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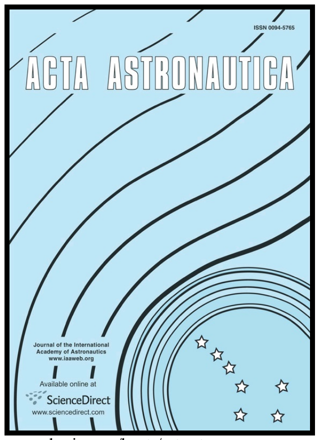

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Extremely Long-Duration Storage Concepts for Space

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Abstract

Recent advances in data storage technologies, such as optical storage and DNA storage, allow data storage for timescales of millions to billions of years. Alongside these developments, initiatives such as Lunar Mission One, the Long Now Foundation and the Human Document Project have promoted the long-term storage of data in order to foster public engagement and to preserve important data for future generations. However, proper concepts for long-term data storage in space are currently missing which match to the needs of stakeholders via the newly available technology. This paper explores the rationales for data storage over millions to billions of years in space and develops three 'time capsule' concepts addressing specific stakeholder needs. First, existing stakeholders are identified and categorized with respect to their motivation. Stakeholder needs are interpreted from statements of motivation. As key motivations, "encouraging global public engagement", "moving humanity toward becoming a dual-planet species", "embracing and constraining the information age", and "allowing storage of information for a very long time" are identified. These needs are then arranged hierarchically for each stakeholder and the most prevalent needs are selected. Metrics are then assigned to each need. One or more storage technologies and storage locations are recommended for each case study. A key technology for storage durations of millions to billions of years seems to be digital DNA storage. Future work aims at developing more detailed storage concepts along with the interactions with the space system into which it is going to be integrated.

Key words: data storage, time capsule, existential risks

1. Introduction

Preserving data for future generations has been a human urge for millennia (Jarvis, 2003). The Rosetta Stone of Ancient Egypt provides a classic example of the value and challenge of preserving key information for long time periods. Contemporary long-duration data storage challenges are exacerbated by the pace of technological change and resulting digital obsolescence. Current digital data storage systems are capable of storing huge amounts of data, but the longevity of the data is limited to decades (de Vries, et al. 2013).

There are efforts to store information safely and for a long time on Earth. Terrestrial data back-up units have been created in all manner of supposedly safe places: the bottom of mines, the tops of mountains, in the Arctic (e.g. Bezos, 2016; Charles, 2006). However, there are specific threats to data stored on Earth, including a devastating asteroid or comet impact, nuclear holocaust, famine, earthquake, hurricane, super volcanoes, and human interference (Bostrom and Cirkovic, 2011). Data stored on Earth is also subject to slow damage over time due to geologic processes and chemical reactions.

A possible solution for terrestrial data storage issues is to store information in space. Information storage in space is not a new concept. Motivations for long-duration data storage in space in the past have included communication with extraterrestrials and stimulation of the human spirit (Sagan, 1972). An