Nantes, France, 01/12/2012: Realizing the Next-Generation CNC machine-tool

What should the Next-Generation CNC machine-tool look like? This is one of the subjects that FoFdation is trying to investigate and consortium partner EC-Nantes has been busy trying to give a glimpse into the future by creating a prototype platform. This particular prototype uses currently available tools and new developments to build an Open-NC platform for showcasing CNC functionalities that are expected, even demanded, in the future CNC machine-tool.

Envisioning the Next-Generation self-learning, intelligent and efficient CNC controller is important in FoFdation. Even more important is providing pragmatic solutions that address the current needs of the manufacturing industry (legacy solution). Another significant aspect is developing an ambitious vision to anticipate their future needs and direction (Open-NC solution). Realizing these objectives means that all developments are guided by a previously defined FoFdation Smart Machine Controller Open Architecture (FSMC-OA).

EC-Nantes has dedicated one of its functioning industrial CNC machines and a lot of effort to realize this vision. The Cincinnati Milacron 'Sabre' milling machine with a NUM controller has been equipped with the open-source, community-supported LinuxCNC controller alongside it. The LinuxCNC controller is open, modular and a solid environment to test out and demonstrate new ideas unabated. The Original Premise: safeguard the functionalities of the original controller and machine in their current production state. The Challenge: add the LinuxCNC controller to produce a cohabitant Legacy-Open-NC environment. The Outcome: a successful prototype platform was created and tested. *See Figures 1, and 2 for schematics; Figures 3, 4, 5 and 6 for the platform with machining trials.*

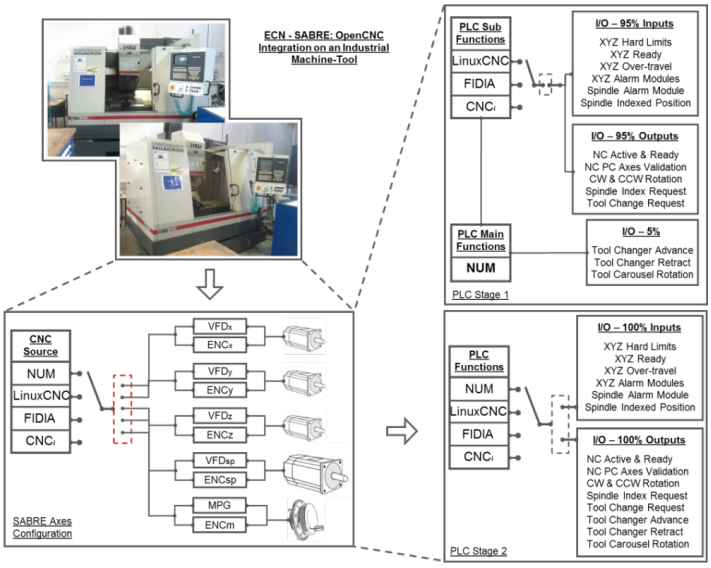

Figure 1: Open-NC Prototype Platform implementation on an industrial CNC [EC-Nantes]

The Open-NC Platform

This platform enables different *guest* controllers such as LinuxCNC (eventually Fidia and any other NC controller from any manufacturer) to be added next to the NUM, all cohabiting within the same machine tool. Essentially switching from one CNC controller to the next using a hard-wired switch, and each would have complete control over the Sabre machine. The switch represents a physical diversion of the signal sources for the input signals that are used to control the axes (spindle, linear machine axes and hand-wheel). The switch also changes the signal sinks of the output signals that are sent out by encoders and limit switches.

Figure 1 illustrates an interior view of the Sabre machine with two PLC implementation stages as well as the hard switch to select which controller source controls the attached motion control hardware. Initially, these implementation stages were performed only on the LinuxCNC side but similar steps are expected for the planned addition of a Fidia guest controller.

