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## Chapter 17

# Romanian Professor Elie Carafoli: Fifty-Five Years of Devotion to Modern Aeronautics and Astronautics<sup>1</sup>

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Romanian Professor Elie Carafoli's professional activity produced more than 150 scientific works on fluid mechanics, aerodynamics and applied astronautics, many of them translated into the English, French, Chinese, German and Russian languages. His works, "High Speed Aerodynamics" (1956), "Wing Theory in Supersonic Flow" (1969) and "Fluid Mechanics" (1981-1982), were appreciated as reference works in this field of engineering. His contribution to aerodynamics and fluid mechanics embrace the profile theory, the finite-span wing theory, supersonic flow around various forms of wing and wing-fuselage assemblies; conic and quasi-conic motion theory etc. In his career he has received numerous orders and medals. He is a member of many academies and important societies, such as Honorary Fellow of the Royal Aeronautical Society-London; member of the International Academy of Astronautics of the International Astronautical-Federation etc. From 1961 Professor Carafoli led the Commission on Astronautics of the Romanian Academy and from 1958 the Technical Science Department of the Academy; in the period 1968-1970 he was president in action of the IAF. An aerodynamic airfoil class for aircraft wings and two performance aerodynamic wind tunnels are associated with his name, and Professor Carafoli is the founder of the Romanian school of aerodynamics; he is also a councilor at the Ministry of Machine Building Industry.

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The Academy of the Socialist Republic of Romania recently celebrated the 80th birthday of the Romanian scientist of international repute, Elie Carafoli. A founder of the Romanian school of aircraft-building, Professor Carafoli, together with Traian Vuia, Aurel Vlaicu and Henri Coandă, comprise the famous quartet of Romanian aviation pioneers that ranks Romania among the countries that have made remarkable achievements in this field of science and technology in the twentieth century.

As a former student, and collaborator for more than thirty years, of academician Professor Carafoli, I am honored to say that this eminent professor's activity materialized in an impressive number of basic works in the mechanics of fluids, aerodynamics, applied aeronautics and astronautics and, also, in some remarkable achievements on aircraft manufacturing and in aerodynamic test units. I will consider the main aspects of Professor Carafoli's life and work, his activity being carried out with youthful energy for the delight and pride of his students and collaborators.

### **Working for Science and His People**

Born on the 15th of September 1901 at Varia, near Salonic, Elie Carafoli was a member of a Romanian family which performed important tasks in the cultural life of their regional community. After graduating from the Romanian elementary school in his native town, he attended to advanced studies at the Romanian High School in Salonic until the beginning of the First World War, which prompted the young Carafoli to go back to Romania in 1916, bypassing areas upset by the conflagration in this region. After his arrival in Bucharest, he graduated High School and, with brilliancy, the Polytechnical Institute as an electromechanics diploma engineer. To complete his scientific education, Elie Carafoli attended, and graduated from, the Faculty of Sciences at the Sorbonne in Paris, obtaining his licentiate's degree in Physics and Mathematics in 1926, and, two years later, a doctorate in Physics, with a thesis entitled: "Contributions à la théorie de la sustentation en aérodynamique" (Contributions to the theory of sustentation in Aerodynamics). In this period the science of aerodynamics became the passion of his life, Carafoli being the founder of the Romanian aerodynamic school and teacher of an important number of specialists, whose subsequent activity was to place Romania in the forefront of research and practical achievements in aeronautics. This activity started in Paris 55 years ago, when Carafoli collaborated with the French professor Albert Toussaint, who was chairman of the Aerotechnic Institute at Saint-Cyr under the auspices of the Sorbonne. At the same time the young Romanian doctor served as an assistant-professor at the Fluid Mechanics cathedra, led by reputed Professor Paul Painlevé. The scientific papers and works published there (a lot of them with Professor Toussaint) brought him the repute of a specialist in aerodynamics.

In 1928, fresh from the Sorbonne, doctor Elie Carafoli returned to Romania and started a rich and fruitful career: he inaugurated the first aerodynamics and flight mechanics course at the Polytechnical Institute in Bucharest, Romania, which was thus among the first countries training aviation engineers; he designed and built (together with Professor Ion Stroiescu) a modern aerodynamic wind-tunnel, the first in the south-east of Europe (in 1930-1931). In this wind-tunnel were tested all the prototypes of the

Romanian designed and manufactured aircraft of the period 1931-1945 and, also, systematic tests were made on the sections of wings drawn to an original method proposed by Professor Carafoli, some of them being mentioned as "Carafoli sections" by the great scientist Milne-Thomson. At the same time, Professor Carafoli performed many technical actions in aircraft engineering, i.e., after 1928 a team of aircraft engineers (the Frenchman Lucien Virmoux included), designed and built, under Carafoli's leadership at the Romanian Aircraft Industry (IAR) factory at Brasov, many low-wing monoplanes (as IAR CV-11, IAR-14, IAR-15, IAR-16, etc.), a daring formula at the time. As one of the directors of this factory, Carafoli built new and modern research and project departments for it. Also, the founding near Ploiesti City of an important factory manufacturing accessories for aviation, named IRMC (Romanian Mechanical and Chemical Industry), is associated with his name.

