Author: M. PONTANI
Università di Roma "La Sapienza" (Italy)
Title: *"Hyperbolic rendezvous with Earth-Mars cycling spacecraft"*
Abstract. In recent years, the scientific community has shown a strong interest toward both robotic and human interplanetary missions, and some space agencies are planning to carry out a human mission to Mars within the next three decades. Several criticalities accompany the design of a similar mission, which will require a spacecraft considerably more massive than those already employed for robotic exploration. Cycler mission architectures consider the use of a large space vehicle that cycles continuously between the Earth and Mars, describing a near-ballistic path that includes flybys at the two planets. While this large "cycler" spacecraft can be equipped with the life support system appropriate for a long interplanetary flight with a crew, taxi vehicles of reduced size are sufficient to ensure the connection between the interplanetary vehicle and each planet. This research addresses the determination of the optimal paths that lead the taxi to rendezvous with the cycler while the latter travels in the proximity of the Earth, where its trajectory is represented by a Keplerian hyperbola. In general, orbit rendezvous between two space vehicles can be achieved through one or more maneuvers, using either high thrust or continuous low thrust. Minimization of the propellant required by the taxi implies maximizing its payload mass. Regardless of the payload nature, propellant minimization can be regarded as the objective of the rendezvous trajectory optimization problem. Two classes of rendezvous problems are considered: (a) multiple-impulse hyperbolic rendezvous, if high thrust is employed by the taxi for short durations, or (b) low-thrust hyperbolic rendezvous, if the taxi is equipped with a continuous, low-thrust propulsion system. In both cases, propellant consumption is minimized through selection of the optimal thrust direction. For impulsive rendezvous (a), this work proposes several solutions, including an option that considers an abort strategy and is therefore particularly suitable for human transportation toward the cycler. Conversely, low-thrust hyperbolic rendezvous (b) requires a longer transfer time, and appears more appropriate for cargo taxis. This research has the ultimate purpose of describing several different optimal options for accomplishing the orbital rendezvous between a taxi vehicle and a cycling shuttle that connects the Earth and Mars, pointing out their respective possible uses, advantages, and disadvantages.

Joint work with Bruce Conway.