## I. Program Overview

| Organization Name/Program Name: | Honeywell International  
F35 Power Thermal Management System |
|-------------------------------|-------------------------------------------------|
| Your Name/Position/Contact information – E-mail, Phone | Kevin Holmes/US Defense Customers Program Manager  
Kevin.Holmes@Honeywell.com  
Office 602-231-7186 Cell 480-285-6818 |
| Customer: Organization/Name/Position/Contact information  
Note: your customer will be contacted to verify performance across the four criteria measured herein. | Lockheed Martin Corporation  
Frank Kirkland  
Director, Air Vehicle Systems F-35  
Frank.Kirkland@LMCO.com  
Office: 817-777-8283 |
| Program Category | (Choose One)  
- Sub-System Production/Sustainment program or project |

**Program Background:** What is this program all about? (No more than one page). Describe:  
- The overarching need for this program  
- History of the program  
- The product that is created by this program  
- Scope of work – original & updated  
- Expected deliverables  
- Current status of the program

The Power Thermal Management System (PTMS) integrates functions of auxiliary power, environmental controls, and emergency power into a single system. This system provides a dramatic contrast between this new form of integration technology and conventional systems. The PTMS integration reduces aircraft weight and length while significantly increasing reliability. The PTMS is currently on the F-35 aircraft and available for use on More Electric Architecture (MEA) aircraft.

The PTMS system was contracted in 2002 and is in the final stages of development. Completion of the SDD portion of the program is scheduled for early 2011. Honeywell was recently awarded the 4th LRIP contract for an additional 33 systems to be delivered through 2012.

The PTMS system has over 85 LRU’s (Line Replaceable Units) that make up the entire system. Total planned aircraft deliveries totals over 3000 units.
I. **VALUE CREATION = 20 POINTS**

**Value:**
What is the value, competitive positioning, advantage, and return created by this program to your:
- Customers – National interests, war fighter
- Company – Strength, bottom line, and shareholders
- Scientific/technical value (particularly for R&D programs)

**Excellence and Uniqueness:**
What makes this program unique? Why should this program be awarded the Program Excellence Award? In what ways is this a stellar program?

| The F-35 Joint Strike Fighter program is a critical program for the Department of Defense (DoD). It is DoD’s largest cooperative program with eight Partner nations participating. The F-35 is a key element of the United State’s defense and ability to deter, and possesses unique and essential capabilities which can be exercised to influence, shape and ‘effect’ the battlespace in favor of US objectives. Honeywell’s Power and Thermal Management System (PTMS) is integral to the successful execution of the F-35’s mission set. The PTMS uniquely integrates auxiliary power, emergency power, electrical power generation, thermal management and environmental control in a single system which provides the aircraft’s power and cooling. Viewed as an enabler, other aircraft systems rely on the PTMS to operate optimally. The Joint Strike Fighter program will produce three variant aircraft for its customers, the Conventional Takeoff and Landing, or CTOL variant; the Short Takeoff and Landing, or STOVL variant, and the Carrier Variant, or CV. Honeywell’s PTMS provides power and cooling on all three variants. For the US Marine Corps, the F-35 STOVL variant will replace its AV-8B and F/A18 aircraft, providing a multi-role, short takeoff and vertical landing capable strike fighter. For the US Navy, the F-35 CV (carrier variant) provides a complement to the F/A-18 as a multi-role strike fighter. For the US Air Force, the F-35 CTOL will replace the aging F-16 and A-10 aircraft fleets, complementing the F-22. The F-35 enhances the operational capability and tactical flexibility of the warfighter and/or combatant commanders. The aircraft serves as a long-range, day-one, strike fighter, capable of executing multiple missions... |
Across the spectrum of conflict, some of which include: Suppression/Destruction of Enemy Air Defenses; Strategic Attack; Interdiction; Offensive/ Defensive Counter Air; Close Air Support; and, Tactical Intelligence/Surveillance/ Reconnaissance (ISR). To successfully accomplish its core missions across the Services, the F-35 incorporates the latest leading edge technology in the areas of stealth, propulsion, mission system sensors, interoperability and supportability, as well as power and thermal management.

