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SOME ACTIVITIES AT MUL2-POLITO ON AICRAFT AND SPACECRAFT

E. Carrera
Politecnico di Torino, Torino, Italy, (e-mail: erasmo.carrera@polito.it)

Abstract: This paper presents shortly some of the projects that have been conducted by the MUL2 research group at Politecnico di Torino in the framework of aeronautics and space science. Among the many projects, see www.mul2.com two activities related to aeronautic and two related to space are shortly overviewed. The first one deals with Prandtl-plane configuration of a possible large aircraft with two joined wing, the other is related to a flying disk aircraft thought for very populated urban areas use. The two space activaties are related to studies on an inflatable reentry capsule and an inflatable manned modules.

Keywords: Prandtl-plane Aircraft, Flying Disk Aircraft, Inflatable Re-entry Capsule, Inflatable Manned Modules.

Prandtplane Aircraft. Some results obtained in the framework of a Italian Research Project directed to both design and develop methodologies for airplane with unconventional architecture. The join wing aircraft has been herein considered. Some pictures with details of Finite Element Models are given in the next figure 1.

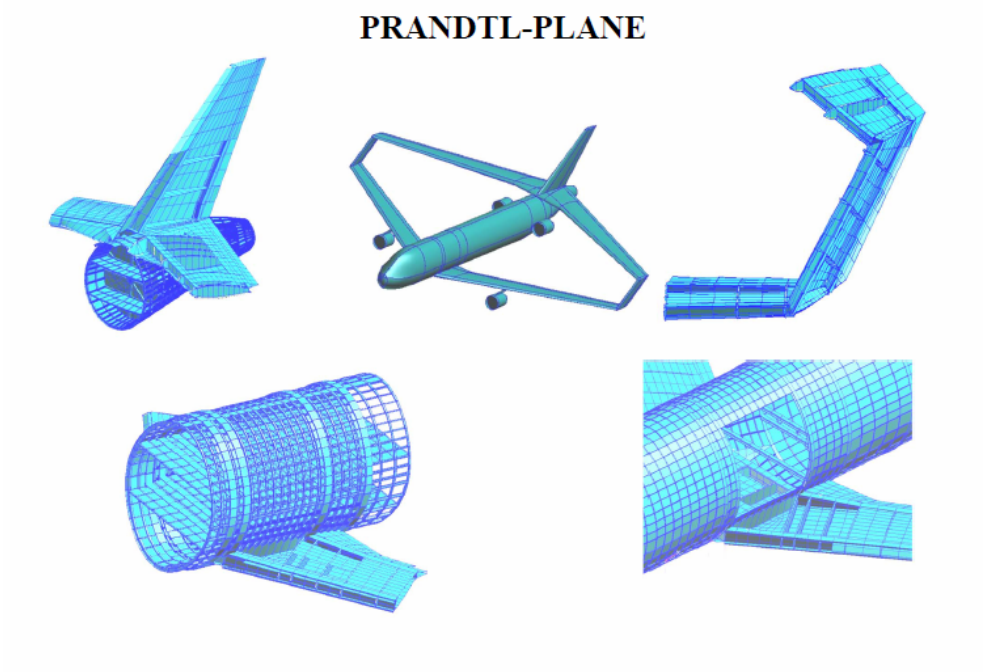


Fig. 1

The main advantage of the joined wing lifting systems, herein denoted *Prandtplane* is due to the fact that according to Prandtl, it consists in the best wing systems (it shows the minimum induced drags). Furthermore, due to the its smaller wing span with respect to traditional airplanes, large aircrafts (more than 600 passengers) with joined wings would not require modifications in existing airports. In particular those analyses that have been made by the research team at Politecnico di Torino are herein illustrated. Simplified aeroelastic analysis which show the possibility of composite tailoring to act on divergence and flutter speeds are discussed.

analyses made by Loocked Aerospace showed that traditional metallic materials would not be capable of increasing the aeroleastic limits to make them suitable for practical applications. The possibility to increase such a limits has been analyzed by implementing a simplified aeroelastic FE model. Geometry of the model has been given in Figure 2.

