



## BOOKS & Reports

### Simulation of Stochastic Processes by Coupled ODE-PDE

A document discusses the emergence of randomness in solutions of coupled, fully deterministic ODE-PDE (ordinary differential equations-partial differential equations) due to failure of the Lipschitz condition as a new phenomenon. It is possible to exploit the special properties of ordinary differential equations (represented by an arbitrarily chosen, dynamical system) coupled with the corresponding Liouville equations (used to describe the evolution of initial uncertainties in terms of joint probability distribution) in order to simulate stochastic processes with the proscribed probability distributions. The important advantage of the proposed approach is that the simulation does not require a random-number generator.

*This work was done by Michail Zak of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-45241*

### Cluster Inter-Spacecraft Communications

A document describes a radio communication system being developed for exchanging data and sharing data-processing capabilities among spacecraft flying in formation. The system would establish a high-speed, low-latency, deterministic loop communication path connecting all the spacecraft in a cluster. The system would be a wireless version of a ring bus that complies with the Institute of Electrical and Electronics Engineers (IEEE) standard 1393 (which pertains to a spaceborne fiber-optic data bus enhancement to the IEEE standard developed at NASA's Jet Propulsion Laboratory). Every spacecraft in the cluster would be equipped with a ring-bus radio transceiver. The identity of a spacecraft would be established upon connection into the ring bus, and the spacecraft could be at any location in the ring communication sequence.

In the event of failure of a spacecraft, the ring bus would reconfigure itself, bypassing a failed spacecraft. Similarly, the ring bus would reconfigure itself to accommodate a spacecraft newly added to the cluster or newly enabled or re-enabled. Thus, the ring bus would be scalable and

robust. Reliability could be increased by launching, into the cluster, spare spacecraft to be activated in the event of failure of other spacecraft.

*This work was done by Brian Cox of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:*

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*Refer to NPO-45379, volume and number of this NASA Tech Briefs issue, and the page number.*

### Genetic Algorithm Optimizes Q-LAW Control Parameters

A document discusses a multi-objective, genetic algorithm designed to optimize Lyapunov feedback control law (Q-law) parameters in order to efficiently find Pareto-optimal solutions for low-thrust trajectories for electronic propulsion systems. These would be propellant-optimal solutions for a given flight time, or flight time optimal solutions for a given propellant requirement. The approximate solutions are used as good initial solutions for high-fidelity optimization tools. When the good initial solutions are used, the high-fidelity optimization tools quickly converge to a locally optimal solution near the initial solution.

Q-law control parameters are represented as real-valued genes in the genetic algorithm. The performances of the Q-law control parameters are evaluated in the multi-objective space (flight time vs. propellant mass) and sorted by the non-dominated sorting method that assigns a better fitness value to the solutions that are dominated by a fewer number of other solutions. With the ranking result, the genetic algorithm encourages the solutions with higher fitness values to participate in the reproduction process, improving the

solutions in the evolution process. The population of solutions converges to the Pareto front that is permitted within the Q-law control parameter space.

*This work was done by Seungwon Lee, Paul von Allmen, Anastassios Petropoulos, and Richard Terrile of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).*

*The software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-44489.*

### Low-Impact Mating System for Docking Spacecraft

A document describes a low-impact mating system suitable for both docking (mating of two free-flying spacecraft) and berthing (in which a robot arm in one spacecraft positions an object for mating with either spacecraft). The low-impact mating system is fully androgynous: it mates with a copy of itself, i.e., all spacecraft and other objects to be mated are to be equipped with identical copies of the system. This aspect of the design helps to minimize the number of unique parts and to standardize and facilitate mating operations. The system includes a closed-loop feedback control subsystem that actively accommodates misalignments between mating spacecraft, thereby attenuating spacecraft dynamics and mitigating the need for precise advance positioning of the spacecraft.

The operational characteristics of the mating system can be easily configured in software, during operation, to enable mating of spacecraft having various masses, center-of-gravity offsets, and closing velocities. The system design provides multi-fault tolerance for critical operations: for example, to ensure unmating at a critical time, a redundant unlatching mechanism and two independent pyrotechnic release subsystems are included.

*This work was done by James L. Lewis and Brandon Robertson of Johnson Space Center and Monty B. Carroll, Thang Le, and Ray Morales of Lockheed Martin Corp. Further information is contained in a TSP (see page 1).*

*This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be ad-*