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of the
Cassini Mission

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1. INTRODUCTION

The technical progress achieved during the period 30 March through 27 September 1992 on Contract DE-AC03-91SF18852.000 Radioisotope Thermoelectric Generators and Ancillary Activities is described herein.

This report is organized by the program task structure as follows:

- 1.X Spacecraft Integration and Liaison
- 2.X Engineering Support
- 3.X Safety
- 4.X Qualified Unicouple Production
- 5.X ETG Fabrication, Assembly, and Test
- 6.X Ground Support Equipment (GSE)
- 7.X RTG Shipping and Launch Support
- 8.X Designs, Reviews, and Mission Applications
- 9.X Project Management, Quality Assurance, Reliability, Contract Changes, Non-Capital CAGO Acquisition, and CAGO Maintenance
- H.X CAGO Acquisition (Capital Funds)

Note: Task H.X scope is included in SOW ¶ Task 9.5. Task H. was created to manage capital funding.

Also included as significant activities in Task 4 are the efforts of the EMQ Campaigns and Process Readiness activities.

2. PROGRESS BY MAJOR TASK

2.1 Spacecraft Integration and Liaison

During this report period discussions with JPL continued on the preparation of the JPL RTG Requirements Specification. Open topics that received attention were the power level predictions and the ground handling equipment requirements. The power level predictions remain open because a final fuel blend plan has not been issued. Once the blend plan is issued and the fuel specification is available, power level values required by the JPL Specification will be calculated and made available to DOE for consideration prior to finalizing the JPL Specification.

For the RTG ground handling equipment to be used at the launch facility, JPL has imposed more stringent requirements. Previously on the Galileo and Ulysses missions the equipment was proof tested at a factor of 3 times higher than the rated static lift weight. For the Cassini mission, JPL is requiring that ground handling equipment be proof tested to 3.5 times its rated lift weight. GE believes the previous factor of 3 is adequate for Cassini. However, to comply with the 3.5 requirement and avoid proof testing at higher test loads, GE has proposed reducing the rated capacity of the affected ground support equipment from 200 to 170 pounds. By reviewing the RTG lift configurations expected at the launch facility, GE has concluded that a rated capacity of 170 pounds is adequate for the anticipated launch site lifts. For the existing RTG shipping container, margin for derating is not available and proof load testing at higher test loads will be required. A review of the equipment design indicates that it has adequate strength to support the higher test loads.

2.2 Engineering Support

2.2.1 Specifications/Drawings

The drawing changes and ECNs required to incorporate the barometrically operated PRD on the ETG and RTG assemblies were issued in the beginning of this reporting period. A major activity throughout this period was the processing of ECNs in support of the uncouple EMQ activities.

Two candidate coatings and a backup were identified for use on the inner surface of the PRD housing to prevent galling by the bellows when the PRD is operating during the launch dynamic environment.

The following five tests were identified in order to down select the coating:

- 1) Outgassing.
- 2) Temperature shock resistance,
- 3) ASTM—adhesion test,
- 4) ASTM—wear test, and
- 5) Galling test.

The candidate coatings have successfully passed the first four tests and a coating selection will be made in October 1992. The first PRD housing will be coated in November 1992, prior to the dynamic and operating testing of the PRD.

2.2.2 Government Laboratories Interface

The Interface Working Agreement (IWA) which provides guidance for DOE, EG&G Mound, and GE activities to support the fueling and acceptance testing of RTGs, was revised based on DOE and Mound reviews. After incorporation of the review comments, the IWA was returned to DOE to begin the full review process prior to eventual sign off. At the close of this report period the document was under review at DOE.

Also under this task, a Recommendations and Options Report was prepared for existing units F-5, E-2 and Q-1. GE reiterated its conclusion concerning the acceptability of F-5 for flight use. To correct the intermittent indication noted in one of the four Resistance Temperature Devices (RTDs), GE is planning the replacement of the RTDs and wire harness. With this replacement, F-5 is considered to be a fully functional flight unit. F-5 power output is reduced in relation to the units to be newly fueled for the Cassini mission, F-2, F-6 and F-7, because for F-5, a substantially longer period exists since fuel separation occurred. The option report also reiterated GE's expectation that E-2 will be fully acceptable for fight use after it is fueled and acceptance tested. For Q-1, GE recommended that it be retained as an Engineering Unit after the upcoming shipping container thermal tests are completed. This recommendation is made based on the scarcity of high fidelity, full size operational models and precludes, or at least delays, committing Q-1 to destructive safety tests. After completion of the shipping container tests, Q-1 would be used for manufacturing training at GE, possible (as yet undefined) nondestructive testing, and/or post operation diagnostic evaluation. Only after the completion of such tasks would Q-1 be considered for destructive safety tests.

2.3 Safety

2.3.1 RTG Safety Assessment

At the beginning of this reporting period, it was understood that the EIS Titan Data Book, except for "System Failure Probability Analysis" (Section 10) had been approved by

NASA/HQ. However, DOE was requested by NASA not to use the Data Book at that time. Consequently, finalization of the Draft RTG Safety Assessment (RSA) was delayed over a considerable period of time, since it was contingent on the approval to use the Data Book.

A draft RSA was issued, and comments were received from DOE contractors and laboratories. Appropriate comments and suggestions were then factored into this document and this revised draft was subsequently reviewed again by DOE, and then finally transmitted to NASA HQ as the Draft RSA for the Cassini EIS toward the end of this reporting period. Also at the end of this reporting period, the approved Section 10 to the EIS Titan Data Book was received from NASA. The vehicle failure probabilities from this section will be factored into the final RSA to be released during the first calendar quarter of 1993.

A meeting was held in May 1992 at NASA LeRC to discuss the content and schedule needed for the Titan Data Book for the Cassini SARs. Several options were discussed with regard to considerations of accelerating the launch approval schedule along with potential deletion of either the PSAR or USAR and preparation of only a final Data Book. There were no decisions reached at the meeting since an agreement would have to be reached jointly between NASA and DOE with input from INSRP. Subsequent discussions between DOE, NASA, and INSRP concluded with the decision that three issues of the safety reports would be produced and that at least two versions of the Titan IV Data Book would be required in support of the safety reports. Thus, the safety report schedule results in the PSAR publication targeted for August 1994, the USAR for August 1995, and the FSAR for August 1996. To support this schedule, the preliminary Data Book will be needed in the August 1993 period, and the final in the September 1994 period.

A June 1992 meeting of the RTG Working Group for the Titan Data Book was attended at NASA Lewis. This was the kickoff of activities for the preliminary Data Book scheduled to be published in August 1993.

2.3.2 Safety Test Program

Drawings of the RTG end support structures for the GPHS stack were sent to Fairchild Space at the beginning of this reporting period. These drawings have been used to develop the analytical model structure to be used in the hydrocode analysis for the RTG end-on impact test. The hydrocode analyses were subsequently conducted by Fairchild based on both weak and strong fuel simulant in order to bracket the response of the RTG for impacts on both the inboard and the outboard ends of the RTG. Hydrocode analyses also included the response of the RTG to impacts by edge-on thin plate fragments hitting the side of the RTG. The results of these analyses will be used to select the test configurations for the Safety Test Program Plan such that the use of the limited hardware is optimized.