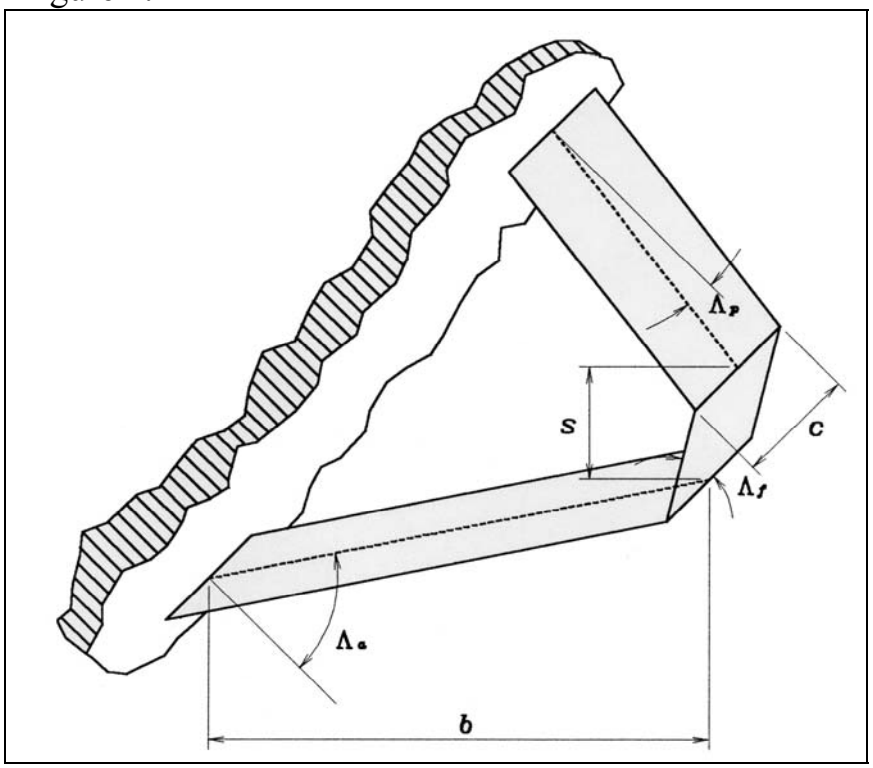


Fig. 2. Geometry of Simplifed Aeroelastic Model

Results are given in Table 1. Effect of tailoring on the two wings has been reported. The possibility of increasing the divergence speed of backward wing (which is statically unstable) is made evident. Divergence can be practically eliminated while 10% of increase can be obtained for flutter.

Table 1

Effect of fibers orientation angle of backward wing on flutter and divergence speed

θ_{Post}	$V_{Flutter}[m/s]$	$V_{Div}[m/s]$
-90	19.03	>40
-60	20.52	25.22
-20	23.31	12.61
20	22.44	26.99
60	20.36	>40
90	19.03	>40

A possible tilt configuration of prandtplane which is currentely under investigation is shown in Figure 3.

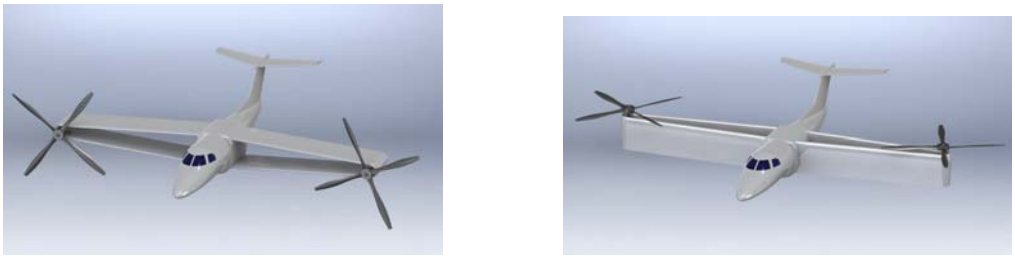


Fig. 3. Tilt Prandplane

Anuloid Aircraft. It consists of an innovative disk-shaped VTOL (Vertical Take Off and Landing) aircraft. The Anuloid concept is based on the following three main features: the use of a ducted fan powered by a turboshaft for the lift production to take-off and fly; the Coanda effect that is developed through the circular internal duct and the bottom portion of the aircraft to provide further lift and control capabilities; the adoption of a system of ducted fixed and swiveling radial and circumferential vanes for the anti-torque mechanism and the flight control. The project has been funded by FP7 EU framework with partners depicted in Figure 4.

