Mars ISPP Autonomous Controller
Technical Project Plan

Introduction

[Discuss the purpose of the Technical Program and the impact on or value-added to Center customers (program/project and institutional).]

Kennedy Space Center's Roadmap to the Future places an emphasis on NASA's efforts to develop the technologies necessary to send a manned mission to Mars. A key element of NASA's strategy to send a manned mission to Mars is the utilization of resources present in the Martian environment. This element is known as In-Situ Resource Utilization (ISRU). One component of ISRU is the production of fuel and oxidizer for the Crew Ascent Vehicle. This is called In-Situ Propellant Production (ISPP). The development of an Autonomous Controller for ISPP meets the goals of KSC's strategic plan. It also will make a significant impact in a technology area which is key to many of goals of the Human Exploration and Development of Space (HEDS) strategic enterprise.

Background

[Discuss any Center Program/project needs, which have driven the contents and products of this Technical Project Plan (TPP).]

Communication lags between the Earth and Mars make it impractical to directly control the ISPP plant from Earth. Therefore, autonomous control software is necessary to operate the ISPP plant with little or no help from ground controllers. Since the plant has to operate for over a year, the control software must be adaptive. It must be able to handle component failures as well as degradation of the chemical processes. When examining other areas of the Mars Reference Mission design, it becomes clear that this type of autonomous control is needed in many different systems. Therefore this project will help increase the body of knowledge for all autonomous control system needs; whether it is targeted at manned missions to Mars or ground launch systems for Shuttle.

An important aspect of this project is the partnerships with other centers that make it possible. JSC is the lead center for the development of ISRU technologies but they are partnering with other Centers to capitalize on their areas of expertise. For the ISPP project both Ames Research Center (ARC) and KSC have experience with artificial intelligence (AI) software for autonomous control. For the ISPP effort KSC will create the AI "program" for autonomous control using a "language" created by Ames. As the project progresses KSC will help ARC extend the capabilities of their "language" to incorporate process modeling capabilities needed to fully implement the ISPP controller.

Objectives

[Define the primary objective that will provide the direction of the Center Technical Program Plan; i.e., which process improvement areas are most important to the Center programs. This section should provide the hierarchy linkage between the Center objectives (strategies), and the Center Program/project customer needs.]

There are a number of objectives for the Mars ISPP Autonomous Controller project. The prime objective is to develop Autonomous Control software that will operate a prototype ISPP plant constructed at JSC. However, JSC is still experimenting with several techniques for ISPP so immediate pursuit of the primary objective is premature. In order to elevate the AI technology needed for ISPP to the necessary readiness level, an intermediate objective will be pursued during the next 14 months.

The initial project goal will be to develop a simplified Autonomous Control package, using the ARC "language", which will operate a simulated ISPP plant. This will facilitate the development of the software modules to communicate with the user and interface with the "hardware". It will also serve to identify the enhancements the ARC "language" needs to handle the quantitative modeling issues presented by ISPP. (The ARC "language" is state-of-the-art, but presently only handles discrete models, not quantitative models.) As these enhancement needs are identified, KSC will work with ARC to develop solutions. Once the enhancements are completed, KSC will use this enhanced "language" to create a comprehensive Autonomous Controller for the ISPP simulation. When the JSC ISPP prototype is completed, KSC will deliver the Autonomous Controller software to JSC, where it will be integrated with

their Adjustable Autonomy Testbed. KSC will make all modifications necessary to adapt the Autonomous Controller to the JSC prototype hardware.

Center Point of Contact

[Designate a single point of contact for Center Technical Project Plan. For multiple tasks, designate a Center PI of Contractor point of contact. Include phone number, Organization Code, e-mail address and FAX number.]

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Customers

[Identify customer program/projects and the process by which you will identify their needs/requirements. Customer endorsement is required for each plan.]

Johnson Space Center - ISPP Autonomous Controller Simulation
Rob Moreland
Lyndon B. Johnson Space Center
National Aeronautics and Space Administration
Code EP4
2101 NASA Road 1
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Ames Research Center - Livingstone Model Based Programming Language Enhancements
Daniel J. Clancy
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NASA Ames Research Center
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Priorities

[Identify the customer-focused process by which you will continuously update and refine this program area. Describe how the customer's needs/priorities will prioritize your efforts.

Monthly telecons will be conducted with the customer to assure that task prioritization aligned with the customer's needs. At least three face to face reviews will be conducted during the course of the project.

Products

[List the key products that will be produced from the collective task efforts. A product is what a customer uses to improve his product or process. Milestones, reports, and papers are not products. This section must also describe how you will work with your customers to define specific products, how the products will meet customer requirements, and customer commitments to use the products.]

Simplified ISPP Control Program

KSC will create an autonomous control program for a simplified model of the ISPP plant using the Livingstone AI engine created by ARC. This provide a means for the KSC team to develop an intimate understanding of Livingstone so that we can better recommend ways to enhance it. At the same time this will allow us to prototype the framework for the final ISPP autonomous controller and review it with JSC to ensure that it meets their needs.