2.3.3 Risk Analysis Codes Development

During this period, technical progress was made in the following areas of nuclear risk analysis:

- 1. SATRAP KSC Site Dispersion Code Development and Testing*
- 2. DOSE/Health Effect Methods Testing and Documentation*
- 3. Data Acquisition and Processing*
- 4. SATRAP/NUS Code Comparison Runs*

1. SATRAP KSC Site Dispersion Code Development and Testing

The local/mesoscale (KSC site) meteorological dispersion and deposition models previously developed were coded and tested within the SATRAP computer code. In addition, a concentration and receptor grid calculation was developed and implemented. The primary objective in implementing this set of calculations was to permit use of fully 3-dimensional wind, turbulence parameter, and surface condition data. Such 3-D data sets have also been acquired. These calculations use a continuous parameterization of turbulence (stability) that is the same for both dispersion and deposition models. This approach permits a coherent treatment of the dispersion of sub-micron aerosols released as puffs, which is the normal case for site accident scenarios.

The receptor grid structure and concentration calculation developed during this period has features that are highly useful for analysis of multi-sized aerosol releases. The

receptor grid structure adapts itself to the geometry of the particular release cloud of each scenario being analyzed. This permits an accurate representation of the distribution of dose levels around the KSC site, while minimizing execution time on the computer. The calculation of surface level air and ground concentrations of radioisotopes uses this grid. The method permits superposition of the contributions from two components of the source, namely the sub-micron aerosols and the larger aerosols. Accommodating both large and small aerosols is challenging because of the very different time and distance scales involved. Sub-micron aerosols stay airborne on a worldwide scale while the largest particles may deposit in a very local footprint. The code accommodates this by having a Cartesian grid nested to several levels that adapts to the shape of the actual footprints.

2. DOSE/Health Effect Methods Testing and Documentation

The equations and data sources used for inhalation radiological dose conversion as well as dose-to-health effects conversion for internal pathways are basically the same as those used in the Ulysses FSAR: namely, the Dose Conversion Factor (DCF) models of ICRP 30. However, use of updated model parameters is proposed as indicated in ICRP 48. The DCF values thus obtained have been published as DOE/EH-0070. The major improvement is in use of a higher absorption rate of Pu238 oxide into the body fluids. This causes a shift of the majority of the dose from the lung to bone.

The dose to-health effects conversion equations are based on DOE/EH-0071, BEIR IV, and BEIR V. These methods are the same as those of the Ulysses FSAR.

Actual calculations were performed using the equations and new DCF values. Overall results were not significantly different from those of the Galileo/Ulysses FSARs. In addition to this evaluation of the new DCFs, the fractions of inhaled particles deposited in each of the three lung regions were calculated using the mono-size data from the original ICRP 30 source study. These were compared to the use of the lung compartment deposition fractions in ICRP 30 which apply to distributions of varying size rather than mono-size. Differences of up to a factor of 2 were noted, but the overall effect on dose

should be much less. This study was done because most of the particle-size bins for RTG source terms are much narrower than the distributions of ICRP 30; hence, they are more like ~one-sized particles. Although the dose conversion models discussed above have been coded to permit testing, they are not yet fully integrated into the various codes of the SPARRC system.

3. Data Acquisition and Processing

The following data required for performance of the risk analysis for the SARs has physically been acquired during this period.

- 1) a 3-D time-varying sea breeze wind field for one day, obtained by fitting a simulation to actual data by J. Leone of Lawrence Livermore National Laboratory;
- 2) the GRAM 90 computer code and data files, NASA's Global Reference Atmosphere Model, capable of producing worldwide wind fields at all altitudes averaged by month;
- 3) CCAFS radiosonde data and KSC wind tower data obtained from Halliburton NUS for a large number of towers;
- 4) KSC demographic and surface type data projected to 1995 from 1990 Census data by Halliburton NUS;
- 5) a current estimate of global population and surface type data referenced to the DOE standard 720 equal-area global cells obtained from Halliburton NUS;
- 6) hourly rain intensity data obtained for a station near Miami, which should be applicable to the KSC area.

With the exception of the GRAM 90 data, all of the data files received were checked for computer readability and completeness. GRAM 90 is a complex system that must be thoroughly studied before use. A computer program was written to perform statistical analysis of the KSC multiple wind tower data because of its voluminous nature. The data covers the month of October for five years and 20 towers. This analysis is only partially complete at this time. Brief climatological studies of the KSC area weather data and the Miami rain data were conducted.

4. SATRAP/NUS Code Comparison Runs

Selected meteorological dispersion and dose analysis results from past computer code runs were obtained from NUS. After a survey of these runs, it was determined that a few more cases would be highly useful for comparison with SATRAP. A list of ten additional radiological release scenarios was sent to NUS. NUS ran these ten cases using KSC EMERGE and provided the results. The SATRAP meteorological dispersion and deposition model on these ten cases have subsequently been run. Comparison is in progress, and results will be reported later.

2.4 Qualified Unicouple Fabrication

During this reporting period, efforts in this task were focused in three areas: 1) continued production from operations having already completed process readiness (vacuum casting through thermoelectric parts machining); 2) achievement of process readiness and start of qualification lot production for first bond through the subsequent assembly operations leading to final unicouple assembly; and 3) fabrication of 18 couple module assemblies for long term testing of unicouples.

Operator training, certification, and process readiness status as of the end of this reporting period is reflected in Table 1:

The Process Readiness and Unicouple EMQ Activities sections of this report provide a detailed description of the work completed in achieving process readiness. Additionally, the Unicouple EMQ Activities report section discusses the involvement of the EMQ team in resolving matters related to continued production.

Table 1. Status of Unicouple Training, Certification, and Process Readiness

Process	Training	Certification	Process Readiness
Vacuum Casting	Complete	Complete	Complete WE 9/8/91
Powder Blending	Complete	Complete	Complete WE 9/8/91
Hot Pressing (N-Type)	Complete	Complete	Complete WE 11/1/91
Hot Pressing (P-Type)	Complete	Complete	Complete WE 10/20/91
Hot Pressing SiMo	Complete	Complete	Complete WE 1/26/92
Hot Pressing N-P Bond	Complete	Complete	Complete WE 1/26/92
Machining TE Parts			
Pellets & Segments	Complete *	Complete	Complete WE 2/2/92
Hot Shoe Fabrication	Complete *	Complete	Complete WE 2/16/92
First Bond	Complete *	Complete	Complete WE 5/10/92
Silicon Nitride Coating	Complete *	Complete	Complete WE 5/24/92
Second Bond	Complete	Complete	Complete WE 9/13/92
Nickel Plating			
Moly Compensators	Complete	Complete	Completed WE 7/12/92
Electrical Insulators	Complete	Complete	Completed WE 7/12/92
Couple Preassembly	Complete	N/A	Completed WE 9/27/92
Cold Stack Assembly	Complete	N/A	Completed WE 8/30/92
Unicouple Assembly	In Process	N/A	10/23/92
Wrapped Unicouple	In Process	N/A	10/30/92

WE = Week Ending

** = Cross Training Effort: Indicates additional personnel (other than primary) are receiving training in this area.*

A summary of unicouple hardware production at the end of this reporting period is shown in Table 2.

