CONCEPTUAL DESIGN FOR AEROSPACE VEHICLES

By

Louis B. Gratzer
Associate Professor
Department of Aeronautics and Astronautics
University of Washington
Seattle, WA 98195

The designers of aircraft and more recently, aerospace vehicles have always struggled with the problems of evolving their designs to produce a machine which would perform its assigned task(s) in some optimum fashion. Almost invariably this involved dealing with more variables and constraints than could be handled in any computationally feasible way. Of necessity, therefore, the design approach was usually limited to consideration of only the most obviously important variables which were known from experience to have significant effects on the performance and mission effectiveness of the vehicle. The focus on design constraints was similarly limited so that the overall design process tended to be decoupled and result in solutions which could only be characterized as sub-optimal.

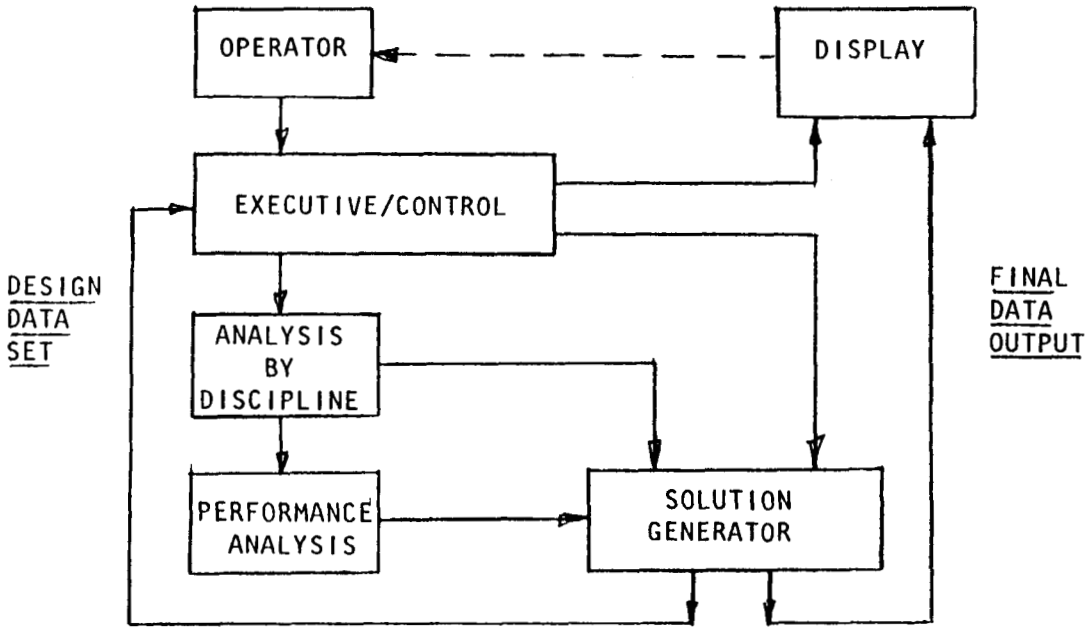
With the advent of the electronic digital computer, the possibilities for introducing more variables and constraints into the initial design process led to greater expectations for improvement in vehicle (system) efficiency. This was chiefly because of the capability thought to be implicit in computer based methods to allow a closer approach to true optimization, i.e., selection of the vehicle geometry to achieve the best possible result within imposed limits. Unquestionably, better aircraft have resulted from the implementation of computer-aided conceptual design programs. However, the creation of the large scale systems necessary to achieve optimum designs has, for many reasons, proven to be difficult. From a technical standpoint, significant problems arise in the development of satisfactory algorithms for processing of data from the various technical disciplines in a way that would be compatible with the complex optimization function. Also, the creation of effective optimization routines for multi-variable and constraint situations which could lead to consistent results has lagged.

The purpose of the assignment this summer was to evaluate the current capability for carrying out the conceptual design of aircraft on an interdisciplinary basis, to determine the need for extending this capability, and if necessary, to recommend means by which this could be carried out. Based on a review of available documentation and individual consultations it appears that there is extensive interest at Langley Research Center as well as in the aerospace community in providing a higher level of capability that meets the technical challenges indicated above. By implication, the current design capability is inadequate and it does not operate in a way that allows the various technical disciplines to participate and cooperatively interact in the design process. Moreover it does not appear that any significant concensus has yet emerged as to how this can be accomplished.

Based on the above assessment, it has been concluded that substantial effort should be devoted to developing a computer-based conceptual design

system that would provide the capability needed for the near-term as well as a framework for development of more advanced methods to serve future needs. A preliminary plan has been outlined which would address the problems of coping with a matrix of variables and constraints in an efficient optimization scheme leading to a true conceptual design capability.

The block diagram shown below suggests a program architecture which could meet the basic objectives and allow the technical disciplines to contribute individually and collectively to the system development.



CONCEPTUAL DESIGN SYSTEM

The most critical elements involve the creation of the sections titled Analysis by Discipline and Solution Generator and are expected to require the greatest expenditure of time and resources. As implied by the flow diagram, progress to a final solution is iterative as required to carry out the complex optimization process. The final data output results from the completion of this process. Multi media presentation of results to the designer may be in the form of printed data, graphics display or continuously by film or tape. A capability for tradeoff analysis is contemplated by which the desirability of relaxing certain constraints or revising design concept features, etc., can be studied. This would allow the designer to more nearly approach important design goals not explicitly included in the conceptual design process due to difficulty of precise formulation or changing the requirements.

It has been recommended that the feasibility of such a system be explored at a modest level without excessive focus on technical detail and using only those variables and constraints which would contribute directly to better design optimization. Nevertheless, the product of this effort should represent a significant improvement over today's capability. It can also be expected to provide the prototype of the more sophisticated conceptual design system of the future.