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# SELF-REPLICATION TECHNOLOGY FOR UBIQUITOUS SPACE EXPLORATION

**Abstract**

Self-replication technology offers a radical approach to space exploration that effectively circumvents high launch costs by exploiting extraterrestrial resources. It offers an efficient, rapid yet low-cost approach to lunar industrialisation. The capital cost of launch of a single "cellular" unit is amortised over the subsequent exponential growth in population afforded by self-replication. Indeed, the capital cost may be minimised by launching a "seed" unit (10 tonnes) that initially grows to maturity (100 tonnes) before undergoing self-replication. The concept is not new – it was the central theme of NASA's "Advanced Automation for Space Missions" (1980) that suggested that the approach was highly desirable but required significant technological development. Since then, significant technological advances have occurred which render the self-replicating machine more plausible today. There are several key features that are crucial to self-replication technology. In-situ resource utilisation has migrated from being a minor space research activity to a mainstream one. Although most effort has been focussed on mining water for propellant and 3D printing regolith for outer structures, in-situ resource utilisation may be extended to utilise all the Moon's resources to build a lunar infrastructure. This is the rationale behind the lunar industrial ecology inspired by the constraint of sustainability through recycling. The sustainability constraint is enforced by the necessity for material, energy and information closure. The central spine of the industrial ecology is aluminium processing – we have shown experimentally that lunar highland simulant representing anorthite-rich lunar regolith yields silica and alumina, the latter of which may be reduced to aluminium metal with high purity using the efficient FFC process. Furthermore, aluminium may be supplemented with other lunar-derived additives to yield a suite of alloys for multifunctional applications. We have been characterising the properties of these lunar-derivable aluminium alloys. We expand this resource suite to include iron from lunar ilmenite and nickel-cobalt from buried M-type asteroid material. This generates a demandite list of functional materials that maps to specific applications that include mechatronic components. Manufacture of components may be accomplished by 3D printing, a rapidly evolving technique that minimises material waste. We have demonstrated that DC electric motors may be 3D printed, a major step towards demonstrating 3D printing as a universal construction mechanism. Universal construction is a sufficient condition for self-replication. Mastery of this technology offers exponential industrialisation of the Moon at minimum cost. Self-replication technology represents a revolutionary approach to space exploration whose time has come.