Table 2. Cassini RTG Program Unicouple Hardware Production Status
(Period Ending 24 September 1992)

	First Lot		Qual Lot							E-6						
	Started This Week	Started This Week	Accepted This Week	Cumulative ITD			Total Planned Starts	Planned Yield	Started This Week	Accepted This Week	Cumulative ITD			Total Planned Starts	Planned Yield	
				Total Starts	Total Accepted	Actual Yield *					Total Starts	Total Accepted	Actual Yield *			
Vacuum Castings	0 1)	0	0	91	90	98.9%	91	92.9%	0	0	50	50	100%	50	95.0%	
Powder Blends	0 1)	0	0	45	42	93.3%	45	94.3%	0	0	24	24	100%	24	96.0%	
Hot Pressing	0 1)	0	0	172	165	95.9%	172	85.7%	8	5	84	75	94.9%	149	90.0%	
N-P Bonds	0 1)	1	1	34	28	82.4%	40	85.7%								
Pellets	0 1)	0	0	3128	1049	68.0%	3264	78.6%	272	0	272	0		2992	85.0%	
Segments	0 1)	0	0	2786	1780	89.4%	3582	78.6%	796	0	796	0		2388	85.0%	
Hot Shoes	41 1)	41	0	1312	389	73.0%	1710	78.6%								
First Bonds	8 1)	38	16	300	195	93.8%	810	74.3%								
Coated First Bonds	0 1)	16	0	192	77	80.2%	568	85.7%								
Coated Spacers	0 1)	0	0	0	0		400	85.7%								
Second Bonds	0 1)	0	0	0	0		486	85.7%								
Nickel Plating	22 2)	0	0	412	139	94.6%	4598	90.0%								
Couple Preassembly	37 1)	0	0	0	0		362	85.7%								
Brazed Radiator Assembly	0 1)	21	0	21	0		534	88.6%								
Cold Stack	0 1)															
Unicouple Assembly	0															
Wrapped Unicouple Assembly	0															

1) Process Readiness approval completed for these processes.

2) Process Readiness approval completed for:

- Moly Compensators
- Ceramic Insulators

* Cumulative Actual Yield is computed as the ratio of the Total Number Accepted (ITD) to the Total Number Completed and processed through Inspection (ITD). The difference between Total Starts (ITD) and Total Accepted (ITD) is a combination of hardware in-process that has not been completed through Inspection, and hardware that has been rejected.

Table 2. Cassini RTG Program Unicouple Hardware Production Status (Cont'd)
(Period Ending 24 September 1992)

	E-7							E-8						
	Started This Week	Accepted This Week	Cumulative ITD			Total Planned Starts	Planned Yield	Started This Week	Accepted This Week	Cumulative ITD			Total Planned Starts	Planned Yield
			Total Starts	Total Accepted	Actual Yield *					Total Starts	Total Accepted	Actual Yield *		
Vacuum Castings	0	0	49	48	98.0%	51	96.0%	9	0	17	5	83.3%	48	96.8%
Powder Blends	0	0	22	20	100%	22	96.8%	0	0	2	2	100%	22	97.4%
Hot Pressing														
N-P Bonds														
Pellets														
Segments														
Hot Shoes														
First Bonds														
Coated First Bonds														
Coated Spacers														
Second Bonds														
Nickel Plating														
Couple Preassembly														
Brazed Radiator Assembly														
Cold Stack														
Unicouple Assembly														
Wrapped Unicouple Assembly														

* Cumulative Actual Yield is computed as the ratio of the Total Number Accepted (ITD) to the Total Number Completed and processed through Inspection (ITD). The difference between Total Starts (ITD) and Total Accepted (ITD) is a combination of hardware in-process that has not been completed through Inspection, and hardware that has been rejected.

High yields in the vacuum casting through hot pressing (including N-P bond) operations for the Qualification Lot continued to be maintained throughout this reporting period. An important effort conducted during this period to help maintain satisfactory yields in N-P bonding operations was the EMQ team work to improve N-P bond strengths. As described in the EMQ Activities section, efforts were successful in raising the overall strengths of N-P bonds, thus minimizing rejections. The yields of hot shoes steadily improved throughout this reporting period as higher strength N-P bonds were produced. A steady increase of the acceptance yield was also acquired on machined pellets. A consistently good yield was produced for segment machining. Table 3 shows the improvements in machining yield throughout this reporting period.

Table 3. Improvements in Machining Yields

	29 May	26 June	25 July	30 Aug	24 Sept
Hot Shoes	24%	33%	39%	45%	73%
Pellets	40%	59%	66%	63%	68%
Segments	85%	85%	85%	85%	90%

A key contributing factor to the improvement gained in pellet machining yields is due to EMQ team implementation of a hydrogen peroxide based cleaning method to remove stains from pellet surfaces. The initial portion (30 - 40%) of pellet production for the Qualification Lot had stains which were caused by machining coolant drying on the parts prior to cleaning. After its detection, the root cause of this problem was corrected by modifying the machining planning so that all parts are rinsed with water, thus preventing coolant from drying on the parts. While the root cause was corrected, there still existed a large number of pellets with stains that had to be resolved. An EMQ team conducted testing utilizing the hydrogen peroxide based cleaning method that is used on first bond assemblies prior to silicon nitride coating. Test results showed the cleaning method was successful in removing the coolant stains. Additionally, the EMQ team also conducted TGA tests utilizing pellets cleaned by the hydrogen peroxide based technique to ensure

that the silicone nitride coating effectiveness was not adversely impacted by this added cleaning step. Based on the positive EMQ team results, cleaning of stained pellets using the hydrogen peroxide technique was permitted (via MRB) and the acceptance yield of pellets increased as cleaning activities progressed.

The Qualification Lot production of first bonds and coated first bonds is only in the initial stages. The yields for first bonds is well above the planned yields showing very good performance in that area.

Process Readiness:

Background

Startup of the unicouple production line has been separated into 13 separate campaigns or processes. Figure PR-1 shows these campaigns and their sequence for unicouple assembly. Prior to producing Qualification Lot and then Flight Lot hardware from a particular campaign, process readiness of that campaign must be achieved. A timeline showing the phases of unicouple production as established in the contract in relationship to process readiness is shown in Figure PR-2. A full description of process readiness requirements is provided by GE document GESP-7233, Process Readiness Review Plan.

Expanded detail of activities during the training lot production leading up to final process readiness is shown in Figure PR-3. The last portion of the training lot is the production of hardware items to demonstrate that the campaign is ready for final process readiness and hence, the production of Qualification Lot hardware. In instances where results from the demonstration runs show that the process yields are not sufficient and/or a technical problem needs to be resolved, Engineering, Manufacturing, and Quality (EMQ) team involvement is employed to investigate and provide a course of corrective action. Following EMQ team interaction, demonstration runs are repeated to prove process readiness.

Figure PR-1. Process (Campaign) Assembly Sequence for Unicouple Fabrication

Accomplishments:

Substantial progress was accomplished this reporting period with final process readiness being achieved for the following seven campaigns:

- Silicon Nitride Coating
- First Bond Assembly
- Second Bond Assembly
- Nickel Plating
 - electrical insulators
 - molybdenum compensators
- Radiator Attachment Assembly
- Cold Stack Assembly
- Couple Preassembly

Figure PR-2. Relationship of Process Readiness in Unicouple Production Line Startup

Figure PR-3. Progression Toward Final Process Readiness

The significant technical aspects and resolution of problems associated with the completion of process readiness for each campaign is addressed in the following EMQ report section. Only two campaigns, uncouple assembly and uncouple stuffing/wrapping remain to be completed to allow the start of uncouple production for the Qualification Lot. At the end of this reporting period, activities on these two campaigns were well underway with demonstration runs planned for early October 1992. and final process readiness expected by the end of October 1992.