In 1948, Professor Carafoli was elected a full member of the Romanian Academy and received the task of organizing the scientific research in applied mechanics; for two decades, successively, as chairman of the Institute on Applied Mechanics, and as chairman of the Institute of Fluid Mechanics, and last as honorary chairman of the Institute of Fluid Mechanics and Aerospace Buildings, professor Carafoli trained many researchers, the results being determinants for the practical use of mechanics in the national economy. As proof, there are many scientific contracts carried out and implemented in various branches of the Romanian economy by researchers of the institutes headed by Professor Carafoli. The scientific reports and papers of these researchers were published in journals such as, *Studies and Researches in Applied Mechanics* (in Romanian) and *Applied Mechanics Review* (in other languages), Professor Carafoli being their permanent editor-in-chief.

Academician Elie Carafoli made major contributions to the popularization and acknowledgement of the great merits of Romanian forerunners in aviation and astronautics. In 1961 the International Astronautics Federation welcomed the Commission on Astronautics of the Academy of the Socialist Republic of Romania as a full member, while Professor Carafoli was elected to positions of high responsibility, including the chairmanship of this international body (1968-1980).

### **High Scientific Level Works**

Professor Carafoli's large and diverse scientific work reflects his constant and efficient preoccupation with directing the basic science to its practical applications. We must chronologically specify the results of the aerodynamic sections theory, the method to draw and, also, the important class of sections named "Carafoli Sections" (with round trailing edges). In his studies referring to formations around a contour, Professor Carafoli was the first to solve the motion problem of a general shape section rotating around a fixed point. Together with the research of the winglets influence on the aerodynamics of a wing, Professor Carafoli was the first to establish the formula of the forces and couples of hinges acting on the winglet and/or on the moving part of the tailplane. The tests carried out at the Aerotechnic Institute at Saint-Cyr (France), and later at the polytechnical Institute wind-tunnel at Bucharest, confirmed the section theory and the

finite-span wing theory. Professor Carafoli drew up a general method to study these wings and the general solution of the variable incidence wing problem based on it, and he established the lateral command winglets theory and the turning wing theory.

Another ample work entitled "Aerodynamics" was translated into German and Russian, including important and efficient solutions, i.e., for the minimum drag at the generalized lift systems, of the wings with central fuselage, etc. After 1952, Professor Carafoli oriented his research to high-speed aerodynamics, where he carried out, and then published, many ideas in the basic handbook *High Speed Aerodynamics* (1956), translated into English and Russian. In 1969 at Pergamon Press, Professor Carafoli edited, with some of his collaborators, the prestigious book *Wing Theory in Supersonic Flow*, including some important results obtained in a supersonic wing study based on the conic motions of a higher order; the first theoretic solution for cross wing problems; the straight wing with normal lateral discs; the complete study of the supersonic wing with conic fuselage, etc.

Professor Carafoli had the merit to attract at such modern studies, in the laboratory or at the working desk, a number of collaborators, giving them the possibility to become well-known abroad. Many actual problems of supersonic aviation were solved by the Romanian aerodynamic school, Professor Carafoli's collaborators using his theoretical model of the supersonic conic motion by separating the subsonic flow at the leading edges of the wing. For supersonic motion and, starting from it for moderate-hypersonic, Professor Carafoli established a unitary formula for the pressure coefficient, to be used in a large range of motions. Together with his collaborators, Professor Carafoli studied, in addition, the round cone having or not having an incidence in supersonic or moderate-hypersonic motions; the effect of the lateral plane jets ejected from the ends of a small aspect ratio wing; the combustion waves in supersonic velocity; the variable geometry wing, etc.

As chairman, moderator or lecturer at many international congresses and symposia, Professor Carafoli contributed to Romania's prestige abroad and to international scientific cooperation. His continuous preoccupation with aerodynamic and fluid mechanics is today also confirmed by his rich editon program, i.e., a new, ample handbook/monograph entitled *Dynamics of Incompressible Fluids* (1981-1982). Professor Carafoli's works were mentioned as reference works in many foreign handbooks on fluid mechanics and aerodynamics, his original scientific ideas and solutions receiving praise from great personalities in aeronautics. Some of his solutions, moreover, served as starting points for the master of science thesis preparation in our country and abroad.

We can make a brief overview of Professor Carafoli's important handbooks and main groups of published works.

General handbooks, and monographs:

1. *Aérodynamique des ailes d'avion* (Aerodynamics of the aircraft wings), Librairie Chiron Editeur, 40 rue de Seine, Paris, 1928.
2. *Théorie et tracés des profils d'ailes sustentatrices* (Theory and designs of the portant wing sections), collabor, with A. Toussaint, Librairie Chiron Editeur, 40 rue de la Seine, Paris, 1928.