Designed as an integrated system from the start, the F-35 PTMS would be considered the ‘second’ generation of integrated systems. PTMS is both evolutionary and revolutionary – it integrates traditional Federated components into an integrated system which provides a weight savings of over 1000 pounds per aircraft and a reduced footprint or size savings of approximately 10 inches per aircraft. As an integrated system, it provides efficiencies and lower equipment count (fewer parts), enabling a smaller, lighter and lower cost aircraft. The PTMS provides optimum commonality to minimize life cycle costs. Common across all variants, PTMS utilizes the latest technologies to provide improved reliability, supporting the Joint Strike Fighter’s global sustainment strategy. Inherently, the PTMS contributes to improving the deployability of the F-35 and reducing operating and support costs to the warfighter.

The PTMS continues to prove its value as warfighter power and cooling requirements grow. Honeywell showed its’ commitment to the program with the construction of a systems integration lab (SIL) and is currently working on a ‘third generation’ integrated total energy management system (ITEMS).

Honeywell’s PTMS team works very closely with the Prime to investigate performance improvements or increased capability based on warfighter requirements, supporting a F-35 block upgrade program. Often, these improvements provide increased savings and support program affordability initiatives. Honeywell’s extensive experience with power and thermal architectures and systems integration assures a production rate of 220 to 240 aircraft per year and our technology advances have potential applications on future programs which include: long range strike, advanced mobility aircraft, directed energy weapons and persistent ISR. Because of the advantages previously mentioned (weight/size savings,
reliability and efficiencies), PTMS is especially attractive to aircraft OEMs and operators for new, smaller platforms like unmanned systems. The F-35 PTMS capitalizes on extensive unequalled experience solidifying Honeywell’s position on over 2000 planned aircraft. Ensuring our nation’s aviators are provided the best, most capable aircraft to execute their missions is paramount—that said, our PTMS partnership with Lockheed Martin will provide a significant long term commitment to our stockholders. The F-35 will be critical to Honeywell for years to come; our commitment to affordability, on-time delivery, exceptional product quality, performance and reliability, as well as system sustainment support clearly identify PTMS as a program to emulate, and one most worthy of Aviation Week’s Program Excellence Award.

### III. Organizational Processes/Best Practices: (How do you do things) = 30 points

<table>
<thead>
<tr>
<th>Strategic: Describe how you developed your program strategy and competitive advantage in support of your company strategy, how you monitor progress toward achieving this strategy</th>
<th>The F35 PTMS challenge was to integrate the previously federated functions of the auxiliary power unit (APU), the environmental control system (ECS), and the emergency power system into a single integrated system. The team’s competitive advantage was to leverage proven system integration techniques developed on F15, F16, F18, and F22 and ensure robust execution by strict adherence to Honeywell program management guidelines.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strategic:</strong> Requirements Management – How do you define, revise and control your requirements?</td>
<td>F35 PTMS has an agreed upon Performance Based Specification (PBS) for the system. Any changes are classified as in or out of scope, negotiated, and processed through a formal Change Request process. For changes deemed out of scope, the customer is required to submit a Request for Proposal. Once the proposal is approved, changes are incorporated into the Statement of Work via a contract change notice.</td>
</tr>
<tr>
<td><strong>Strategic:</strong> Systems Engineering – Describe your systems engineering planning and management processes.</td>
<td>Honeywell has an Enterprise level standard process for Systems Engineering planning/management titled Integrated Product Delivery and Support (IPDS) procedure, AP-1235. AP-1235 drives our development programs and accordingly, is integral to our PTMS development program. This standard procedure has ensured strict adherence to design phase gate exit criteria as we have progressed through System Requirements Review (SRR) Preliminary Design Review (PDR), Critical Design Review (CDR) and will continue through the life cycle of this product.</td>
</tr>
</tbody>
</table>
**Strategic:**
Opportunity Management -
Describe how your program identifies opportunity and manages this opportunity.

Opportunities are identified during weekly meetings held between the Honeywell and Lockheed engineering and program management teams. Once identified, specific action items are identified and tracked using a standard RAIL.

**Operational:**
Planning, Monitoring, and Controlling -
Describe your planning and resource allocation processes. How do you monitor and review your program’s progress and make corrections to keep the program on track.

Resource forecasts and the latest earned value metrics for each control account are updated monthly. Changes are requested using the Program Change Request document and authorized changes are incorporated in the baseline as soon as practical.

