MCCx Convergent Technologies: Bringing the Mission Control Center to Your Personal Computer

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The current Mission Control Center (MCC) operates in a secure environment at Johnson Space Center (JSC). The center uses a distributed architecture that has been in operation since 1994, featuring separate hardware systems and networks for audio, video, voice, office personal computers (PCs), and flight control workstations. Each console contains Linux workstations for vehicle telemetry, monitoring, and control; a Windows PC for procedures, shift logs, and e-mail; a telephone; video channel monitoring capability; and a separate hardware voice communication system. The control center has evolved to be workstation hardware-agnostic and its distributed software architecture is adaptable to equipment and network modifications. As a consequence, equipment replacement tends to yield minimal operational cost reductions. The MCC system's robust, stable performance is reflected by the number of successful missions, but also by the challenge to reduce total cost of ownership. The MCC is, then, both a challenge and an opportunity.

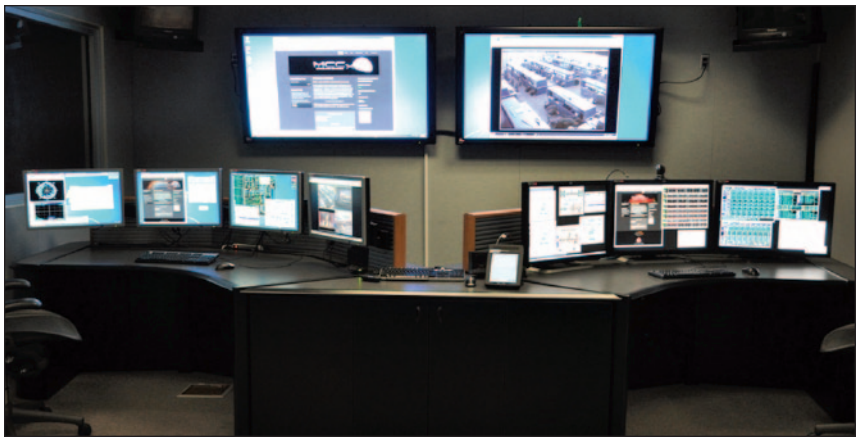

Fig. 1. *MCCx—a "virtualized replica" of Mission Control Center infrastructure.*

The drivers for lower MCC cost of ownership are a combination of budget challenges across NASA, the limited cost flexibility of the MCC hardware replacement cycle, and the new focus on commercial crew services. Collectively, this prompted the Mission Operations Facilities Division of JSC's Mission Operations Directorate to charter a development initiative to demonstrate an alternative set of IT technologies in a future MCC architecture concept. This initiative includes the goal of reducing the development, maintenance, and operations costs, while enabling a more extensible operations concept for human and robotic missions. Through product research and evaluation, the team developed a preproduction system that meets these goals while providing the MCC "as a service." This preproduction configuration, known as MCCx, is currently in use by several operations groups at JSC.

MCCx is a "virtualized replica" of the Mission Control Center infrastructure, as shown in figure 1.

MCCx provides real-time, situational awareness of the International Space Station (ISS) by supporting the majority of the standard MCC flight control applications and live mission data. MCCx is available to authorized users, securely, from any location around the globe. Users perceive very few differences between MCCx and the actual MCC. In fact, the "look and feel" of the MCC is enhanced by the new features such as the seamless integration of the Windows and Linux desktops on a single PC. Owing to the fact this is a "preproduction system" there are policy limits, such as prohibiting vehicle commanding from remote locations. In the context MCCx is operationally serving today, this is not an issue.

MCCx is an implementation of the "2-wire Flight Control Room (FCR)" concept, where power and Internet connectivity are the only services required for mission support other than a PC. The thin client approach integrates easily with technologies such as Voice Over Internet Protocol (VoIP) and Internet Protocol Television (IPTV). These replace the individual, non-integrated networks in the MCC video, audio, and voice solutions as well as the associated complexity, cost, and equipment footprint. The 2-wire FCR significantly increases extensibility, lowering the total cost of ownership, and making it possible for MCC functionality to become a commodity function.

The architecture of MCCx is based on a data center approach that minimizes the hardware system footprint. It leverages hardware virtualization allowing for MCC Linux

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continued

workstations to run in a virtual environment on blade servers, as shown in figure 2. The MCC software load and software architecture is installed into the MCCx system completely without modification.

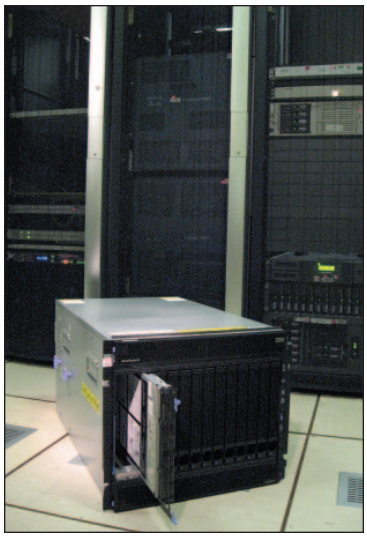

Fig. 2. *The architecture of MCCx minimizes the hardware system footprint.*

A consolidation ratio of 40 Linux virtual machines to one blade is easily achieved, even with very modest blade servers. Of note, the virtual machine runs Scientific Linux 4—a *free* distribution of Linux, instead of a purchased operating system as in the MCC. Therefore, MCCx introduced and validated the potential for significant cost savings on both the hardware platform count and the software required. A commercial off-the-shelf remote access tool, along with additional security layers, allows for secure, remote access to the Linux machines from any Windows or Linux PC. It creates a hybrid desktop for a flight controller. The desktop will run both the MCC Linux and the local Windows applications simultaneously on a single PC.

MCCx was first deployed in 2008, into the ISS System Integrated Simulation facility. Today, MCCx is an integral piece of the ISS training environment—one that enables a new, lower-cost training flow model for flight controllers. MCCx provides the MCC as a service to the ISS training facility, without use of the actual operational MCC. This implementation delivers substantial cost savings in flight control room implementation, hardware costs and configuration, and systems management and administration.

Over 500 members of the flight control community at JSC currently use MCCx for remote mission support from their office or home, and from JSC off-site locations. The Houston Support Group's Houston Support Room in Moscow, Russia, and the ISS Mission Evaluation Room have both adopted MCCx as the platform of choice for mission operations. The attractiveness of MCCx in these applications is enhanced productivity, and substantially lower costs than the remotely located native systems. The Mission Evaluation Room support, previously executed in the MCC, is now remote in the office, with VoIP (voice) and IPTV (video) available. In addition, the Goddard Space Flight Center and other NASA centers are using MCCx for payload mission situational awareness. MCCx services also extend to the software engineering community in the Operations Technology Facility through a "virtual development environment" capability, requiring nothing beyond the user's PC. The architecture of MCCx is flexible enough to support not only current ISS operations, but also those of prototype and future vehicles, including commercial crew. MCCx is currently collaborating with JSC's Engineering Directorate to host flight software displays and live vehicle telemetry from the Morpheus Lunar Lander prototype.

The virtualized environment that MCCx employs is a new operations concept for flight control at NASA, as well as a new architecture. By demonstrating remote operations faithful to MCC functionality, a significant step has been taken in the evolution and validation of design options for the future MCC. With remote, secure access, all NASA centers could be connected to the MCC data center. A robotic, human, or combined human-robotic mission can be executed and the tool set and the number of controllers is limited only on the number of blades in cabinets with identical software loads. In combination with the video and voice over IP, MCCx technologies open new opportunities for the next generation MCC—an MCC "without walls," capable of embracing any new mission NASA as an agency undertakes.