From a schedule standpoint, Qualification Lot uncouple production is planned to start in November 1992 based on the controlling factors of DOE funding limitations and the Cassini launch of October 1997. The significant progress accomplished in uncouple operations over this six month reporting period will permit this fabrication goal to be achieved. Because of the importance of uncouple production on overall program schedule, increased support (primarily use of overtime) was expended to complete the individual process readiness milestones. Use of considerable overtime was assumed when the original schedule was developed.

Availability of new uncouple parts continued to be an area of concern during this reporting period. Nickel plating process readiness could only be completed for two parts due to the unavailability of new unplated parts. To maintain schedule progress on the uncouple subassemblies when new parts were not available, accepted plated residual parts from the GPHS-RTG program were used. As a result of the plated residual part resource, Qualification Lot production of uncouples can proceed prior to the full completion of nickel plating process readiness. Emphasis continues to be placed on obtaining acceptable new parts to complete nickel plating. Additional Manufacturing support has been added to solve technical concerns at vendor facilities. In addition, possible rework of received hardware having minor nonconformances is being explored to help supply parts.

Unicouple EMQ Activities:

During this reporting period, EMQ teams led process readiness demonstration trials for the seven completed unicouple process readiness campaigns finished an activity to improve the strength of hot shoes and began evaluation of replacement coolants for thermoelectric machining operations.

First Bonding:

During the previous reporting period, process readiness demonstration runs had been initiated for the First Bond process. High rejection rates for surface contamination had delayed successful readiness demonstration. Additional acetone cleaning of SiMo hot shoes prior to bonding was introduced following the recollection of several technicians that such a step was performed during the GPHS-RTG Program. This produced only a marginal yield improvement. In this reporting period a peroxide based cleaning procedure routinely employed after first bonding and prior to Si_3N_4 coating was introduced prior to the first bond assembly operation. This added cleaning process reduced the rejection rate for surface contamination from 40% to less than 20% for a group of 45 first bond assemblies. With this success, process readiness approval was obtained.

Second Bonding

Principal issues addressed during second bond process readiness trials included the influence of densities for n- vs. p-type 63.5% SiGe segments on cold shoe-segment bonds and surface contamination arising from the fugitive binder used to aid in second bond assembly. Following assembly of nearly 100 training second bonds, a group of process readiness demonstration assemblies were fabricated using N-P density matches representative of GPHS-RTG experience. Assemblies produced with density mismatches of 0.003 and 0.011 g/cm³ produced consistently acceptable bonds whereas assemblies fabricated with segment density mismatches of 0.030 g/cm³ produced more inconsistent bonds as was experienced during the GPHS-RTG Program.

During process readiness trials, surface contamination problems developed due to excessive loss of acetone solvent from the acrylic binder used as an assembly aid. By diluting the binder before use and restricting lifetime to three months or less, contamination effects were eliminated in subsequent Process Readiness runs. Following assembly of 80 bonds, approval was granted for Qual Lot production of second bonds.

Radiator Attachment

Radiator attachment process readiness trials were initiated early in this reporting period. Significant EMQ activities included definition of hydrogen furnace controller temperatures required to produce acceptable brazed joints and confirmation of shear strengths equivalent to GPHS-RTG values. Hydrogen furnace calibration runs indicated required controller temperatures between 800 and 820°C. A procedure for defining controller temperatures was incorporated into the furnace set-up specification. Shear strength values from a group of five Cassini fabricated assemblies exhibited strengths equal to or greater than a group of GPHS-RTG assemblies recently tested. All samples (both Cassini and GPHS-RTG) failed within the molybdenum compensator. These results in conjunction with satisfactory demonstration run yield data allowed approval of radiator attachment process readiness.

Si₃N₄ Coating

No major technical problems were encountered in achieving Si₃N₄ process readiness. Minimal EMQ support was required for the demonstration of satisfactory Si₃N₄ coatings on first bond assemblies and hot shoe spacers. Beyond the standard specifications requirements for process parameters, coating weight gain and hardware appearance, TGA weight loss tests were performed on several first bond assemblies. Each of the twelve tested assemblies met specification weight loss requirements of being less than 12×10^{-6} g/hr-cm² after 40 hours at 1150°C. Measured rates from the TGA ranged from 1.17 to 4.56×10^{-6} g/hr-cm².

Cold Stack Assembly

Process readiness demonstration for cold stack assembly required EMQ definition of hydrogen furnace controller temperature, clarification of foreign material allowables and confirmation of assembly strengths equivalent to GPHS-RTG values.

Controller temperature settings of 800 to 820°C were identified for proper brazing and incorporated into the furnace calibration procedure. Examination of over 40 GPHS-RTG prime cold stack assemblies provided quality reference standards for grit blasting operations, defining a maximum level of embedded grit acceptable in a finished assembly.

Cold beam deflection tests performed on seven Cassini cold stacks indicated strengths equivalent to values obtained from destructive test of the residual GPHS-RTG cold stacks. Peel test results from another group of seven Cassini cold stacks was also comparable to data from three residual GPHS-RTG cold stacks tested. All cold beam deflection samples (Cassini and GPHS-RTG) failed within the electrical insulator while all peel samples (Cassini and GPHS-RTG) failed within the electrical connectors.

In addition to the training and engineering evaluation runs performed, nearly 60 demonstration assemblies were fabricated producing a high acceptance yield of 91%. The success of the demonstration runs in conjunction with the satisfactory test results led to final process readiness approval.

Couple Preassembly

Principal EMQ activities in support of couple preassembly process readiness included clarification of the grit blasting and cyanide etching procedures. A grit blasting fixture was redesigned for improved run-to-run consistency while the fixture referenced in the etching specification was modified to more closely conform to that used during the GPHS-RTG Program. N-P bond destructive tests of two couple preassemblies showed 10.6 and 13.2 kg loads of failure, well above the 3 kg requirement. As the major step in accomplishing final process readiness, 60 couple preassemblies were fabricated and a satisfactory yield of 73% was achieved.

Ni Plating (Electrical Insulators and Molybdenum Compensators)

Due to the limited availability of unplated cold stack parts, process readiness for the Ni plating operation was completed for only two components: electrical insulators and molybdenum compensators. Specifications were modified to incorporate the new plating facility. The EMQ team recommended a significant cost and schedule savings associated with the measurement of plating thicknesses by replacing current destructive metallography techniques with nondestructive X-Ray Fluorescence (XRF), using existing GE owned equipment. Parallel collection of thickness data by both destructive and nondestructive methods was approved in order to assess this potential change. Final assessment for all plated parts is anticipated by early 1993.

Unicouple Assembly

Operator training for the unicouple assembly brazing process was completed during September in preparation for process readiness demonstration runs. Hydrogen furnace controller temperatures were defined based on multiple calibration runs. Additional process issues addressed by EMQ members included definition of grit blasting tooling unique to the unicouple assembly operation and clarification of cyanide etching procedures. Preparations for process readiness demonstration runs were underway at the close of this reporting period.