Short-Midterm Implementation: Stage 1 - In this stage, the motion control (linear axes, spindle and handwheel control capabilities and some security functions) from the NUM controller were ported to LinuxCNC. The

associated PLC functions were transferred to and managed by LinuxCNC. These ported functions represent about 95% of the input/output (I/O) demand of the machine and they are managed by LinuxCNC. They will also be independently managed by the cohabiting guest controller that is active. The remaining I/O functions such as peripheries are still controlled by the NUM PLC. This is the current state of the platform.

Mid-Long term Implementation: Stage 2 - the remaining PLC functions left from Stage 1 would be transferred for independent control by LinuxCNC and other guest controllers. The selected controller will therefore have complete control over all functions of the Sabre.

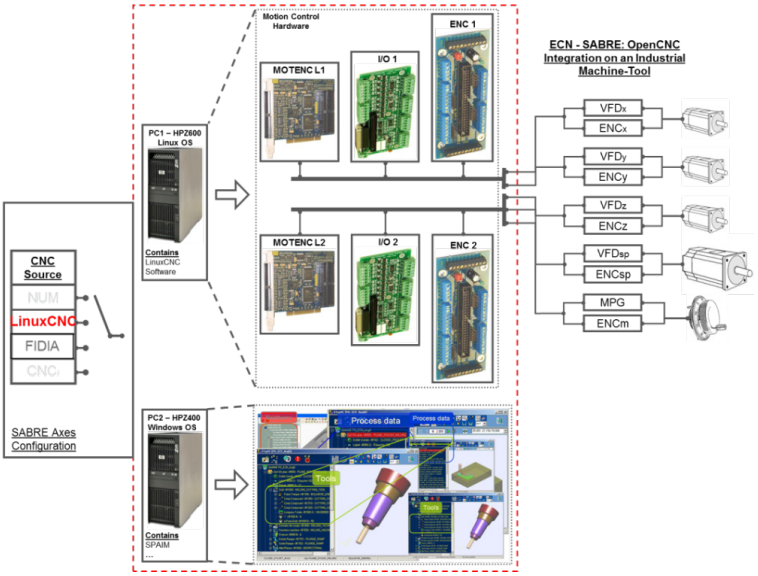

Figure 2: LinuxCNC- Sabre hardware and software connections [EC-Nantes]

Figure 2 shows the connections between the machine's hardware, the LinuxCNC motion control hardware and the software side of this development. It is an expansion of the red section shown in Figure 1. On the machine, two PCs (PC1 and PC2) are installed and they communicate via a local network. On PC1 with Linux OS, the LinuxCNC software and hardware (motion boards, encoders and I/O boards) are installed. The connections between the PC and the machine's axes are handled by this station. It is responsible for the real-time motion control based on a RT-Linux kernel. The PC2 with Windows OS contains accompanying software such as CAD, CAM and other necessary systems and tools. The Next-Generation controller will be STEP-NC compliant and for that the EC-Nantes' SPAIM platform for advanced STEP-NC programming and control will be embedded.

Why is this Open-NC Platform important?

It is important because it is the first industrial machine of this scale to implement LinuxCNC as far as is known. It is the building block towards showcasing the functions of the Next-Generation CNC controller. It is also the test machine for a larger FoFdation multi-controller, multi-machine Integrated Test Platform which will allow comparison of the 3 different types of CNC controller with a single machine configuration. The platform will allow new algorithms for optimization and process control for example, to be implemented and tested in an open environment. Furthermore, the evolution and benefits of the STEP-NC data model and compliant applications will be demonstrated on it. Finally, advanced NC-interpolation and trajectory planning with optimized toolpath programming based on real-time process data will all be performed within this environment.

Figure 3: Prototype Platform - Electrical cabinet, LinuxCNC motion hardware, CNC source switch

Physical Installed Hardware

HardwareinstallationforthePrototypePlatform (Figure 3) showing the electrical cabinet, the two companion Linux and Windows PCs (PC1 & PC2), hardware components for motion control by LinuxCNC and the hardwired CNC controller switch.

