

Selection of a Non-Primary Power Source for a Combat Vehicle

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Abstract

The United States Army is committed to maintaining its current fleet of combat vehicles for the next several decades with continued upgrades to increase both mission capability and survivability. Near term modifications have been identified to include Spin Out technologies from the Future Combat System (FCS) and mission specific upgrades resulting from current operations; all will result in a significant increases in electrical power consumption.

TARDEC's Mobility group is engaged with the Program Executive Office (PEO)/Program Managers Office to capture the full extent of the electrical power generation and usage today as well as the future. Efforts are underway to baseline the current power consumption (based on analytical and user data), gather all information on existing power related projects being conducted in each individual PM Office and recognize the planned upgrade needs as found in the vehicle modernization plans.

Having gathered this information, an approach to managing the supply of non-primary power and its usage will be developed and implemented on the vehicle systems to ensure the mission capability of the vehicle will meet its needs today as well as have the capability to meet future needs. The approach must take into account improving the efficiency of the total system as well as the traditional supply and demand methodology.

This paper will address the process used to baseline the power consumption of the vehicles during both normal and reduced power modes, proper methods of gathering data on existing and future vehicle upgrades, determining the role of the Non-primary Power Source (NPS) on a vehicle and finally how to choose an appropriate NPS based on need, usage and affordability.

Introduction

Over the past two decades, the electrical power needs of combat vehicles have increased with each system upgrade. This need has been put in the simple terms of

Upgrade's Power Required	Z kW
Baseline Power Consumed	Y kW
<u>Vehicle Power Available</u>	<u>-X kW</u>
Total Need to be addressed	N kW

Once this N kW is known, the decision to upgrade is based on the available technology, ease of integration and resource availability. Traditional upgrades include larger main generators, installation of auxiliary power units, additional batteries and power management systems that monitor and control to varying degrees.

Each of these upgrades addressed the immediate problem, but by failing to plan for power needs resulting from future growth of the system, did not provide a long term system solution.

The desire to plan for long term growth and apply a systems approach for the selection of the NPS was achieved by following the four principles below as guidance.

1. Near – Mid - Long term power needs of three targeted vehicles
2. Improve the users capabilities
3. Think about the system while designing the components
4. Use commonality across platforms where it makes sense to solve a common problem

Definition - Non-primary Power Sources

Non-primary Power Sources is a new term created to describe a capability to provide power from a source other than the main generator on

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the vehicle. The NPS can be used when the main generator is not capable of providing power or at times when it is undesirable for the main engine to operate based on the mission. This power source can be storage, conversion or any other device that can provide for the vehicle's power need other than the main generator.

It was important to use the term NPS during this process as opposed to the term Auxiliary Power Unit (APU) which has traditionally meant an engine/generator combination. The desire of this process was not to prescribe a solution before fully understanding the problem. By stating the vehicle will need NPS allowed the process to focus on a system solution where using the term APU resulted in immediate discussions of the material solution.

Need for a Non-primary Power Source

The need for non-primary power can be derived from the Operational Requirements Document (ORD) of the legacy combat system. The ORD will describe a list of capabilities desired under specific operational conditions. For example, the ORD will say it would like to perform surveillance and communication while conducting silent watch operations (silent watch is further described as having the main engine off).

With this description, a need is defined for non-primary power, conducting surveillance and communication. The instinct now would be to add the maximum power levels up for the Line Replaceable Units (LRUs) and supply an engine/generator to meet the power level. Unfortunately, this approach has been tried in the past and, depending on the application, has not always succeeded even as a short term solution.

Note: In some case, such as the M1A2 Abrams, the ORD goes beyond simply describing a capability and goes into defining a solution. The ORD(U) states the "An under-armor Auxiliary Power Unit (APU) is desired... must be fueled from the main engine's fuel cells...". As can be seen, the ORD in this case moves beyond describing a capability and into a solution. Such ORD statements should not be used to limit potential solutions, but rather guidance to the capability desired.

A new way of looking at power needs

Taking a systems approach to problem solving sometimes involves taking a couple steps back from the issue at hand to get a better view of the entire scope of the problem. In this case, the entire power system should be studied before rushing to a material solution. While not completely new, it is a different method than the normal way of addressing the Soldier's needs. This process is more time consuming and can delay the material solution. However, the following benefits are achieved by the application of systems engineering principles:

1. Power documentation is gathered and stored in a central location
2. Increased understanding of the power system by all members working through the process
3. An understanding of how the power is actually used versus mission profile used
4. A traceable path used in the decision making process

The Process

Forming the Integrated Process Team (IPT)

The critical first step in looking at the non-primary power application on a combat vehicle was creating a team of people who were familiar with the vehicle system and technology available to meet the vehicle power needs. Each group was expected to contribute an unbiased knowledge base to be assessed by the team.