Fig. 4. Anuloid Aircraft artistic view and partners

Many studies have been focused on the CFD analysis of the Coanda effect and of the control vanes; the fly-ability analysis of the aircraft in terms of static performances and static and dynamic stability; the preliminary structural design of the aircraft. The results show that the Coanda effect is stable in most of the flight phases, vertical flight has satisfactory fly-ability qualities, whereas horizontal flight shows dynamic instability, requiring the development of an automatic control system.

Reentry Inflatable Capsule. The construction of an efficient and reliable reentry capsule (Figure 5) has played and continues to play a fundamental role in the

space activities. Current applications include International Space Station sample return, the delivery of networks of small stations to the Martian surface, and the return to Earth of launcher upper stages users, ranging from the Space Station to planetary science, and even possibly launcher or technology developers. However, the analysis and design of an inflatable re-entry capsule consists of a cumbersome subject. So many different and difficult problems arise in its design process: aerothermodynamics, material sciences, shield design, multi-body mechanics, inflatable structures blow up simulation and stress analysis, etc.

The numerical simulation of the mechanical behaviour of the Inflatable Space Structures, is an important tool for the validation of the design solutions.

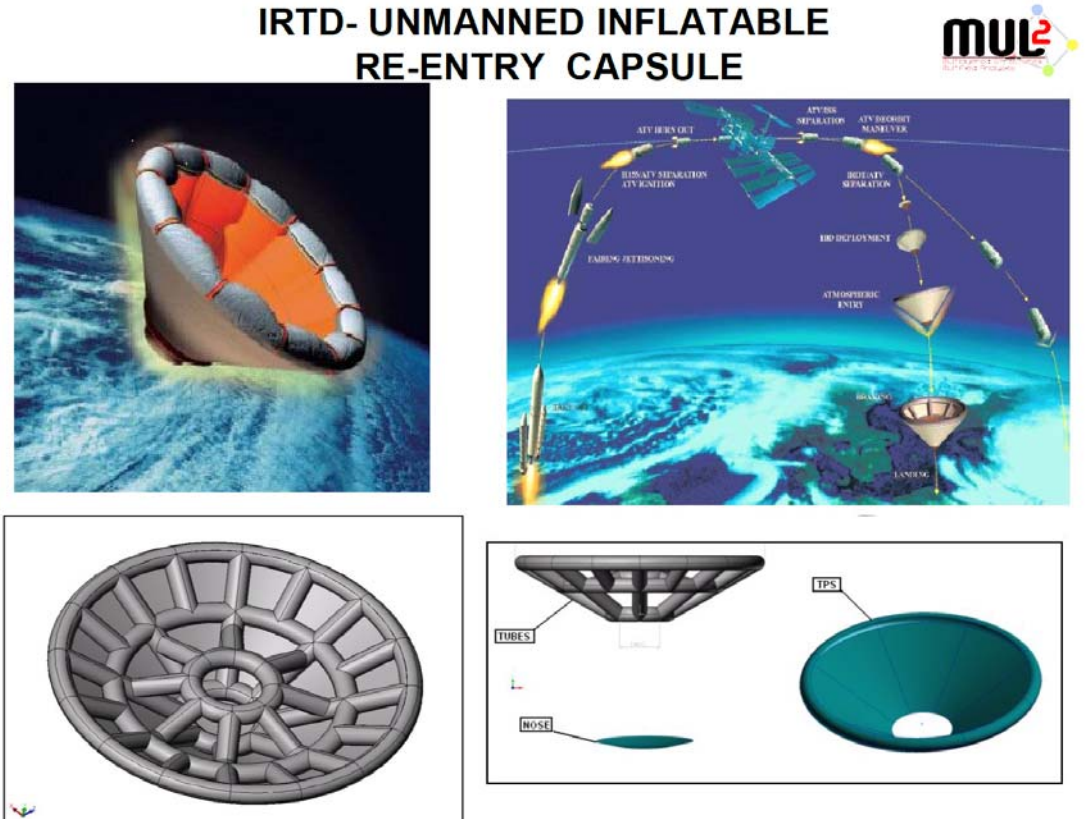