Initial project requirements were established through a series of both face to face meetings and telecons. Due to the dynamic nature of the ISPP development at JSC, regular monthly telecons will continue to allow the incorporation of ISPP design changes into our simulations. A face to face demonstration of our product will be conducted near the completion of this phase of the project to enable feedback from the customer prior to continuing with the more rigorous

modeling phase. All decisions reached during these telecons and meetings will be documented via Memorandum of Understanding (MOU) which will become part of the project record.

Livingstone Model Programming Language Enhancements

ARC's Livingstone artificial intelligence product currently operates only on discrete models. KSC will use their experience in developing KATE (Knowledge-Based Autonomous Test Engineer), a quantitative modeling product, to advise and assist ARC personnel with the enhancement of Livingstone. ARC and KSC will work together via monthly telecons to define a framework for Livingstone enhancement. This may result in specific products that KSC is required to deliver to ARC. If this occurs, documentation will be generated to record the product requirements.

Rigorous ISPP Autonomous Control Program

KSC will develop a rigorous and complete Autonomous Control Program for the ISPP plant simulation using the ARC/KSC enhanced Livingstone product. Requirements will be based upon the experience gained during our Simplified Control Program implementation and refinements in the ISPP design concepts at JSC. Meetings and telecons will be used to finalize the requirements, which will then be documented in writing. Monthly telecons will continue throughout this phase of the project. At least one status review will be held at JSC midway through the project and a final demonstration will be conducted for at JSC for the exploration office.

After the completion of the Autonomous Control software, the code will be delivered to JSC where it will be integrated into the Adjustable Autonomy Testbed. The integration will be the responsibility of JSC with KSC providing consultation and any required software patches. However, it should be noted that while this activity is planned, it is not yet funded.

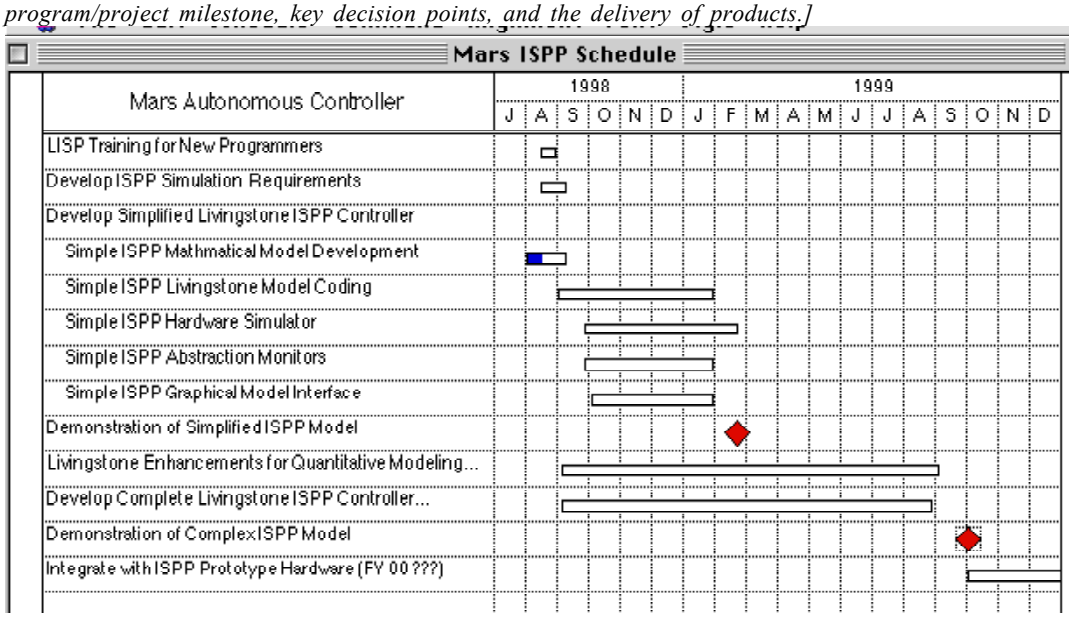
Metrics

[Define how you and your customers will establish the metrics that will be used to measure the value of this project; i.e., work with the customers to define those project attributes that are worth measuring. Metrics must also measure attainment of customer requirements and customer satisfaction.]

Schedule
Adherence to Cost Plan
Software Performance (Performance criteria not yet determined.)

Project Schedule

[This should be a top-level, three year program schedule relating program content to time spans, program/project milestone, key decision points, and the delivery of products.]



Resource Requirements

[Define resource requirements, including whole dollars (not $K) by Program Year (PY), contractor and civil servant staffing, can cost sharing opportunities. For FY 1998, the resource requirements for that year should be well defined. For the out-years, a best estimate is good enough. Enclosure 2 has addition data on phasing funding requirements.]

Manpower

FTE	Requirement
4	LISP Programmers for implementation of Livingstone ISPP models & Livingstone enhancement.
1	LISP Programmer to implement interfaces between Livingstone and the Graphical Interface.
1	Chemical Engineer to develop ISPP mathematical models.
1.25	Graphical Interface and ISPP simulation
0.25	Project Engineer

Financial Requirements

FY 98

$75,000. Manpower

$25,000. Materials

FY 99

$212,000. Manpower ($125,000 CDDF; $87,500 ETB)

$15,000. Materials