Software Additions

A custom GUI was developed to add alongside the existing LinuxCNC interface for added information display and CNC state monitoring (Figure 4).

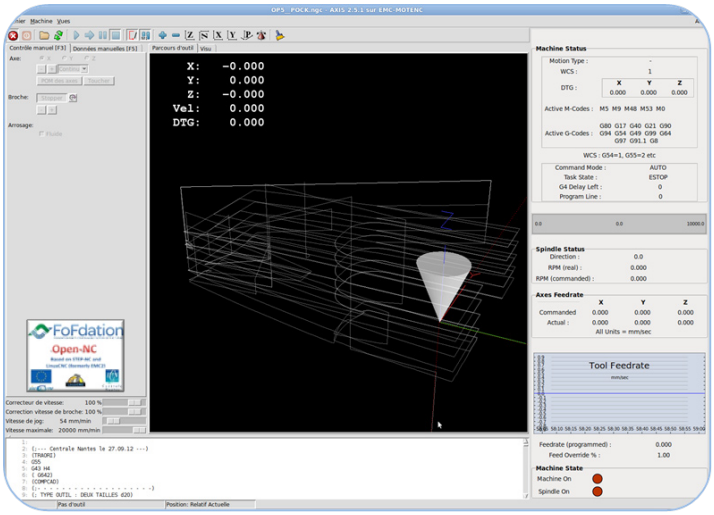

Figure 4: LinuxCNC HMI with custom GUI [EC-Nantes]

Going Further

After hardware and software implementation, the platform was tested by milling test parts such as this STEP-NC Fishhead part and the Butterfly Bi-arcs from the LinuxCNC community (Figure 5). Developments have already started to embed STEP-NC capabilities onto the platform with the SPAIM environment and this test part shows just a glimpse of the results.

Even further, Figure 6 shows LinuxCNC, NUM and SPAIM cohabiting on the same machine and used to mill the Fishhead test part. The shop-floor modifications and benefits of STEP-NC are already functional on this platform.

Figure 5: Milling with LinuxCNC [EC-Nantes]

For more information about the FoFdation project visit **http://www.fofdation-project.eu** and the project's social media pages, including Facebook (**#fofdationproject**) and Twitter (**@FoFdation**).

Acknowledgements:

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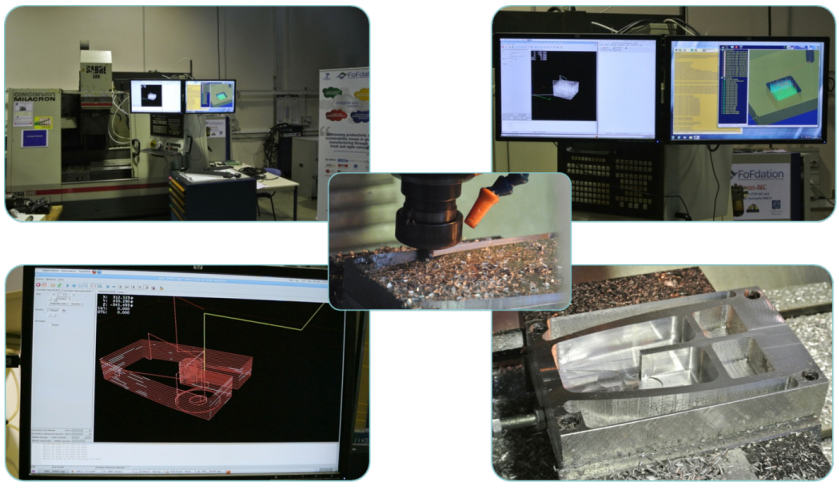

Figure 6: Overview of the Integrated Test Platform [EC-Nantes]

For further information please visit:
http://ec.europa.eu/research/industrial_technologies/factories-of-the-future_en.html