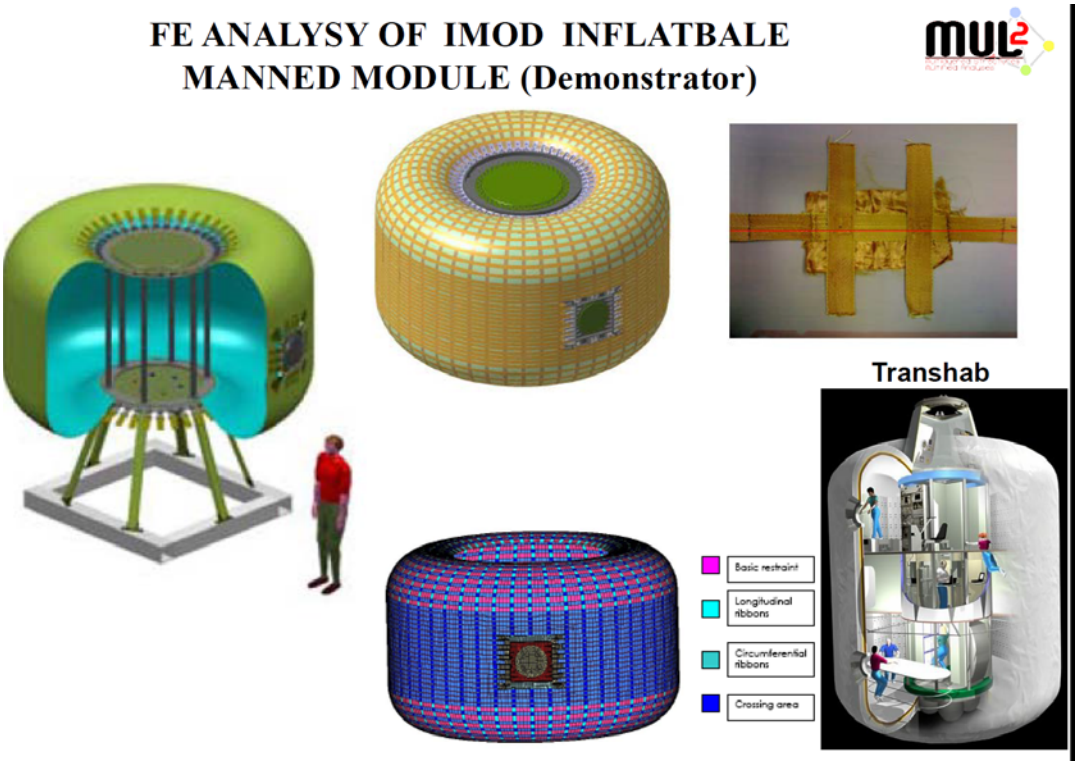


Fig. 5. Re-entry inflatable capsule and typical mission profile

Unfortunately the numerical simulation of the physical behaviour of these structures is of a certain level of difficulty. The choice itself of a numerical code, among the commercial ones, which allows these numerical simulation is not easy to be done. In fact there are several significant physical phenomena which characterize the mechanical behaviour of the Inflatable Space Structures and then a numerical code must be able to allow the simulation of all of these peculiar aspects. In order to perform these simulations, many different numerical approach are feasible to simulate the folding phase.



Fig/ 6. Typical manned modules

Manned configuration, such as those in Figure 6, would require further investigation for the inflation phases starting from a packed shape and considering the actual thick shell, since it is a fundamental aspect of the study of Inflatable Structures, to predict the on orbit correct deployment. The connection among the thin membrane sheets and the mechanical part of the Inflatable Module, like flanged openings, have also to be carefully investigated. Finally the interaction between the deployment of a mechanism device, which can guide the membrane shell to reach the final operative shape, and the inflation phase itself, is also foreseen to be investigated. These type of structures appear mandatory for future manned mission to Mars.

References

For major description see www.mul2.com