The fifth generation of mobile telephony (5G), which is currently being introduced all over the world, as well as the more and more common sixth generation of local area network solutions (IEEE 802.11ax, also known as WiFi-6), offer their customers very advanced solutions in the field of wireless data transmission. The applied techniques allow, on the one hand, to guarantee very high data rates, and on the other hand, they offer adaptation to the various expectations of users. In both cases, a very important role in ensuring high transmission speed at the required quality level is the use of many antennas on the transmitting and receiving side, commonly known under as MIMO (Multiple-Input Multiple-Output). If the number of antenna elements is large, we speak of the so-called massive MIMO. In practice, it is difficult to imagine the installation of several dozen antennas in a smartphone or laptop, so this solution is rather intended for base stations.

It turns out, however, that the idea of using many passive or active elements in one matrix can be extended in a very interesting way, i.e. to be used outside the base station in the surrounding environment. Namely, in recent years, the concept of intelligent antenna arrays (or reconfigurable reflecting surfaces) gained great attention. These matrices contain hundreds or even thousands of elements made of the so-called meta-materials – these are in fact small elements, e.g. electronic, which, through appropriate manipulation from the controller, can influence the behavior of the incident wave. Such reconfigurable surfaces can be deployed in various places in the surrounding environment - for example on the corners or walls of buildings, allowing the signal to be redirected to any place. These properties open up completely new fields for research to further increase the efficiency of wireless systems. It is conceivable that by placing such reflecting planes at the corner of the building, it is possible to transmit the signal to users who are outside the signal range (e.g. in the street behind the building). In addition, the case of using such planes to minimize radio interference is also very promising - the matrix, thanks to its ability to influence the signal transmission, can completely disperse the interfering signal. In other words, for the expected signal, the plane would act like a mirror, and for interference - like a non-reflecting wall. From an architectural perspective, such planes could in the future be made in such a way that they blend in with the surrounding architecture. However, the effective use of the possibilities offered by deploying reflecting planes in the surrounding environment is conditioned by a reliable transmission of steering information to the matrix controller. It is the controller who is responsible for the appropriate modification of the meta-elements of the plane so as to achieve the selected goal. With hundreds or thousands of such elements, the amount of control data required can be very large, so large that real-time control of the plane becomes impossible. The problem increases when the number of planes increases to two or more. For this reason, it seems necessary to use machine learning and access to rich context information about the environment to be able to control the matrices with a limited amount of control information.

The last very interesting observation made in the last few years in the context of reflecting planes is the use of holographic principles for signal transmission. In this extremely innovative approach in signal transmission, it is suggested to observe the minima and maxima of the signal produced from the receiver's perspective thanks to the presence of intelligent matrices.

All these scientifically intriguing observations became the basis for proposing a research project, the main goal of which is to focus on the use of access to rich information about the environment to control intelligent planes with the use of machine learning. Moreover, the project will explore possibilities to improve three important aspects of wireless systems such as resource sustainability (minimizing any matrix-related resources used, and considering powering the matrices from renewable sources), dynamic spectrum access, and the quality of communication between vehicles or between drones. In each of these areas, reconfigurable matrices can lead to a significant improvement in wireless system performance. In addition, a separate area of research will be the study of the possibility of implementing holographic communications, an extremely innovative approach to signal transmission. Next, theoretical work will be confirmed by the implementation of a hardware experiment in which the impact of the real environment on the tested solutions will be examined.