GE’s aeroderivative Millennium units were introduced as the calendar approached 2000, a time when the need was to have an engine-qualified control system using the Mark VI™ platform with a high degree of standardization. Most Milleniums were Mark VI packages for engine/turbine control, interfaced with GE’s Fanuc 90-70 PLC for package control.

The Mark V control system was GE’s second generation of microprocessor-based turbine control configured as simplex and triple redundant. More than 3300 systems were shipped from 1991 to 2004. Most of these systems are still in service and supported by GE’s lifecycle management solutions.

However, these solutions have reached the later stages of their lifecycle. The Fanuc 90-70 controllers and their associated I/O entered the last stage of support in 2011. GE continues to support the Mark V and Mark VI systems with parts and services, but these systems are limited in comparison to today’s level of technology. The company has since introduced a new control platform that follows a new and improved lifecycle—one designed for easier modernization and maintenance as technology advances.

The Mark VIe solution

Improving upon reliability, flexibility, availability, usability, and maintainability, GE introduced the Mark VIe control platform. The company offers special retrofit packages for the Millennium and Mark V controls that involve an upgrade to Mark VIe at less cost and with less disruption to operations than most customers might imagine. The upgrade helps to ensure continuing support while offering the ability to do more with the new control system.

The Mark VIe expands control capabilities and provides a common architecture for fuel and package control. It also follows a new and improved lifecycle model, with modular design also simplifying the modernization and maintenance process. The Mark VIe’s new features, capabilities, and update opportunities include the following:

- Latest engine core control software.
- HMI hardware, operating system, and latest application software.
- Cimplicity™ HMI software.

GE

John Emery, Product Line Leader for Control Solutions
GE Measurement & Control business unit

- Cyber security solutions in line with NERC/FERC requirements.
- Latest control system hardware: CPUs, fuel/package controls I/O, and network switches.
- Plant control integration (DCS).
- Advanced control algorithms enabled for new turbine functions such as advanced DLE systems and core engine enhancements.

Major advancements

The modular technology of the Mark VIe allows for upgrades on a component-by-component basis, which is a new approach for the modernization and maintenance of GE’s control systems. This presents customers with a better lifecycle for their assets and a control system meant to last and grow, even as technology advances.

The Mark VIe also features a new approach in software. The ControlST™ software suite features significant improvements over the software used on previous systems. It incorporates several high-performance tools for ease of use by operators and maintenance personnel, such as:

- WorkstationST™ application for managing of HMI and historian functions.
- ToolboxST™ application for configuration and diagnostics, with trending capability for analysis.
- Cimplicity™ graphics user interface with vastly improved ease of use, graphics, screen navigation, alarm/event management, and advanced features—such as trending tools, alarm management, etc.

Operators also benefit from the open-system architecture of the Mark VIe. The control and configuration software has been opened to assist operators in troubleshooting and diagnostics.

Increased computational power and I/O capacity of the Mark VIe improves turbine performance derived from the latest core upgrade. This includes the following:

- NOx water injection tables and Sprint™ tables are integrated. Some customers may see a reduction in NOx water consumption of up to 2%, possibly even 3%.
- The current software core decreases the need to do seasonal NOx water mappings and decreases water erosion on compressor airfoils.
- Sprint water flow is dependent on fuel flow to better accommodate load-following or decreased power demands while also reducing water consumption in base-load operation. Some customers will be able to see savings of up to 15 gpm.
- Improved water use reduces heat rate at low power settings.
- A 10-min start capability is maintained.
- The software reduces failed starts attributable to flame-detector faults.
- Percent load calculation for grid frequency response (a/k/a Primary Frequency Control, PFC) is a requirement from an increasing number of grid authorities across the globe.

Additional Mark VIe advantages:

- Provides more efficient maintenance with one modern software tool for configuration of networks, processors, and I/O boards, along with editors, block libraries, and diagnostics.
- Operation is facilitated with improved graphics, alarm/event management, sequence-of-events, and trending.
- Single-point communication failures are eliminated within the control, and options are available for cost-effective network redundancy between controls and HMIs.
- The cyber asset protection program assists customers in complying with NERC Critical Infrastructure Protection Reliability Standards.

Migration

GE’s migration offering for the Millenium and Mark V packages is a new process for upgrading legacy systems to the Mark VIe control platform. Instead of performing a complete replacement of the existing control system, the upgrade is made through a simple plug-and-play exchange of critical electronics.
A GE migration demands less downtime, impact, and risk to operations compared to traditional upgrade solutions. A migration solution is more than just a hardware and software product replacement or upgrade: It is a coordinated process that combines all the elements required to deliver the solution that meets the customers’ operational needs.

**Field experience**

**Millennium.** GE recently upgraded four fully functional LM6000PC units with Mark VIe at a powerplant in the South. These units were successfully commissioned within the customer’s aggressive outage schedule (less than 10 days per unit). To help ensure smooth installation, the company followed customer inputs on the cabinet layout and software.

GE specifically placed close attention to the following:

- Allowing better access to the terminal boards with TCP wiring and cabling between cards.
- Providing advanced HMI screen layouts and display information.
- Designing the right logic for alarms and trip set points.
- Providing necessary drawings to the customer.
- Mobilizing extra support for immediate problem-solving.

**Mark V.** GE has performed more than 150 migrations for the Mark V, the majority on heavy-duty gas turbines. Most of these projects were completed in five days, “breaker to breaker.” A Mark V migration to the Mark VIe can be done, and has been, in as few as three days.

**Other.** GE also has experience in replacing third-party control systems on aeroderivative turbines. For example, the company recently replaced four non-GE control systems for a southern powerplant in need of more reliability during peak season. Before the upgrade, the existing control cabinets were causing input/output issues and unnecessary trips. The plant has not experienced any trips since the new Mark VIe systems were installed.