Unicouple Stuffing and Wrapping

Training for the operations associated with unicouple stuffing and wrapping was resumed during September for the last unicouple process. Clarification of furnaces and fixturing required for firing of both the yarn and stuffing was initiated. In the absence of precise requirements regarding yarn tightness or spacing after wrapping a unicouple, several residual GPHS-RTG wrapped uncouples will be withdrawn from stock to serve as benchmarks. Preparations for Process Readiness demonstrations were underway at the close of this reporting period.

Accomplishments: N-P Bond Strength Improvement

During this reporting period a task was initiated to improve the average strength of SiMo hot shoes from Process Readiness and early Qual Lot values. The objective of this activity was to increase strengths observed during routine destructive tests to values typical of the previous GPHS-RTG Program.

The N-P bond strength improvement plan consisted of two types of activities:

1. Process controls intended to minimize strength variations from N-P bond-to-N-P bond, and
2. process and material modifications intended to increase the average strengths of hot shoes, both as-machined and after first bond assembly.

Process controls were instituted for Qual lot production and included implementation of a hot press thermocouple locating tool for improved temperature repeatability and replacement of the lapping wheel on the hot shoe lapping table. In addition, the procedure for destructively testing hot shoes was also evaluated as a possible source of variability in strengths measured on the Cassini Program as compared with the GPHS-RTG Program. These actions resulted in a gradual increase in Qual lot hot shoe strengths in conjunction with N-P bond temperature adjustments as shown in Table 4.

In parallel with tightening of hot shoe/N-P bond process controls, a series of five (5) N-P bonds were fabricated with modifications from Qual lot processes and materials. Modifications included the following:

- Add boiling water cleaning of SiMo compacts after lapping (prior to polishing and to N-P bonding)
- Increase of N-P bond temperature above specification limit
- Perform N-P bond using newly purchased Ti foil (which does not conform to specification requirement for visual appearance) rather than GPHS-RTG residual Ti foil
- Add water boiling of SiMo compacts after polishing (prior to N-P bonding)
- Add ammonium hydroxide - hydrogen peroxide cleaning of SiMo compacts after lapping (prior to polishing and N-P bonding)

Table 4. N-P Bond/Hot Shoe Qual Lot Results

N-P Bond Lot #	N-P Bonding Temp (°C)	N-P Bond Reaction (%)	Avg. Hot Shoe Elect. Resist. (mΩ)	Qty of Hot Shoes Failing Proof Load Test	High Res Hot Shoe Load at Failure (kg)	Low Res Hot Shoe Load at Failure (kg)	1st Bond Reaction (%)	Avg. 1st Bond Load at Failure (kg)	Final Disposition
UHPBP0001	1285	21	0.098	2	28	32	37	10.4 (11)	REJECT
UHPBP0002	1285	22	0.098	3	26	34	35	10.9 (11)	REJECT
UHPBP0003	1285	31	0.106	0	28	34	37	9.9 (13)	ACCEPT
UHPBP0004	1285	25	0.108	8	26	28	54	9.64 (1)	REJECT
UHPBP0005	1285	28							
UHPBP0006	1285	26							
UHPBP0007	1285	31	0.098	15	28	35	34	12.1 (1)	REJECT
UHPBP0008	1285	23	0.122	3	26	32	44	10.1 (1)	ACCEPT
UHPBP0009	1285	24							
UHPBP0010	1285	---	---	---	---	---	---	---	REJECT, hot press failure
UHPBP0011	1285	38							
UHPBP0012	1275	22							
UHPBP0013	1285	35	0.093	0	35	30	36	12.6 (1)	ACCEPT
UHPBP0014	1300	28	0.100	0	37	38	42	10.6 (1)	ACCEPT
UHPBP0015	1300	36	0.109	0	38	37	45	13.1 (1)	ACCEPT
UHPBP0016	1300	33	0.108	1	44	41	47	12.6 (1)	ACCEPT
UHPBP0017	1300	24	0.112	0	35	38	36	10.6 (1)	ACCEPT
UHPBP0018	1300	15	0.103	0	38	32	39	12.6 (1)	ACCEPT
UHPBP0019	1300	21	0.101	0	32	39	39	10.6 (1)	ACCEPT
UHPBP0020	1300	21	0.091	0	40	40	35	11.6 (1)	ACCEPT
UHPBP0021	1300	27	0.088	0	39	41	33	11.1 (1)	ACCEPT
UHPBP0022	1300	32	0.093	3	40	50	39	>14.1 (1)	ACCEPT
UHPBP0060	1300	26	0.090	0	40	43	38	12.6 (1)	ACCEPT
UHPBP0061	1300	35	0.115	0	38	44	43	10.1 (1)	ACCEPT
UHPBP0062	1300	28	0.104	0	40	40	37	12.1 (1)	ACCEPT
UHPBP0063	1300	35	0.109	0	40	45	30	13.1 (1)	ACCEPT
UHPBP0064	1300	36	0.092	0	44	43	42	12.7 (1)	ACCEPT

Hot shoes were machined from these compacts and subjected to standard hot shoe acceptance tests. The quantity of hot shoes and first bonds destructively tested as part of the standard tests was increased to provide a better statistical basis for comparing modifications. As shown in Table 5, each of the five N-P bonds produced strengths exceeding N-P Bond Process Readiness values. However, only the assembly boiled after polishing equaled GPHS-RTG production averages without exceeding specification limits for other parameters such as bond reaction percentage or hot shoe electrical resistance. As a result a boiling water step after polishing will be incorporated into the remaining Qual Lot N-P bonds for further assessment. After completion of the remaining N-P bonds (approximately six as of the end of this reporting period), a final decision will be reached on whether to incorporate this procedure for flight unit production.

Accomplishments: Thermoelectric Machining Coolant Replacement

During both the GPHS-RTG Program and the Cassini Program significant attention has been paid to the type of coolant employed in the thermoelectric material machining operations. Coolants contact the thermoelectric hardware and offer the potential for surface contamination. To date all grinding and slicing operations on the Cassini Program have employed the same coolant as was used during the GPHS-RTG Program - White & Bagley 1500. The existing Cassini RTG Program supply of White and Bagley 1500 is expected to be fully depleted in October 1992. Efforts to obtain an additional supply of White and Bagley 1500 have not been successful since the manufacturer no longer makes or distributes this product.

Qualification of replacement coolants has been initiated in this reporting period. Based upon recommendations from the coolant supplier and the machining equipment vendors, two products are undergoing evaluation - Trim-Clear and Synlube E55. A series of EMQ tests were completed in which hardware was machined using each coolant, and inspected for visual contamination. Both candidate replacement coolants were found acceptable in these tests.

