Wireless systems of the future will offer an ample range of services that require transmission capacities which vastly exceed those associated today with voice communications. In this project three subjects, closely related to each other, in the area of the wireless telecommunications will be approached. Furthermore an important objective of the project will be applying the scientific expertise of the proponents to industrial applications, taking advantage of the expertise acquired in the design and construction of microwave systems. Specifically, the topics to be dealt with are the following:

Modeling of the MIMO wireless channel. The temporal and spatial characteristics of indoor and outdoor MIMO channels will be studied, with the purpose of characterizing the nature and origin of their random behavior. Narrowband and Wideband Multiple Input Multiple Output (MIMO) channels will be the objectives of the investigation. The purpose of this study is the prediction of the performance of telecommunication systems that use these types of channels. The effect in capacity of directive antennas will be analyzed. Several transmission schemes that can be deployed in such channels will be compared in terms of achievable capacity. Also in the context of MIMO systems the effect of using compact antennas such as IFA (Inverted-F- Antenna) , XA (X-Antenna) and CA (Chip-Antenna) will be studied, emphasizing aspects related to mutual coupling and spatial correlation between multiple elements. One of the important objectives of this work is the investigation on the interaction between the parameters that characterize an antenna array and the MIMO capacity of a system that uses such an array. As in previously completed work on this subject, the investigation will be based on theoretical analysis combined with software simulation of electromagnetic systems and empirical study of prototypes. A related topic to be investigated is the MIMO channel capacity for medium to short range line-of-sight (LOS) fixed wireless links. Capacity will be evaluated by simulating the MIMO channel for spherical propagation, which is a non-far field condition for relative large antenna arrays. Exploiting this condition the MIMO channel can provide orthogonal sub-channels for practical transmission ranges and array sizes, and thus maximum theoretical capacity. Linear and square array configurations will be evaluated empirically and by simulation for LOS links and angular coverage of the base station that are realistic. Preliminary results have shown that for practical array sizes and for ranges of a kilometer or less, it is possible to achieve high MIMO capacity for line of sight fixed links, at typical frequencies of 2.4 GHz or higher. The experimental evaluation, which also will include antennas design, will be performed preferably at 3.5 GHz.

Analysis of communication protocols in wireless channels. Analytical methods, validated by means of simulation and experiments will be used to study the effect of different parameters on the throughput and delay of the IEEE 802.11, 802.15 and 802.16 wireless protocols. The analysis will focus on the performance of these protocols when mixed traffic (real time and data) is present and the interaction of the MAC with the physical (PHY) and TCP/IOP or UDP/IP layers, depending on the application.

Design of lenses/antennas embedded in constructions. The objective is to obtain new advances in the theory, numerical analysis and applications of lenses and antennas based on Fresnel zone plates (FZP). This includes the study of diverse configurations such as the planar FZP lenses mounted on building walls and arrays of FZP elements conformal to building panels and the study of dome type curvilinear FZP structures. The aim is to improve the radiation efficiency, the bandwidth, and the focusing characteristics of these novel FZP lenses and antennas.

Industrial applications: As a consequence of the expertise acquired by the group, an increasing demand for applied research has begun to appear. Among these demands, only those that have an ingredient of scientific research are to be included as a part of this proposal. One of these subjects is the use of microwaves for the determination of humidity in wood, which will be investigated under the sponsorship of an industrial partner. The objective is to design a system capable of performing measurements through non-invasive techniques, in order to determine the humidity of wood transported in trucks.

The methodology to be used in this project can be described in general as the combination of theoretical analysis, numerical simulation and empirical results. As a direct consequence of this project, the acceptance of at least 4 journal papers per year is expected. The project is also aimed at the support of the increasing activity at the post-graduate level, particularly the doctoral plan soon to be submitted to the re-accreditation process. The work plan proposed for this project represents the continuation of the current successful efforts in these areas by the proponents. These efforts have resulted in an increasing number of papers accepted in ISI indexed Journals.