3. *Influence des ailerons sur les propriétés aérodynamiques des surfaces sustentatrices* (The winglets influence on the lift surfaces aerodynamics), Publications de l'Aéro-Club de France, Centre de Documentation Aéronautique Internationale, 1931.
4. *Recherches expérimentales sur ailes monoplanes* (Experimental researches on monoplane wings), Publications scientifiques du Ministère de l'Air, Librairie Gauthier-Villars, Paris, 1932.
5. *Travaux du Laboratoire Aérodynamique* (Aerodynamic Laboratory Review), Publications scientifiques de l'Ecole Polytechnique de Bucharest, Imprimeriile Statului, Bucharest, 1938.
6. *Théorie des ailes monoplanes d'envergure finie* (Finite-span monoplane wings theory), Analele Academiei, Române, serie III, XX, 4, 1945.
7. *Aerodinamica* (Aerodynamics), ed. tehnică, Buc., 1951  
*Tragflügeltheorie* (in German), Verlag Technik, Berlin, 1954  
*Aerodinamika krila samoleta* (in Russian), Izd. Akademii Nauk SSSR, Moskva, 1956.
8. *Mecanica Fluidelor* (Fluid Mechanics), collab. T. Oroveanu, Edit. Academiei RSR, vol. 1, 1952, vol. II, 1955.
9. *Miscări conice în regim supersonic* (Conic movements at supersonic speeds), in Chinese, Acad. de stiinte Beijing, 1955.
10. *High-Speed Aerodynamics* (in English), Buch. Ed. techn., 1956  
*Aerodinamica vitezelor mari* (in Romanian), Ed. Acad. 1957  
*Aerodinamika bolshih skorostei* (in Russian), Izd. Akad. Nauk SSSR, Moskva, 1960.
11. *Wing Theory in Supersonic Flow* (collaborators, Dan Mateescu and A. Măstase), Pergamon Press, Oxford, 1969.
12. *Dinamica fluidelor incompresibile* (Incompressible Fluid Dynamics), Bucharest, Edit. Academiei, vol. 1, 1981; vol. 2, 1982.

Ten scientific reports, published in Comptes-Rendus of the Academy of Sciences of Paris.

Eighty-four scientific reports presented at the Romanian Academy or published in the Academy's journals.

Thirty-one scientific articles or papers presented at various international congresses or published in foreign journals.

Thirty-five scientific notes and international articles published in Romania or abroad.

Some important technical or experimental achievements (aircraft, factories, wind-tunnels, aerodynamic laboratories, etc.).

## **An Ample Prestige in His Country and Abroad**

The assignment and award of Romanian and foreign distinctions, the appointment to various important functions, and also, the election to many prestigious international scientific societies and their committees, obviously speaks to Professor Carafoli's merits.

A full professor since 1928, a member of the academy since 1948 and chairman of its technical sciences department, honored scientist, Laureate of the State Prize, awarded the Order of Labor first class, the Star of Republic second class, and Scientific Merit first class, Professor Carafoli is widely known abroad, too. Evidence of this is the international acknowledgement of his lifetime activity in education, research and aerospace development; Professor Carafoli is an Honorary Fellow of the Royal Aeronautical Society of London, a member of the International Academy of Astronautics, a corresponding member of the Academy of Sciences and Arts of Toulouse (France), a former member of the Executive Committee of the International Council of the Scientific Union and of the Council of GAMM (Society for Mathematics and Applied Physics), a member extraordinary of the Hermann Oberth Astronautische Gesellschaft and foreign member of the Braunschweigische wissenschaftliche Gesellschaft (the last three in the Federal Republic of Germany). Professor Carafoli received numerous foreign orders and distinctions: the "Louis Bréguet prize" (1927), the "Médaille d'Monneur-argent" awarded by the French National Society for Progress (1928), the "Paul Tissandier diploma" of the International Aeronautical Federation (1956), the "Silver Medal" awarded by the French National Society for the Promotion of Research and Inventions (1967), the outstanding "Carl Friederich Gauss Medal" (1970), awarded every year by the Braunschweigische Gesellschaft to but one scientist in the world.

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## Bibliography

Milne-Thomson, Sir V. *Theoretical Aerodynamics*, London: Macmillan Publishing House, Fourth Edition.

Oroveanu, Teodor. "Cuprilejul aniversării academicianului Elie Carafoli" (At the anniversary of Professor Elie Carafoli) *Studii si cercetări de mec. aplic. (Applied Mechanics Review)*, Vol. 40, No. 6, 1981.

Zăgănescu, Florin. *De la Icar la cuceritorii Lunii (From Icarus to Moon Conquerors)*, Albatross Publishing House, Bucharest, 1975.

Zăgănescu, Florin. "Ailes roumaines" (Romanian Wings), *Romanian Review*, Vol. 35, Nos. 6-7, 1981.

Zăgănescu, Florin and Gheorghui C., "Historical Data on the Romanian Industry," *Aviation, Techn.*, Bucharest, 1981.

Zăgănescu, Florin. "Elie Carafoli," *Contemporanul Journal*, No. 14 (1847), 2 April 1982.

Zăgănescu, Florin. "Elie Carafoli at 80," *Romania Today*, No. 8 (333), August 1982.