projects and was selected for funding. In the case of the fracture technology study, a new department for space applications of lasers is being established at HiLase in Dolní Břežany. The change was therefore very positive for the fulfilment of the project objectives.
- The economic line: the economic balance sheet of space mining was abolished as an economic outcome by the amendment process, but the arguments in both law and governance models emphasized the link between the principle of *benefit of mankind* and the potential gains from mining all the more. Thus, the economic line did not disappear from the project, it merely transformed from precise (speculative) calculations into political argumentation.

C. SOCIAL CHANGE AS REQUIRED BY THE ÉTA PROGRAMME.

In addition to the aforementioned SLAVIA follow-up project (and a list of others, including many unsuccessful submissions, listed below), among the most significant tangible positive social changes are:

1) The emergence of corporate interest in developing technologies for space mining.
   The approved SLAVIA project demonstrates this, where there are two branches: industrial and scientific, the industrial branch has a number of companies that did not get involved in mining, the scientific branch is run by the Institute of Physical Chemistry of the Heyrovsky Academy of Sciences.
   It also demonstrates the intensive participation of companies in a number of other submitted projects, which, apart from SLAVIA, have not yet been successful. However, a number of these projects are now being used to further develop the new Space Applications Department at HiLase in collaboration with HiLase and its new department.
2) The establishment of several new scientific departments.

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It demonstrates the establishment of the Centre for Governance of New Technologies at the Institute of International Relations, which was mentioned in the National Space Plan for 2020-2025.
Another new research facility is the space applications department at HiLase (the name is not final at the time of writing).

3) Impact on national strategy documents.
Planetary defense, space mining, and breakthrough projects are all part of the National Space Plan, which the project team participated in developing.
4) The impact of the project results on the political programme of the political party
The Pirate Party has developed a complete program for the European elections and a number of the project's topics have been included in the Pirate Party's election program for the 2021 general elections through the direct participation of the team.
5) Establishment of the PULS initiative supported by Nobel Prize winner.
The PULS initiative was created after the Prague Laser SpaceApps Workshop 2019 in cooperation with Breakthrough Initiatives directly as a spin-off project. As part of the initiative, the project team engaged in an international discussion on the regulation of dual-use systems in space. See the dedicated website at www.lasers4space.com for more information.
6) Policy recommendations on which to build a progressive state policy in the years ahead.
The non-binding, bonus results of the project include all policy papers and studies analysing Czech science and technology capacities. In both cases, new scientific departments are being created, new projects are being submitted and a discussion is taking place that was not there years ago. In the case of a potential political change, it is of course necessary that there is political will.
7) The emergence of a community of experts interested in planetary defence and mining.
Among the most ambitious goal beyond any binding deliverables is our vision that after the project is completed there will be a community of scientists, experts and companies in the Czech Republic interested in planetary defence and mining. We have undoubtedly achieved this goal with the above, which ensures that the topic will continue to develop after the project is completed.

Definition of the objective from the project application

The main objective stated in the project application was:

- TO SHAPE THE POSITION OF THE CZECH REPUBLIC ON THE ISSUE OF PLANETARY DEFENCE AGAINST ASTEROIDS.

We want to achieve this goal by:

1. *private sector initiation of mineral extraction,*
2. *with public sector support,*
3. *who will perceive this national interest in the context of a cosmopolitan responsible state,*
4. *we will recommend a regulation of international law, which will be given to the Czech Republic as a foreign policy recommendation*

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5. *and with this approach we will set an example for other states in the world by demonstrating that both commercial (space mining or asteroid mining) and security issues (asteroid impact defense) can shape the international security regime in the cosmopolitan tradition.*

Analysis of the achievement of the target according to the steps announced three years ago

1. The SLAVIA project, which was submitted by a consortium of Czech research institutes to the financial framework of ambitious ESA projects under the National Space Plan, has been approved and is under implementation, includes private companies such as SAB. The LIBS instrument has a direct application in asteroid prospection, an activity suitable for asteroid character analysis and resulting planetary defence mission planning.
2. The Ministry of Transport has been a mainstay in this regard. The team had the opportunity to participate in the creation of the National Space Plan (see attached letter to the 2020 report), where strategic objectives of the Czech Republic were proposed, reflecting the key themes of the project: planetary defence, space mining and breakthrough projects. The creation of new scientific departments was initiated.
3. Several policy papers, a dedicated study and an entire edited monograph have been produced, focusing on the concept of the cosmopolitan responsible state, which can become the backbone of a responsible foreign policy. All these recommendations and studies are oriented towards all three key themes: planetary defence, space mining, and fracture projects. There is support within the ranks of several ministries, but the actual action remains with the politicians.
4. The Ministry of Transport received not only a draft position on the regulation, or development, of international law on space mining, but also a number of additional studies addressing this issue. No progress has been made on the substance of the bill due to lack of political will, see point 3.
5. The Czech Republic, especially under the third key theme of fracture projects, but also all related activities linked to the key themes of planetary defence and mining, has already presented the PULS initiative in the context of cosmopolitan traditions at the UN COPUOS plenary in spring 2020. Space law is de facto and de jure cosmopolitan. The State Department has been active in this matter, is interested in developing the topic and is enthusiastic about pursuing the ideas of the project (see letter from AG / DOT on the 2020 Interim Report). In this case, it is a very substantial achievement with the potential for significant societal impacts of the project even after its completion, i.e. exactly fulfilling the purpose of the ÉTA programme.

- Closed/classified lecture on global governance in space at the Council on Foreign Relations for the American security community (2019).

Submitted follow-up projects in the final stages of solution

- **SECTECH - Development of an optical system for protection of satellite systems oriented to laser applications against space debris.** One of the identified potentials for the use of breakthrough technologies of the Czech Republic within the project was a system for detection of objects in orbit and destruction of space debris. Thanks to the project, this potential was developed into a concrete collaboration between several

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industrial and scientific institutions in the form of a joint project submission to the Security Research Competition.

- A project for the European Defence Fund in the field of space traffic control. Previous SECTECH activities have been developed into other areas for the EDF project.
- 3D Additive Endeavour on the Moon: 3DAEMOON. A project for ESA bringing together a number of Czech companies and research institutions focused on additive manufacturing on the Moon.
- HiLASE's involvement with a number of companies. Studies of the potential of the Czech Republic in breakthrough technologies and space mining have identified a number of potential avenues for Czech science and industry. Based on the cooperation established within the project, this potential was fulfilled through the establishment and development of several projects with foreign entities for the development of technologies in the field of space mining, space safety, laser communication or other laser technologies.
- Development of a research team on the use of lasers in space at HiLASE. A number of new projects in the field of space lasers, including cooperation with foreign entities, led to the decision to create a dedicated workplace for space lasers at HiLASE FZU AVCR.
- Report on the peaceful use of lasers in space for the UN Secretary-General. Due to its activities in the field of Peaceful Use of Lasers in Space (PULS), this initiative was selected for support through the Policy Leader Fellowship programme at the European University Institute. This support also led to a report for the UN and other follow-up activities for the development of the PULS initiative.
- Developing multilateral foreign policy by supporting the peaceful uses of lasers in space initiative, TAČR ÉTA. The project developing the PULS initiative received a 90% score in the opponents' evaluation, yet was not selected for funding. We anticipate a second attempt in ÉTA 6.

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