Table 5. N-P Bond/Hot Shoe Strength Improvement Matrix Results

N-P Bond ET#	Process change from Qualification hardware	N-P Bonding Temp (°C)	N-P Bond Reaction (%)	Avg. Hot Shoe Elect. Resist. (mΩ)	Qty of Hot Shoes Failing Proof Load Test	High Res Hot Shoe Load at Failure (kg)	Low Res Hot Shoe Load at Failure (kg)	Avg Hot Shoe Load at Failure (kg)	1st Bond Reaction (%)	Avg. 1st Bond Load at Failure (kg)
3867-1	H ₂ O boil after lapping	1300	20	0.096	0	34	40	37 (4)	34	13.6 (3) 1317°C
3846-2	n-p bond temperature	1310	25	0.097	0	39	44	44 (4)	30	12.3 (3) 1315°C
3846-3	new Ti shlm lot (3215SL)	1300	30	0.115	0	40	40	38 (3)	50	12.6 (3) 1317°C
3868-1	H ₂ O boil after polishing	1300	23	0.089	0	43	46	43 (4)	41	13.3 (3) 1317°C
3869-1	peroxide clean after lapping	1300	27	0.108	0	36	32	37 (4)	28	13.1 (3) 1315°C
CASSINI QUAL		AVG N=17	29	0.102	0.4	37	39		39	11.8
CASSINI PR		AVG N=10	30	0.089	0.7	33	36		38	10.9
GPHS PRODUCTION		AVG N=213	24	0.099	0.5	41	42		38	13.1
CASSINI SPEC LIMITS		1300±20°C	35 max. (process control limit)	0.135 max	Test all at 22 kg	30 min. (process control limit)	30 min. (process control limit)		45 max.	7.5 min.

- NOTES:
1. All N-P bonds made in hot press HP-3.
 2. Avg hot shoe load at failure data do not include hot shoes failing 22 kg proof test.
 3. Numbers in parentheses represent the number of parts evaluated in test for which average values are calculated.
 4. Cassini Qual averages are calculated from results of ACCEPTED lots only.

Chemical analysis of each coolant as well as White & Bagley 1500 was subsequently completed, indicating variations in elemental constituents from coolant to coolant. Due to concern about elevated boron levels in Trim-Clear and elevated metallic constituents in Synlube E55 as compared with White & Bagley 1500, further chemical analysis is underway. High resolution SIMS (Secondary Ion Mass Spectroscopy) surface analysis has been done for n- and p-type SiGe pellets machined using each coolant type. Preliminary results suggest equivalent surface contaminants for both White & Bagley 1500 and the replacement coolants. Parallel TGA weight loss tests of similar pellets coated with Si_3N_4 and cycled through downstream thermal processes is in progress to determine any Si_3N_4 coating performance impact from each coolant. These results and a selection of coolant to replace White & Bagley 1500 is anticipated during October.

2.5 ETG

Production of unicouple hardware for flight units is presented in Table 2. As shown, the majority of production for the flight units is in vacuum casting, powder blending and hot pressing. The production of machined pellets and segments for flight was approved 11 September 1992.

18 Couple Module

A considerable amount of progress was achieved in fabrication of 18 couple module assemblies. During this six month reporting period the following accomplishments have been achieved:

- The end cap foil and cloth panels for the first two assemblies were completed,
- all the thermopile foil and cloth panels for three 18 couple module assemblies had been completed,
- the end cap assemblies and the thermopile foil insulation assembly of the #1 Unit 18 couple module were completed,
- training of operators for spot welding (used for thermopile assembly) was completed and acceptable weld samples were produced. (Additional refinement of the welding techniques is being performed before final welding of the #1 Unit thermopile assembly is performed).

The major technical problem which was encountered in the fabrication of the 18 couple module assembly during this reporting period was developing the proper method to punch foil and cloth (fibrous) panels. Former procedures from the GPHS-RTG program called for the use of a single hole punch fixture to produce panels. Efforts during May and June showed that the single hole punch fixture could not repeatably produce the required hole to hole dimensions. To remedy this problem the multi-punch set up used in converter foil production was employed. The 18 couple module assembly planning for panel production was updated to used the multi-hole punch. Panel production was in steady production by July of this reporting period.

The effectiveness of the multi-hole punch fixture and the increased skill gained by the operating staff is evidenced by accomplishments of : producing the thermopile foil and cloth panels for all three assemblies (Total = 1128 pieces); producing the end cap panels for two assemblies (Total = 484 pieces); and completing the assemblies as statused above in the July to September period.

Preparation of Q-1 for Shipping Container Test

The Q-1 ETG was received by GE on 22 April 1992. Upon arrival of Q-1 at the GE loading dock radiology checks of the shipping container were taken and no contamination was detected. The ETG shipping container was then opened and radiology smear samples of the ETG were taken and again no contamination was detected. The ETG was then removed from the shipping container and loaded into the ETG handling fixture for transportation to the ETG convector assembly area.

Process planning documents had been prepared and approved for the disassembly of Q-1. The gas processing valve was opened allowing the ETG to stabilize at room pressure. The inboard dome assembly was removed and internal radiology smears were taken. These smears showed no indications of contamination.

After the radiological checks proved negative, disassembly of the inboard heat source support assembly was performed. The Electrical Heat Source (EHS) was then removed.

In the process of removing the EHS, one mid-span assembly was found to have a nut jammed on the mid-span support stud. The jammed nut was removed and the support stud reworked to repair the damaged threads.

Tooling for repair of the sealing surfaces of the dome, spool piece, convector shell, and mid-span ports and caps had been fabricated and inspected in advance. Rework of the sealing surfaces of the ETG housing, dome, spool piece, and mid-span caps was completed with this tooling. The 45° mid-span cap had to be replaced with a modified cap due to tolerance problems in the seal area. The spool piece and dome assembly were leak tested. The spool piece pass leak test, but the dome assembly was found to have a leaking gas processing valve. The gas processing valve was removed and the dome fitting was capped to seal the port.

An ETG leak test was performed and approximately 128 unicouple thermocouple screw seals were found to be leaking. All of the leading thermocouple screws were removed, the sealing surfaces were polished, and new thermocouple screws and 'C' seals were installed. A second leak test was performed and a leak up rate of .24 psia in 24 hours was recorded. This leak rate is approximately three times better than required.

Installation of the refurbished and instrumented EHS was completed and the inboard heat source support assembly was completed. EHS instrumentation was connected and a foil top jumper connected to 'J4' connector. Electrical resistance readings were taken and recorded for EHS power leads, thermocouple instrumentation, and ETG power circuits. The modified inboard dome assembly was installed with an 'O' ring and a leak test was performed to verify the converter seal integrity. The external instrumentation was wired dressed and bonded in place. Electrical resistance measurements were taken and recorded for each thermocouple. After completion of the external instrumentation, Q-1 was given a final leak test and prepared for loading into the shipping container. Q-1 was installed in the shipping container and loaded onto an air ride truck for delivery to Mound on Monday, 24 August 1992.

PRD:

The design of the test fixtures for the PRD tests (Lance/Diaphragm, bellows, dynamic and operating) were completed during this period. All test requirement documents were issued and the fixtures for the Lance/Diaphragm test and bellows test were fabricated.

The preliminary Lance/Diaphragm test was completed which included the puncturing of six diaphragms. The force to puncture the diaphragms ranged from 13.2 lbs. to 14.5 lbs., well within the maximum allowable of 20.0 lbs.

2.6 GSE

The new Gas Management System (GMS) was delivered and is awaiting GE installation prior to check-out. In addition, the two Gas Service Carts were flow cleaned and put back into service to support the Q-1 activities and subassembly checks. A shipping container has also been flow cleaned and leak-checked in support of the Q-1 shipment to Mound. Finally, all converter handling equipment had their annual loads applied per the proof load plan.