The F35 PTMS program has a specific set of approved procedures covering Earned Value Management, contract change management, baseline change management, program scheduling, risk management, and configuration management. Overall program execution and progress is monitored using the Integrated Master Schedule, cost performance metrics are reported monthly, and technical requirements are maintained in the Systems Verification and Validation matrix.

**Operational:**
Supply Chain Management – What processes, tools and relationship-building methods have you used to develop, refine and improve supply chain and stakeholder integration? This is one of the most imperative needs of our industry – please provide specific details and data that assisted you in gauging the effectiveness.

Internal weekly site level meetings are held between the program office and supply chain to ensure the customer delivery requirements are met. These internal meetings support a weekly external meeting between Honeywell and Lockheed to address customer needs and monitor delivery performance. During this meeting close coordination with Lockheed concerning needed repairs or upgrades to flight test equipment ensures complete support of Lockheed’s flight test program by Honeywell.

**Operational:**
System Integration, Testing & Reviews -
Describe the activities and processes used to succeed in your system design, integration, and testing. How did you conduct system design and technical reviews?

F35 PTMS system required an unprecedented level of integration with the aircraft. Therefore the team modeled a large number of aircraft interfaces during the design phase and incorporated customer furnished aircraft hardware into the Integrated Test Stand (ITS) which allowed problems to be discovered and resolved early in the program. Preliminary and Critical design reviews were conducted with customer participation for all hardware. A validation and verification (V&V) plan was developed and Test Readiness Reviews held for all critical integration tests.

**Operational:**
Risk Management
Describe the processes used to identify risk and avoid future/potential

Program risks are identified by all members of each IPT, categorized, ranked, prioritized, and mitigation plans developed. Risk status is reviewed by the program office weekly and with the customer monthly.
### Team Leadership:
**Team Spirit and Motivation**
Describe how you created your team spirit and culture, and accomplished full team integration and team member motivation.

Program news and highlights, such as completion of critical flight test milestones, are passed on from the customer to the program team. This reinforces a team success mentality by highlighting instances where cooperation directly resulted in a significant program achievement.

### Team Leadership:
**Lessons Learned and Knowledge Management**
Describe how you collect lessons learned and best practices, and how they are shared with your team and company to improve performance.

Lessons learned from previous programs were reviewed for applicability and incorporated into component and system design. Lessons learned during the F35 program have been documented in the Honeywell Lessons Learned database, accessible via the web, for future programs to use.

### Team Leadership:
**Leadership Development**
How do you develop team’s skills and build future leaders?

Clear expectations for each program team member were established and communicated. Team members who consistently performed were provided opportunities to expand their role within the program team often moving from a component role to a system integration role.

### Best (& Next) Practices:
**Identify your program’s specific Best Practices that you believe are unique, and could be shared with others and become industry’s Next Practices.**

Best Practices:
- Forward looking risk communication with the customer
- Communication and resolution of complex technical issues between Honeywell and customer engineering teams
IV. **Adapting to Complexity: (How do you deal with your program’s unique complexities) = 20 points**

| Identify the Program’s Market Uncertainty level | The PTMS system that is on the F-35 fighter is the most complex aircraft Thermal Management System that Honeywell has developed. The PTMS system brings two new breakthrough technologies to the market. At the heart of the PTMS is an integrated power package which integrates the thermal management (ECS) functions with the auxiliary & emergency power functions through a shared turbine wheel and several permanent magnet generators. The system is controlled via a liquid-cooled integrated electronic controller capable of providing 140kW of power for main engine start while simultaneously sensing and responding to system inputs in the millivolt range. |
| -- How new is your product to your market and users, based on the definitions below. Then describe how you deal and address this specific uncertainty: | Honeywell addressed the market uncertainty to this breakthrough technology by developing a prototype demonstrator of the turbomachine and control system. This prototype system successfully performed a main engine start at the Pratt & Whitney engine test facility, and this success paved the way for Lockheed-Martin Aeronautics to select this Honeywell system for the F-35 aircraft Power and Thermal Management System. |
| - **Derivative** – an improvement of an existing product/system. | The PTMS system is a complex, high technology system with technological uncertainty associated with the two main components, the turbomachine and the electronic controller. |
| - **Platform** – a new generation in an existing product line. | From the onset, the baseline F-35 PTMS program plan allowed for the mitigation of these technological risks. A rigorous development program was established using analysis and modeling to develop the first prototypes. These prototypes were then tested functionally, as well as under the aircraft environmental and electromagnetic conditions. The results of the development testing were fed back into design updates prior to the commencement of the final qualification testing against the system requirements. A hardware-in-the-loop system was developed to allow the electronic controller to control a real-time dynamic model of the PTMS system. This tool allowed the controller input/output capabilities as well as the system mode transitions to be verified with the real hardware. A rapid prototyping system (RPS) was also developed to control the turbomachine during development testing. This RPS allowed the control system to be modified in real-time allowing the development testing to be accelerated. |
| - **New to the Market** – a product or system adopted from another market |  |
| - **Breakthrough** - new to the world product or system. |  |
| Identify the Program’s Technological Uncertainty using the definitions below. Then describe how you deal and address this uncertainty: |  |
| - **Low-tech**: application of mature, well-established technology |  |
| - **Medium Technology**: existing technology modified to meet new design requirements |  |
| - **High-Technology**: recently developed new technology |  |
| - **Super High-Technology**: non-existing technology that needs to be developed during the program. |  |
Honeywell’s standard IPDS (Integrated Product Delivery and Support) approach was deployed on this project. This approach ensures that key stakeholders approve and sign off on the product design as it moves through the preliminary design and critical design gates to ensure that all risks are mitigated and that lessons learned are considered.

