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ASTRIC Module System Design Workbook 01 (Phase 2, Design 2020)

[No graphics are yet incorporated into this document]

PREFACE

This workbook begins Phase 2 of the ASTRIC Project (aka "Design 2020"). With continuity going back to earlier work conducted over the past several years, ASTRIC now enters a more rigorous form of R&D and a more expansive team of collaborative opportunities now exist.

"ASTRIC" is described now as "Astro-Terrestrial (Robotic/Remote) Intelligent Constructors" although its implementation-focus is still very much directed to space objects such as asteroids, comets and also man-made space debris. This emphasis on "Intelligent Constructors" reflects the changing and more comprehensive nature of the operational framework and the engineering concepts.

It can be said in broad terms that everything within ASTRIC, in terms of machines and components, performing tasks with natural and man-made objects, is based upon a completely and universally modular, biologically-inspired model of cooperative machines. These machines operate individually and cooperatively in diverse environments, on planetary surfaces and subsurfaces, including Earth, Moon, Mars and other bodies, on asteroids, and in open space, ranging from NEO to deep space. This more inclusive and also more open design is a significant change from the original and recent early-stage ASTRIC designs, with a dramatic emphasis upon modularity, reconfigurability, self-assembly, and cooperative assembly, among the different machines involved, and furthermore, with no limitation to asteroids as the operating environments. However, asteroid manipulation and in particular trajectory and orbit modification for purposes of deflection from impact and collision courses is still a principle engineering objective and foremost in the design and development of prototypes, simulators, and fully-operational platforms.

The entire design process, moreover, is also based upon the following premise:

> Design a RW (real-world) system of machines for constructing (+ or – construction; i.e., assemble or disassemble) "anything, anywhere, anytime" by first designing and experimenting with a VR (virtual reality) system of machines that use simulation and gameplay for all the intended and imaginable functions and situations, and use that simulation and gaming apparatus in a commercial way in order to generate part of the funds for designing and building the RW system for actual mission operations on Earth and in Space.

This may seem like a very different approach in systems engineering and particularly in space sciences and robotics. However, it is very practical given what is now highly evolved and mature in simulation and modeling, and in visualization including VR systems. Moreover, as will be pointed out later in this document, there is an economic rationale at work here; simulations in different forms can be used commercially and this generates revenue which can be turned back into research and development of a primary system such as ASTRIC for operations with asteroids and other space objects.

INTRODUCTION

As remarked earlier in the Preface, a revised interpretation of the acronym, ASTRIC, can be: *Astro-Terrestrial (Robotic/Remote) Intelligent Constructors*.

Gradually, we begin to employ something like the CUBIT taxonomy of logic devices and physical devices (2010-2014). This taxonomy can be used to implement a classical object-oriented design: classes, objects, instances. [That will be produced, formally, later.]

[Describe how the module architecture is not that dissimilar in concept from Lego, Knex, and similar constructor kits, as well as modern NC machining systems that are in use throughout industry.]

[More intro material and some revised diagrams from 2017-2018]

MODULES

ASTRIC machines are multi-component devices that are constructed from modules which are interchangeable among most (ideally all) machines.

There are six (6) classes of modules:

Base modules (torso mods, cores, bases) – different types of units into which other modules (the 5 other types) attach, bind and operate.

The function of the base module is to provide precisely a physical base for all other module types, and a functional base with such "basic" functions as power, general system-wide computing, communications, connectivity.

Currently these are cubic modules of four basic types. All have faces with connectors by which other modules can be directly coupled. These connectors are virtual; these are locations – not all are necessarily implemented in each module.

Static cubic modules: no moving faces or sections
Dynamic cubic modules: the faces rotate (as in a Rubik's Cube, for illustration)

- 4-con-static: 4 connectors on each face (total of 24 possible connectors in the module)
- 9-con-static: 9 connectors on each face (total of 54 possible connectors…)
- 4-con-dynamic: 4 connectors " " " (total of 24…)
- 9-con-dynamic: 9 connectors " " " (total of 54…)

The base modules contain main power generation and storage and main computing resources.

Extension modules (limb mods, extensors) – essentially, arms and legs, units that extend the machine and to which are attached other modules of the 4 remaining types.

Extensors are principally designed for having manipulator, mobility, sensor and transformer modules located at one or more points (connectors, as with base mods) on the extensor. Think of these are different architectures of arms and legs but keep in mind that these are not implying that any machines with these extensors are "ambulatory" robots in their motion.

