ASTRIC Project

Astrophysical Object Reconnaissance Intervention and Construction

Abstract

The ASTRIC Project is a multidisciplinary, multinational program of scientific research and engineering development that will produce an integrated system for space-based robotic missions. These missions will have a primary objective of providing measures of security and protection to Earth from potential collisions by hazardous extraterrestrial objects such as asteroids. These defensive functions will be accomplished by means of multiple reconfigurable operations to alter trajectory or otherwise mitigate a collision threat. The technologies include modular components that can provide reconnaissance and interventions that result in alterations to object trajectories. These tasks are accomplished by means of mechanical leverage as well as coordinated ballistics. Certain tasks involve direct contact with the target object and other tasks are managed without physical contact.

Of central importance within ASTRIC is the development of intelligent semi-autonomous cooperativity among modular and reconfigurable robots that can operate in a fault-tolerant architecture, in deep space environments. In the context of an asteroid or similar space object, ASTRIC will enable a multi-tasking solution to trajectory modification and collision-threat mitigation, and it will support diverse alternatives such as those explored by NEOShield and other programs. In other contexts, ASTRIC provides an engineering platform for exploration, mining and industrial uses of asteroids and space objects.

ASTRIC research places strong emphasis upon cybernetics and automatic control of extreme complex systems and applies proven mathematics and well-demonstrated computational results to the challenges of operating multiple devices including robots in an environment with unknown parameters concerning the target asteroid or other object. This emphasis upon command, control and computing is a major-needs area for the tasks and an area in which the core team and projected partners have excellent foundations and capabilities.

ASTRIC will be conducted as a research and development project involving a consortium of institutions and experts, in close cooperation with such programs as NEOShield (asteroid defense and countermeasures; EU), NASA (USA), Roskosmos (RU), and others in Russia, Europe, North America and Asia. Support will be obtained from both private and public sources already engaged in the problems and challenges of near-earth-object threat mitigation and in the cybernetics and control of extreme complex systems. There will be a strong educational component to ASTRIC through special courses, seminars, conferences and workshops which will be offered both onsite and online for students, scientists, engineers and other professional interest groups.

ASTRIC Project – Technologies Outcomes (Summary)

ASTRIC systems will be deployable in a variety of mission types and orbital configurations relative to Earth. Mission components will employ technologies including ion propulsion, solar power and high-strength carbon fibres and composites. Mission planning and operations include intervention techniques for object trajectory modification or target break-up. Such control methods employ synthetic intelligence technologies specialized for extremely complex, non-linear, stochastic systems comprising multiple components. ASTRIC incorporates a strong emphasis upon the cybernetics of multiple non-linear dynamical systems and cooperative, semi-autonomous, multi-axial robotic operations.

The outcomes of ASTRIC provide dual-function resources and applications: a long-term deployable system for

planetary defense, incorporating a comprehensive and open-ended suite of technologies capable of adaptation and reconfiguration for uses in space-based applications. An ASTRIC operation for asteroid threat mitigation involves deployment of a system to an identified point in the target asteroid's trajectory. The object is manipulated by a physical net of cooperative robotic units, among which some may have specific functions such as preparation or delivery for ballistic charges, if straightforward trajectory alteration is insufficient for the defensive mission outcome.

The ASTRIC component technologies and particularly the semi-autonomous cybernetics will support other applications include lunar and planetary exploration, mining and manufacturing, as well as terraforming, agriculture and human habitation. Each of these applications are direct outcomes of the electro-mechanics, informatics, cybernetics, and propulsion technologies developed and integrated within ASTRIC.

In addition, the combined developments in analysis, computation, and materials science will produce results directly applicable to other earth-based, present-term problems characterized by extreme non-linearity, uncertainty, randomness and non-algorithmic dynamics. This is a particularly strong benefit of the ASTRIC Project overall. Among such complex systems that may be more successfully addressed by the results from ASTRIC are the control and transformation of aerodynamic and hydrodynamic turbulence, cardiovascular monitoring and predictive diagnostics, and the modeling and forecasting of large-scale population, finance and meteorology dynamics, through the maturation of a fundamentally new generalized computing architecture, one that incorporates biologically-inspired quantum field effects in its computation. These additional outcomes are the result of common fundamental problems and unified methodological solutions, particularly in domains of sensing, computation and control.

Thus, the scope of outcomes from ASTRIC are important in both the direct sense, through the production of an operational system that can be employed in deep space, for both planetary defense and space-based commerce, and in indirect manners, through an integrative family of electronics, mechanics and informatics that will have applicability to solving many complex system problems of today and tomorrow for industry and society.

ASTRIC Project Plan and Structure

ASTRIC is now commencing as a four-phase Project:

Phase-1 --- “Proof of Concept” including computer simulations and models, and earth-based experimental prototypes including air/land robotic engineering

Phase-2 --- Pre-launch prototype (operational software and instrumentation, extended computer-based models, laboratory models, and selected field-based experimentation and demonstration

Phase-3 --- “LEO” (low-earth-orbit) simplified prototype operating with artificial targets (e.g., “space debris”) and multiple deflection/redirection functions (e.g., leveraged trajectory modification plus ballistics and kinetics)

Phase-4 --- Deployable system for actual use in a planetary-defense, asteroid-countermeasure operation

ASTRIC Project – Consortium of Partners

The ASTRIC Project will constitute an international consortium of select members and partners based upon scientific expertise, accomplishment, capability and commitment. The research, implementation and deployment will become integrated into existing and projected asteroid intervention and planetary defense programs currently established and underway in EU, Russia, USA and other nations. ASTRIC will have a strong complement of educational, public communications, and technology-transfer components. The educational activities are unique in their emphasis upon structured projects for youth in both university and pre-college schools, wherein students will participate as interns and in both onsite and online (distance-based) project activities. These students will engage with scientists, engineers and other experts and have opportunities for extended learning and for making active contributions to ASTRIC and similar programs, by means of internships in both academic and corporate laboratories.