<table>
<thead>
<tr>
<th>Identify the level of your System Complexity using the definitions below. Then explain how you are dealing with this level of complexity:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- An <strong>Assembly</strong> performing a single function.</td>
</tr>
<tr>
<td>- A <strong>Sub-system</strong> fitting within a larger system.</td>
</tr>
<tr>
<td>- A <strong>System</strong> – a collection of subsystems performing multiple functions.</td>
</tr>
<tr>
<td>- An <strong>Array</strong> – a “system of systems”; a widely dispersed collection of systems serving a common mission.</td>
</tr>
</tbody>
</table>

The PTMS is a major system on the F-35 aircraft. The control system simultaneously executes 50 control channels in order to support the system electrical and ECS demands under all aircraft conditions. The control system also coordinates system mode transitions between the 15 valid operating modes for the PTMS. This is complicated by the fact that the electrical functions are highly intertwined with the ECS thermal management functions. Finally, the control system also performs continuous prognostic and diagnostic health monitoring for the system to facilitate maintenance operations.

Honeywell took a two-pronged approach in dealing with the complexity of the F-35 PTMS system. Initially, dynamic models of the entire system were developed to facilitate the design and test of the control system in a safe environment. These physics-based dynamic models could execute in non-real time in order to evaluate system performance, and could also execute in real-time to allow rapid control system tuning. Finally, an integrated test stand that was fully representative of the PTMS system on the aircraft was developed on which to conduct development testing of all the system components, and ultimately the final qualification testing of the system against its performance requirements.

<table>
<thead>
<tr>
<th>Identify the <strong>Pace and Urgency</strong> of your team’s effort using the definitions below. Then describe how you deal with the program’s pace requirements:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- <strong>Regular timing</strong> – no specific time pressures.</td>
</tr>
<tr>
<td>- <strong>Fast/Competitive</strong> – time to market is important for competitiveness.</td>
</tr>
<tr>
<td>- <strong>Time Critical</strong> – there is an absolute and critical-to-success deadline.</td>
</tr>
<tr>
<td>- <strong>Blitz</strong> – there is a crisis element driving the need for immediate response</td>
</tr>
</tbody>
</table>

The F-35 PTMS schedule was built against a fast/competitive pace in order to achieve the milestone for the F-35 aircraft first-flight. The milestone was achieved 5 years after contract award. Honeywell’s IPDS process ensured that the design progressed correctly and efficiently through sequential phase gates to ensure that a mature, qualified design was ready for the aircraft first flight.
**Other Complexities & Uncertainties -**
Describe other complexities and unknown factors faced by this program and how you address them.

One major technical uncertainty for the PTMS system was its susceptibility to Electromagnetic Interference (EMI). In order to mitigate this risk, Honeywell used a large EMI test chamber to test the full PTMS electrical system, including aircraft wiring harnesses. This significantly reduced the risk of unknown EMI effects causing disturbances to the PTMS on-aircraft.

