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Spacecraft Demand Access: Autonomy for Low-Cost Planetary Operations

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January 15, 1997

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In this paper we describe a new concept and prototype for dramatically reducing the cost of contact with planetary spacecraft. Known as Spacecraft Demand Access, a suite of spacecraft and ground automation technologies, it enables future intelligent spacecraft to act as initiators of cost effective contact with the ground - doing it only when necessary. It represents a reversal of the traditional, labor intensive and costly ground initiated procedures for contact. It is our objective that implementation of Spacecraft Demand Access technologies to support future missions reduce the amount of costly contact time by a factor of ten, while increasing the volume of information from a single contact by at least a factor of 2.

Analysis of recent patterns with NASA planetary spacecraft, indicates that most spacecraft arc in contact with the ground between 1 and 2 passes per day, with some missions consuming support cent i nuousl y and/or with multiple arrayed antennas. At a cost to NASA of $1 -3K per hour for antenna time (not including real-time ops support team costs), it is easy to sec that the cost of contact can easily exceed $ 10M per spacecraft per year. In the current NASA environment which desires to increase the mission rate while at the same time instituting full cost accounting for total mission costs, these kinds of expenses have been deemed unacceptable.

The drivers for contact with planetary spacecraft can be decomposed into four parts, a)health and safety, b)science telemetry, c)radiometric navigation, d)commanding. Current methods for contact with spacecraft often utilize 2 or more of these components simultaneously. We make the point that any efforts to effectively reduce the cost of contact must make provision for each of these components; j ust solving one component may not reduce the amount of contact at all or could even cause it to increase!

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In order to achieve our objective, wc have devised a concept that utilizes a suite of five technology components,

1. Onboard self-monitoring
2. Onboard navigation
3. Beacon Signaling
4. I ligh Efficiency Tracking
5. Virtual Emergency Room

Our operations concept for utilization of these technologies is as follows: 'l'he spacecraft, utilizing an intelligent onboard system **(such** as is planned for New Millennium 1)S 1), monitors its own subsystems and manipulates resources, generating commands as necessary. The spacecraft also establishes its own position, velocity, and orientation utilizing an onboard attitude control system and navigation (such as optical nav). The spacecraft then transmits a simple Beacon signal to the ground that indicates "I 'm OK", or "I need HELP!", or "I want to dump data". **"l'his** Beacon signal is received on the ground by a low cost **(3-6** meter) antenna that polls each spacecraft once per day for its beacon state. This information is forwarded to a Virtual Emergency Room (no operators required) which interprets the Beacon signal, logs it and decides what action is necessary. In the simplest case, an email message is forwarded to the mission manager that says "Your spacecraft is OK today". in the emergency case, the mission manager can be immediately "beeped" to respond, while at the same time a request for an emergency pass from a large (34-70 meter) antenna is forwarded to the network scheduling system. in the usual case, the Virtual Emergency Room, using a mission specified urgency algorithm, forwards a request for a telemetry pass with a large (34-70 meter) antenna to the network scheduling system. 'l'he large antenna, utilizing the} ligh Efficiency 'l'racking concept, communicates its performance parameters for the next 8-12 hours (including weather) to the spacecraft in near-real time, and commands the spacecraft to send telemetry at its best possible (varying) rate within the envelope based on those parameters and the spacecraft's own telecom state. This information, primarily science telemetry, is forwarded to science investigators.

This paper will concentrate on the prototyping efforts at J]']. for the Beacon Signaling, 1 ligh Efficiency Tracking, and Virtual Emergency Room.