Information supplied by IPT members included

1. LRU list with power consumption
2. Complete ORD statements as to total operational needs
3. System Specifications
4. Detailed descriptions of ongoing power generation programs (upgraded alternators, etc.)
5. Modernization paths, which detail when specific technology is planned to be added
6. Future technology power profiles
7. User power consumption data (mission profile and actual if available)
8. Access to conduct Voice of the Customer/Quality Function Deployment (VOC/QFD) with soldier and vehicle office representatives.

- 9.. Conduct of VOC/QFD sessions
10. Knowledge base of currently available technologies
11. Guidance on emerging technologies
12. Independent analysis of technologies
13. Preliminary assessment of solutions
- 14 Market data to verify availability of technology
15. Leadership throughout the process

Vehicle Familiarization

Data gathering was conducted during this step in the process. Team members created a comprehensive list of the documentation needed to form a complete view of the vehicle power generation and consumption. Included were LRU power data, mission profiles of power consumption, ORD review for operational considerations and specifications. More often than was expected, the information available was out of date, incomplete and not reflective of real world application of the vehicles (mission profiles vs. actual usage). All information was gathered and organized into a report showing the baseline power generation/consumption on the vehicle.

Gap Assessment

The gap assessment had three distinct portions that were addressed.

1. Information Analysis

The information was analyzed to determine if there is a current shortcoming in the available power to perform a specific vehicle mission. During this stage, the analysis of previous upgrades and power consumption was conducted. This provided insight into the method used in the past.

2. User Input

In performing this analysis, it was important to conduct VOC/QFD sessions with the users. In this case, a selection of Soldiers who used the subject equipment were interviewed and encouraged to describe how they used the vehicles in training and combat. This gave a first hand account as to the scope of the power deficit on the vehicle and where electrical problems exist.

An added benefit to this process was a first hand account of new equipment desired on the vehicles that would have otherwise been unknown.

Note: The Soldiers interviewed only represented a small sample of the user population. This must be taken into account so as to not over generalize a small group's experiences as an overall Army experience.

3. Technology Insertion.

This final portion of the gap assessment focused on when the NPS technology should be implemented onto the vehicle. The IPT was provided the rebuild and reset schedules, as this is the logical time to insert new equipment on the vehicle.

Modernization plans were also used at this time to ensure the NPS selection process addressed the future growth in power demand of the vehicle.

All this information must be used to pick an NPS power level suitable to meet the desired mission at the desired time.

Refinement of Requirements and Technology Assessment

Until now, the process focused on information gathering. The process then transitioned into refinement of the information into useful parameters for possible material solutions.

At this time, the aforementioned analysis was combined with specific vehicle parameters, such as space and weight allocations, to form a preliminary NPS specification. This specification was used to perform an internal technology assessment based on past, current and future work being conducted by the TARDEC. In addition to the internal assessment, a Request For Information (RFI) was issued to receive Industry's input on available technology and the ability to implement it on the targeted vehicle.

Technology assessed may or may not achieve the total performance desired, but can answer the following

1. Can the NPS requirements be met with existing technology?
2. What is the level of risk associated with each solution?
3. What technology is available at the desired implementation time?

The technology assessment also included a review of previous attempts to include NPSs on similar combat vehicles. This provided a basis for assessing the likelihood of success as well as educating the team as to the problems encountered so that they are not repeated.

Presenting the Information

A clear understanding of the entire process plays an essential role in how the information was accepted by the vehicle Program Manager's Office.

The presentation included the problem statement as issued, how the team was staffed and the activities used for gaining the system view of the issues (both current and future). At this time, the preliminary material solutions were also presented. These were characterized as falling between:

Cheap and Easy – may not meet all requirements but will be inexpensive and low risk

Expensive and Difficult – has great potential to meet all desired performance but will require development and have a higher risk

Recommending a Path Forward

At this point, the IPT recommended a path forward to a material solution based on vehicle needs and available resources. While the solution may or may not be the 100% solution to the problem, the recommendation was backed by a traceable process.

Conclusion

The process used on this project yielded multiple benefits.

By following a process, a traceable path was created and used in the decision making process. This is invaluable when met with questions regarding why decisions were made and providing background for recommendations.

Shortcomings in information were experienced in this process, most notably in duty cycles and wartime power consumption profiles. By following the process, it was shown that information thought to be complete was in reality incomplete. Vehicle offices can now work to gather the information as it was proved to be valuable in studies such as this.

New and future gaps, such as thermal management, came to the forefront during this exercise. Simply looking at the data without the input of the Soldiers would have let the issue remain hidden to the IPT.

While the process was by no means perfect or complete, it has been a starting point for problem solving by the organizations involved. The IPT created a mechanism of communication between all organizations enabling the timely transfer of information and capabilities to one another. All groups involved considered the work a success and have continued addressing the issue of NPS on combat vehicles.