Manipulator modules (handler mods, grippers) – their functions are to make contact with other objects and grasp or attach to them, with or without tools (which are a type of transformer modules)

Examples:
Hand-like, finger-like grippers
Pliers
Other types based upon suction or other forms of bonding

Gripper mods can hold onto some object (which may be another module in the system)
Grippers can, in principle, perform transformations, by turning motions, for instance, but this is not the same as the transformations performed by transformer mods which are tools that actually change the target object.

Mobility modules (mover mods, movers) - their functions are to move the system in some fashion through some medium

Examples include ion propulsion rockets for space maneuvers, and both wheeled and track-type movement systems for ground operations.

These mods are attached to the base mods typically, but they could also be attached conceivably to extensor mods.

Sensor modules (sensor mods, sensors) – their primary functions are to acquire data and do some processing and then sharing.

[Refer to the EcoVita and AgroIntel architecture documents since much of that originates from and now goes back straight into ASTRIC]

Transformer modules (operator mods, transformers, operators) – their function is to perform some transformative operation on some object. Examples are drills, saws, cutters, lasers, presses, hammers, pincers.

[Refer to the EcoVita and AgroIntel architecture documents since much of that originates from and now goes back straight into ASTRIC]

Functions and Operations

All modules operate following a set of defined process types – these are also classes and sub-classes and ultimately instances of functions within software engineering.

[future – this is about the simple and composite functions performed by module assemblies]

Modules and their Components and Interfaces

[future]

Cooperative Operations among Multiple Modules in one Integral Unit Machine (IUM)
[future - bring in from other docmts]

Cooperative Operations among Multiple IUM comprising one Cooperative Network Group (CNG)
[future - bring in from other docmts]

IUM Navigation, Orbit and Localization Optimization
[future]

CNG Navigation, Orbit and Localization Optimization
[future]

Asteroid Operations Planning
[future]

Space Debris Operations Planning
[future]

Asteroid and Space-Debris Manipulative Operations
[future]

Tether-and-Tow Options
[future]

Gravitational Tractor Options
[future]

Ballistic Projectile Impact Options
[future]

Mining and Mass-Reduction Options
[future]

Chemical-base Explosive Options
[future]

Nuclear Force Options
[future]

ASTRIC as Simulation and Game

ASTRIC – The Simulator
The Simulator is a system that uses the core software that will be used in the full implementation, but a variety of modules, in fact most of them initially, are replicated through software models. This includes visualization and haptics.

The Simulator is what we use to refine the final system implementation(s). The Game (described further below) is what we use to refine the Simulator.

ASTRIC – The Game
The game is an MMORPG-type game played via internet and using computers, tablets, and phones by players who can operate as individual "solo" players or as team "member" players, but even as individual players, they must at different points in their gameplay do some activities involving direct, explicit teaming with other players.

The objective of the gameplay is to perform one or several missions that involve the control of multiple machines which do tasks in space locations, such as on the Moon or in earth-orbit and usually involving asteroids or space-debris objects.

A mission may be of many different types and is composed of phases (stages). A phase is a combination of steps (task sets) that can or must be performed in some sequence or in parallel. Mission phases are multi-action sequences and parallel processes that must be completed in order to proceed to the next phase.

Each mission is intended to exercise with the machines and also with human operators all the different functions that need to be performed and can be performed, bringing operators and machines to their limits in different situations, some of which will be extreme in complexity, difficulty, endurance, physical stamina and

constitution (for both machines and operators).

In the context of simulated exercises and tests, and purely in the context of gameplay for sport, the operators (players) and the machines receive points for different types of actions and these include points for specific performance, for quality, for quantitative elements, and for matters concerning damage, fault tolerance, and also cooperativity and “coopertition” with other operator-players.

In the gameplay, the points are convertible into awards and other measurable data that can eventually result in payments of prize monies, special gifts, scholarships, trips, etc.

Examples of Missions

Rendevous with asteroid AST01 and perform mining to obtain ores and return them to Lunar Base.

Rendevous with asteroid AST02 and perform trajectory deflection to avert impact collision with Earth.

Dig trenches on lunar surface, pile up rocks and other lunar material into earthworks formations, and carry lunar materials to ore processing station.

Assemble maglev cannon in stationary or stable lunar orbit and catch material launched up from lunar surface, position material into cannot, and fire it successfully at target asteroid AST03, causing its trajectory to modify to desired new parameters.

More…
[future]