In addition to the technical complexities of the PTMS, the Honeywell F-35 PTMS team also dealt with the issue of being spread at various Honeywell locations across North America. Special tools were developed to allow system testing to be conducted and monitored from remote locations. Advanced tools for remote data capture, transfer, and analysis were developed to allow rapid analysis to take place.
### V. Metrics (How do you measure program’s performance) = 30 points

(Note: We are not looking for $ results, but the relative percentage achieved. In particular indicate what specific metrics and data you are using that drive the program beyond standard measures of schedule, budget, and performance, and which have contributed to your program’s focus and its success.)

<table>
<thead>
<tr>
<th>Customer</th>
<th>Performance</th>
<th>Preparing the Future</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>How do you measure the impact of your program on your customer and your customer’s satisfaction?</strong> Include a description of your metrics, as well as numerical evidence.</td>
<td><strong>How do you measure your program’s performance in traditional terms such as schedule, budget, requirements, and business results?</strong></td>
<td><strong>How do you measure and assess the long-term contribution of your program to the corporation/organization?</strong></td>
</tr>
<tr>
<td>Because this is a major system on an advanced Fighter aircraft, the success criteria for the customer revolve around a light-weight system that delivers the desired performance and has the desired system reliability. Because this is the Joint Strike Fighter program, one of the major tenets is affordability. These measurements, along with the traditional EVMS basic measurements (SPI/CPI) serve to provide the customer with a measure of level of satisfaction. One of the reasons the integrated architecture of the PTMS was chosen over a legacy-type federated system is that it does provide a significant weight and volume benefit. A weight report was provided to the customer on a monthly basis – the PTMS component weights summed to a value less than the allocated target. A reliability report was provided to the customer bi-annually – the PTMS system reliability is higher than the allocated target. A dedicated affordability program was instituted on the JSF PTMS program and quarterly submittals were provided to the customer – the PTMS average unit recurring flyaway (URF) cost is less than the allocated target. Cost Performance Reports (CPRs) containing current period and cum-to-date Earned Value information was provided and reviewed on a monthly basis with the customer. Additionally, semi-annual interviews of our customer by our internal Customer and Product Support group were conducted to get very candid feedback on the customer’s level of satisfaction.</td>
<td>Traditional Earned Value Management metrics were maintained throughout the program and reported monthly in the form of Cost Performance Reports (CPRs) to the customer. CPI and SPI were both in the .99 range for the PTMS SDD program. Our internal Mgmt Operating System was developed to require adherence to financial reporting and detailed schedule adherence and risk mitigation processes. Resource Demand and Fill was forecast and statused using the Manpower Allocation Tool. Monthly Operating Reviews were conducted to evaluate these aspects of the program.</td>
<td>The long-term contribution of the JSF PTMS program to the corporation comes in the form of the very significant quantity of anticipated production shipsets for the Joint Strike Fighter Program. The current anticipated Production Quantity, included aircraft to be provided to the partnering nations of the JSF program, is 3173 aircraft. This program (production, provisioning, sustainment) is a major contributor to the long-</td>
</tr>
<tr>
<td><strong>Team</strong> - How do you measure and assess the impact of your program on your team development and employee satisfaction?</td>
<td>Team building events have been conducted throughout the life of the JSF PTMS program. A Rewards and Recognition program has been in place to recognize individuals or groups that have demonstrated exemplary support of the program. Many individuals that have been involved with the JSF PTMS program have advanced in the ranks – Chiefs, Directors, Vice Presidents.</td>
<td></td>
</tr>
<tr>
<td><strong>Unique Metrics</strong> - Describe any unique metrics you are using to measure your program's progress and focus it for outstanding success.</td>
<td>As mentioned earlier, because this is a major system on an advanced Fighter aircraft, there are several unique metrics associated with the success criteria; weight is of paramount importance to an advanced Fighter. Also, one of the major tenets of the Joint Strike Fighter program is affordability (along with lethality, survivability, and supportability). Weight reports were provided to the customer on a monthly basis and Affordability reports on a quarterly basis. Because of the importance of Affordability to the JSF program, a dedicated affordability program was instituted on the PTMS program. In fact, a Value Function was created by us (and approved by the customer) to allow quantifiable trade-offs between Weight, Unit Recurring Flyaway Cost, Non-Recurring Investment, Reliability, and Power Generation. The use of this value function ensured that the results of any trade studies in the Design and Development program would provide the best overall VALUE to the JSF aircraft program.</td>
<td></td>
</tr>
</tbody>
</table>