2.7 RTG Shipping and Launch Support

RTG Shipping Container

Substantial effort was provided by GE during this report period to support DOE's development of a new RTG transportation system. GE activities included the following:

- Analysis of generator response to a hypothetical 30 foot drop and the resulting smallest heat producing entity expected to be found within the transportation package containment vessel.
- Initial description of a possible mock-up of the transportation system to be used to develop operational procedures and train operations personnel.
- Review and comment on the thermal qualification test plan outline and subsequent plan revisions.
- Active participation in qualification test planning involving definition of instrumentation and power leads, cabling and connectors, hardware interfaces definition, and ETG performance characteristics.

- Extensive evaluations of the proposed transportation system design and expected equipment operation.
- Refurbishment and installation of an electric heat source into Q-1. Rework of Q-1 for leak tightness and the installation of external thermocouples for the qualification test of the new transportation system.

Launch Support

During this report period GE participated in launch site ground operations and launch planning by providing RTG related information for the following topics:

- Considerations in ground operations to determine when the RTGs should be attached to the spacecraft.
- Possible options under consideration at JPL for attaching the RTGs to the spacecraft through the launch vehicle payload fairing.
- The thermal adequacy of RTG cooling within the payload fairing after RTG-spacecraft mating prior to launch.

2.8 Design, Review, Mission Studies

No significant activity this reporting period.

2.9 Project Management, Quality Assurance and Reliability

2.9.1 Project Management

During this period the Management System established for the Cassini RTG Program continued in effect. Normal Control Room activities continued where detailed work schedules are posted on the walls and daily meetings are held to review priorities and resolve problems. Business and operations reviews/status meetings are held weekly in the Control Room. Government representatives regularly attend the weekly operations review and a separate weekly status briefing on topics selected by the in-house DOE representative. Monthly program reviews were held on 5 May 1992, 11 June 1992, and 24 September 1992. GE also supported a quarterly program review on 22 August 1992.

Contract Modification M010, dated 13 July 1992, incorporated the following changes to the technical work:

- Add purchase of Hakke Model F3C refrigerated bath and circulator.

Contract Modification M011, dated 17 April 1992, incorporated the following changes to the technical work:

- Add refurbishment of gas cart.

Contract Modification M013, dated 10 June 1992, incorporated the following changes to the technical work:

- Delete E-10 (unicouples, ETG fabrication, assembly, and test).
- Delete E-9 (unicouples, ETG fabrication, assembly, test, and fueling).
- Delete CRAF safety and launch support activity.
- Delete ancillaries (electric heat source and pressure relief device) for ETG-9 and ETG-10.
- Add support for RTG shipping container qual at Mound (delivery date modified by M016).
- Invoke Quality Assurance DOE Order 5700-6C requirements.
- Incorporate GSE modification/refurbishment plan.
- Incorporate additional CAGO approved by DOE Contracting Officer.
- Change Cassini launch date to October 1997.
- Extend contract to April 1998.

Contract Modification M017, per letter dated 19 August 1992, incorporated the following changes to the technical work:

- Add Task 8.B (Individual and Module Multicouple Testing) and Task 8.C (Structural Characteristics of Candidate Improved N and P Type SiGe Type Thermoelectric Materials).

Acquisition of additional Contractor Acquired Government Owned Property was authorized. Cost impact will be included in M013 Cost Proposal.

Updated cost proposals for GE proposals VF91114 (Contract Modification M006) and VF92018 (Contract Modification M009) were submitted to support of the negotiations process. GE proposal VF92052, the response to Contract Modification M011, was submitted, negotiated, and definitized this period.

A plan for refurbishing/replacing existing Ground Support Equipment was submitted. Costs will be incorporated into the proposal being prepared in response to Contract Modification M013.

The proposal in response to Contract Modification M013 was initiated this period and will include the impact of M013 changes and additional work scope as previously listed.

Schedule management activity during this period included monthly status report submissions, an update to the Milestone Schedule Plan to incorporate Contract Modification M013 changes, and updates to the Control Room schedule displays. The program schedule generated for the M013 proposal was substantiated by analyzing total labor required for manufacturing activities and determining the schedules that can be obtained given the labor available and the funding constraints.

GE PMS operation continued during this period. A single point cost and schedule adjustment as of 1 October was requested and, except for Task 4 cost, was authorized by DOE.

Monthly status updates to the Program PMS Plan established in September 1991 were submitted during this period. Data from the GE PMS system was adapted to the content and format required by the DOE Program PMS. There have been no unresolved difficulties even though the two systems use different algorithms to calculate earned value.

An interim updated Program PMS Plan was submitted to incorporate the effects of Contract Modification M013. It is based on a planning exercise carried out to provide a basis for the M013 proposal. Hence, the interim plan is less detailed than the final updated plan, which will incorporate M013 proposal data.

All contract required reports and data were delivered on schedule. The following nonrecurring documents from the Contract Deliverable Requirements List (CDRLs) were submitted in this reporting period:

- Recommendations and Options Report for Q-1, F2, and F-5 (CDRL B.17)
- GSE Refurbishment Estimate and Plan (CDRL B.19)

The following plans were issued as DOE-approved documents:

- Configuration Management Plan (CDRL A.4)
- Quality Assurance Program Plan (CDRL A.3)
- Reliability Program Plan (CDRL A.5)
- 18 Couple Module Test Plan (CDRL B.5)
- Non-Destructive Test Plan (CDRL A.11)
- Procurement Plan (CDRL A.6)
- Property Management Plan (CDRL A.8)

Plans not yet issued formally include:

- Inspection and Test Plan (CDRL A.12) - Submitted to DOE July 1992 for approval.
- Software Management Test Plan (CDRL A.7) - Submitted 12 April 1991 for approval. Waiting for DOE formal comments.
- Safety Test Program Plan (CDRL A.10) - Submitted 12 April 1991. On hold.
- GPHS-RTG Interface Working Agreement (CDRL A.21) - Draft submitted 21 July 1992. Revision in process.

Attached are the Cassini RTG Program calendars for 2Q92 and 3Q92 showing program meetings and other important program-related events for this reporting period.

2.9.2 Quality Assurance

Quality Plans and Documents

The Cassini Inspection and Test Plan, CDRL A.12 was revised to incorporate comments from DOE.

The Cassini Process Readiness Plan was revised to incorporate changes requested by DOE. The major change was in the concept of how the thermoelectric material Production Readiness Reviews would be conducted. The revised concept is that the Production Readiness Review will be done on the individual processes after the planned material for the Cassini Qualification Lot unicouples is produced, and prior to the beginning of production of material for flight unicouples (E6 and subs). *Note: Process Readiness Reviews are required prior to the start of Qualification Lot production.*

At the request of DOE, DOE Order 5700.6 Rev. C was reviewed for impact on the program. This revision is significantly different from the earlier versions. The conclusion from the review is that this document is the DOE plan for TQM (Total Quality Management). Training and orientation of all program personnel (not just Quality Assurance personnel) is necessary to implement these requirements to a significant degree.

Process Readiness Reviews

Process readiness reviews were a significant activity during this reporting period. Quality Assurance supported the EMQ review of the drawings and specifications for various operations. The hardware built during operator training and for process readiness demonstration runs was inspected. The Training and Certification Team: monitored and audited the hardware production during training; inspected and evaluated the process output; and granted operator certification when sufficient product had been produced with a satisfactory yield and the operator passed an oral test.

