Switching from spacecrafts to cities analysis and optimization

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With the rapid increase in urban population and cities sprawl worldwide – "on average, urban areas are growing twice as fast as their populations"[1] - it is mandatory to control the energy consumption and the thermal balance of large cities. The most important energy contribution, which comes from sun radiation, is strongly related to the shape of the city. Therefore, it is very important to enrich the geometrical and the physical models of the city, introducing radiosity technique and finite element modeling in order to evaluate the thermal exchanges both in the visible and in the infrared spectra.
The problem to be solved is difficult. The loads consisting into sun and sky radiations are time dependent, the system of equations is non linear, and the geometry is complex, leading to an important number of degrees of freedom. In order to convince the scientific community that it is feasible to compute such a model, we examine the situation encountered in satellite thermal analysis[2]. The many similarities between these problems allow getting the conclusion that it is realistic to solve this kind of problem.
The optimization of structures started on during the sixties with intuitive concepts of fully stressed design and optimality criteria[3]. This optimization allowed designers to approach the new simulation programs (like finite element methods) and to combine the analyses with sizing optimization[4]. The beginning of city optimization is performed in the same way as the structural optimization in the field of aeronautics and space. This optimization is either local and, in this case, it focuses on improving details such as reducing stress concentrations or designing better openings to a particular building, either global, i.e. based on very general objectives such as finding a minimum weight of the structure or providing the best overall orientation and heights of a collection of buildings in a residential area.
Today, according to a past practice in aerospace engineering, for the large cities whose development is considerable[5], we discuss a complete thermal analysis by the finite element method and the first steps of an optimization process whose details still remain to be defined.
Presently the analyses are limited to radiation and conduction problems, but later it will be necessary to introduce the convection phenomena in order to connect the model with the atmosphere medium and the fluids circulation.

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