

# DEPARTMENT OF MECHANICAL ENGINEERING

## WILLIAM MAXWELL REED SEMINAR SERIES

### “Optimal Low thrust Orbit Transfers and Picard Chebyshev Methods”

Robyn Woollands, Ph.D.

NASA Jet Propulsion Laboratory

**Abstract:** In this seminar I present a method for solving fuel-optimal low-thrust orbit transfers using an indirect optimization approach and the Picard-Chebyshev numerical integrator. The indirect optimization method leads to a two-point boundary value problem with a bang-bang control structure. A hyperbolic tangent smoothing technique is used on the thrust magnitude to reduce the sharpness of the control switches in early iterations and promote convergence. Two examples are presented to demonstrate this method. The first is a transfer between two Earth orbiting satellites, where the Earth’s nonlinear high-fidelity spherical harmonic gravity model is included in the simulation. Including the high-fidelity gravity model is computationally expensive, however, the Picard Chebyshev integrator is well suited to solving such computationally expensive problems. The fixed-point convergence nature of the algorithm allows local force approximations to be made that significantly accelerate the computation. The second example is an optimal low-thrust orbit transfer from an Earth orbit to a Halo orbit around the Sun-Earth second Lagrange point (SEL2). An application of this type of transfer would to send a spacecraft on a refueling/servicing mission to the multi-billion-dollar space telescopes, such as the James Webb Space Telescope, that will operate at SEL2. This problem is posed and solved using circular restricted three-body dynamics. In this dynamical system, invariant manifolds exist that can be utilized to reduce fuel consumption. I present an example solution that allows the refueling/servicing spacecraft to travel for free along the manifold for a significant fraction of the trip.

**Bio:** Robyn Woollands is an Aerospace Engineer in the Mission Design and Navigation Section at NASA’s Jet Propulsion Laboratory and an Adjunct Assistant Professor at Texas A&M University. She has done mission design for the Europa Lander mission concept, navigation for the Mars Reconnaissance Orbiter, and research and technology development for various mission concepts involving optimal low thrust trajectory design. Robyn received her PhD in Aerospace Engineering from Texas A&M University in 2016, where she was advised by Prof. John Junkins. She is a recipient of the Distinguished Graduate Student Award for Excellence in Research at Texas A&M University.

**Date:** Monday, Feb. 17<sup>th</sup>

**Place:** CB 118

**Time:** 3PM

**Contact:** Dr. Alexandre Martin 257-4462

Meet the speaker and have refreshments

Attendance open to all interested persons