During this reporting period, process readiness reviews were completed on

- First Bond
- Silicon Nitride Coating
- Second Bond
- Nickel Plating *
- Couple Preassembly
- Radiator Attachment Assembly
- Cold Stack Assembly

* Moly compensators and electrical insulators only

Process readiness status, and status of operator training is summarized in Table 1. Production readiness review has been completed for the following processes:

- Vacuum Casting
- Powder Blend
- Hot Pressing
- Machining of Pellets and Segments

For these processes hardware is being produced for flight article use.

Inspection Activities

Quality Assurance continues to inspect all the product produced for training, for Readiness Review, and for Qualification Lot production and for the flight unit production. Configuration and traceability data was maintained and filed. Nonconforming material was processed through Material Review Board, as required. Residual material from the GPHS Program was reinspected and reaccepted for Cassini Program before it was applied for flight article use.

There have been no Class 1 Nonconformances to date on the Cassini RTG Program.

Q-1 ETG

The operations, rework and retest of Q-1 was supported by QA. A QA Engineer was assigned to monitor all operations, review rework and/or test plans, participate in the tests of the ETG, and report and disposition nonconformances. The rework, electrical tests, and leak tests of the ETG Converter were completed in August. The Converter Shipping Container was refurbished, cleaned, and leak tested. Static lifting load tests of all handling devices was performed before they were used to handle the ETG. The ETG was shipped to Mound on 22 August 1992.

Process Audits

Process audits were performed on the Powder Blend Process, Hot Press Operation, and Parts Machining (2 audits), Conformance to procedures and process specifications has generally been good. The audits have uncovered several problems, which have been corrected.

2.H Contractor Acquired Government Owned Property (CAGO) Acquisition

2.H.1 CAGO - Unicouple Equipment

The following activities were completed this period:

- Equipment to upgrade one of the two hydrogen furnaces to meet updated safety guidelines has been acquired, installed, and checked out. It is fully operational. (Upgrade of the second furnace is planned for October 1992.)
- One of the two new Si3N4 CVD furnaces has been installed and checked out. Several problems, including cracking of the quartz tube working section have been encountered so the unit is still in the shakedown period. The plan to defer installation of the second unit until the first unit is fully operational is still the selected approach.
- Plating system power supplies were upgraded this period.
- Hot Press #2 rebuild was completed this period. The rebuilt system has been checked out and declared operational.

Acquisition of the following additional items was authorized:

- Rebuild Hot Press #3
- Leak detector
- Microscopes with light sources (four each)
- Temperature humidity recorder
- Heidenhoen Height Gage with accessories
- Plug and Ring Set Collection

GE is proceeding with DOE Contracting Officer authorization to upgrade and transfer the chlorine analyzer equipment to DOE. Authorization was received this period.

2.H.2 CAGO - ETG Equipment

The plan to assemble, install, and check out the Gas Management System (GMS) for the Loading Assembly Station (LAS) as an in-house project was changed from Make to Buy. The procurement process was initiated. Refurbishment of a gas cart, authorized by M011, was completed. Refurbishment of a second gas cart, authorized as part of M009 proposal, was completed. Repair of the LEPEL induction heat furnace (G37037) was authorized and vendor repair completed during this period.

2.H.3 CAGO - MIS

Additional software for existing MIS units was authorized this period and requisition initiated.

Cassini Program Calendar

As of 1 July 1992

2nd QTR 1992

	M	T	W	T	F	S	S	FW
A P R I L	30 Systems Contractor Program Review GE-Valley Forge	31	1	2	3	4	5	14
	6	7	8	9	10	11	12	15
	13	14	15 Program Monthly Meeting Augusta, GA Reinstrom/Braun	16 Cassini Unique Study Review JPL Reinstrom	17	18	19	16
	20	21	22 QA Meeting Valley Forge Q-1 Received from Mound	23	24 Monthly and Semi-Annual Reports Due to DOE	25	26	17
	27	28	29	30 CVS Welding Meeting Pittsburg Reinstrom	1	2	3	18
M A Y	4 Final Process Readiness Review for First Bond Assembly	5 Monthly Status Meeting with DOE Valley Forge Review of Coating Operation Results for Final Process Readiness	6	7 Q-1 Test Set-Up At Mound Reinstrom/Cockfield	8	9	10	19
	11	12	13	14 N-P Bond DOE-Germantown Hemler/Braun/ DeFilippo/Nakahara	15	16	17	20
	18	19	20 ECNs for Coating Operation Complete Final Process Readiness Achieved	21 Quarterly Program Meeting Fairchild Hemler/Reinstrom/Braun Hanson/Peterson/Waks	22	23	24	21
	25 HOLIDAY	26 Monthly Reports Due to DOE	27	28	29	30	31	22
J U N E	1	2	3 Monthly QA Status Meeting Valley Forge	4	5	6	7	23
	8	9	10	11 Monthly Status Meeting with DOE Valley Forge	12	13	14	24
	15	16	17 CVS Hardware Meeting Oak Ridge, TN Reinstrom	18	19 Initial Process Readiness Meeting Nickel Plating	20	21	25
	22	23	24 Program Monthly Meeting Oak Ridge, TN Hemler/Reinstrom Monthly Reports Due to DOE	25	26	27	28	26

Cassini RTG Program Calendar

As of 30 September 1992

3rd QTR 1992

	M	T	W	T	F	S	S	FW
J U L Y	29	30	1 Q-1 Bake Out Mound Reinstrom/Cockfield ← New Titan Data Book Meeting NASA-Lewis -Bradshaw →	2	3 HOLIDAY	4	5	27
	6	7 Final Process Readiness Review for Nickel Plating Molybdenum Compensator Electric Insulation	8	9	10	11	12	28
	13	14	15	16	17 Final Process Readiness Review for Radiator Attachment	18	19	29
	20	21	22 ← GOWG/GOPWG KSC Reinstrom →	23	24 Monthly Reports Due to DOE	25	26	30
	27	28 New Shipping Container PDR Hanford Reinstrom/Cockfield	29 Qual Test Planning Meeting Hanford	30	31	1	2	31
A U G U S T	3	4	5 QA Status Meeting Valley Forge	6	7	8	9	32
	10	11	12 ← Cassini Delta PDR At JPL Hemler/Reinstrom →	13	14	15	16	33
	17	18	19	20	21	22	23	34
	24 Monthly Reports Due to DOE	25 Quarterly Program Review Fairchild Hemler/Reinstrom/ Hanson	26 CVS Working Group Germantown Reinstrom	27 Final Process Readiness Review for Cold Stack Assembly	28	29	30	35
S E P T	31	1	2	3 Reentry Analysis Cassini Germantown Hemler/Bradshaw	4	5	6	36
	7 HOLIDAY	8	9	10	11 Final Process Readiness Review for Second Bond Assembly	12	13	37
	14 CVS Weld/Test Development Atlanta Hemler	15	16 Ground Operations' Working Group Kennedy Space Center Reinstrom	17	18	19	20	38
	21	22	23 Final Process Readiness for Couple Preassembly	24 Monthly Reports Due to DOE Monthly Status Meeting with DOE Valley Forge	25	26	27	39