# Unified software production process for CERN cryogenic control applications

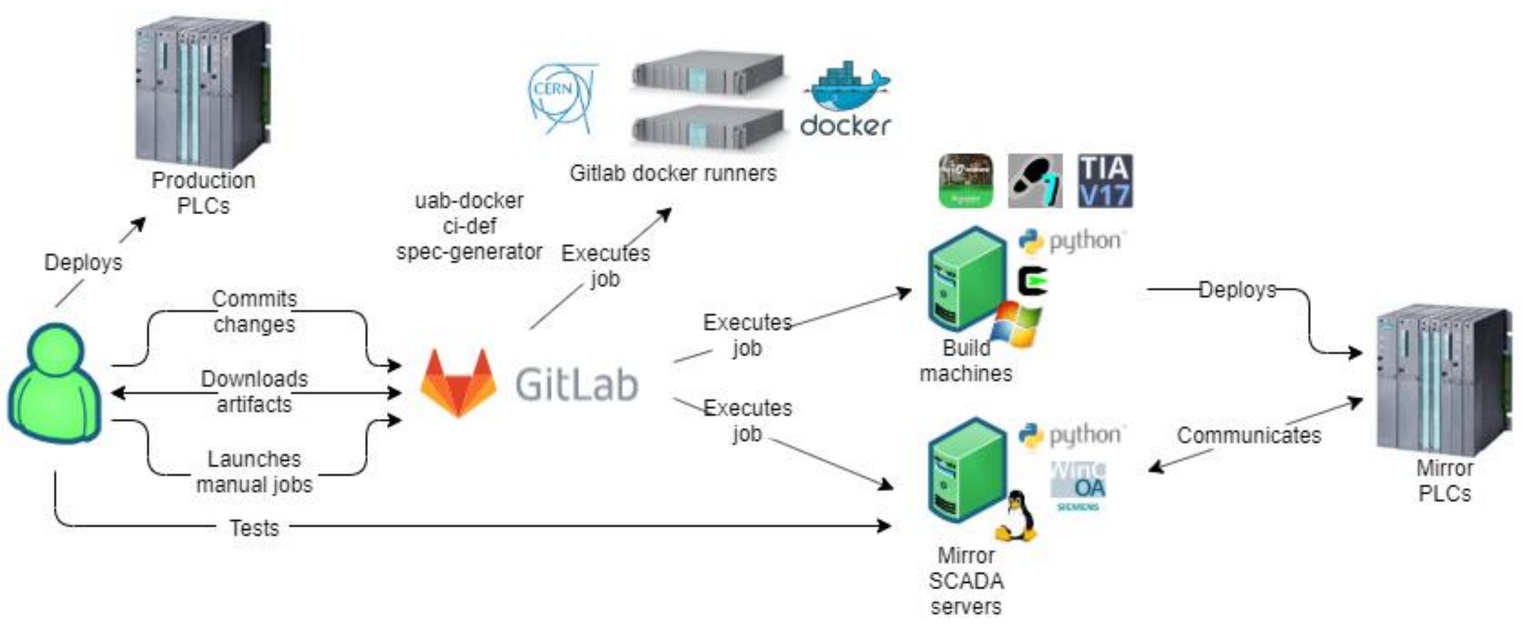
Marco Pezzetti, Thomas Barbe, Czeslaw Fluder,
Tomas Kubla, Antonio Tovar-Gonzalez, CERN, Meyrin, Switzerland
Sebastian Jan Rog, AGH, Cracow, Poland

The software engineering for CERN cryogenic systems uses an automated code production method and continuous integration. Initially designed for LHC Accelerator applications and later adapted for other cryogenic facilities, this approach has enabled successful system upgrades, new applications, and improved quality while minimizing manpower. However, due to complexity and evolving frameworks, a new unified software system was developed, combining previous tools and configurations. This publication introduces this unified solution, highlighting its benefits for various cryogenic domains and summarizing two years of experience with different PLC technologies.

## CERN CRYO CI System History

Continuous integration (CI) has significantly reduced development time, from months to weeks, resulting in high-quality and reliable cryogenic control systems.

- Continuous integration was initially used in the control system for 18 PLCs in the LHC Cryogenic Tunnel Applications.
- It was extended to cryogenic magnet test benches and other cryogenic process control systems at CERN.
- Different control systems used varying PLC technologies, leading to the development of slightly different continuous integration solutions.
- Over time, maintenance challenges prompted the need for a system redesign.




## CI system application principles

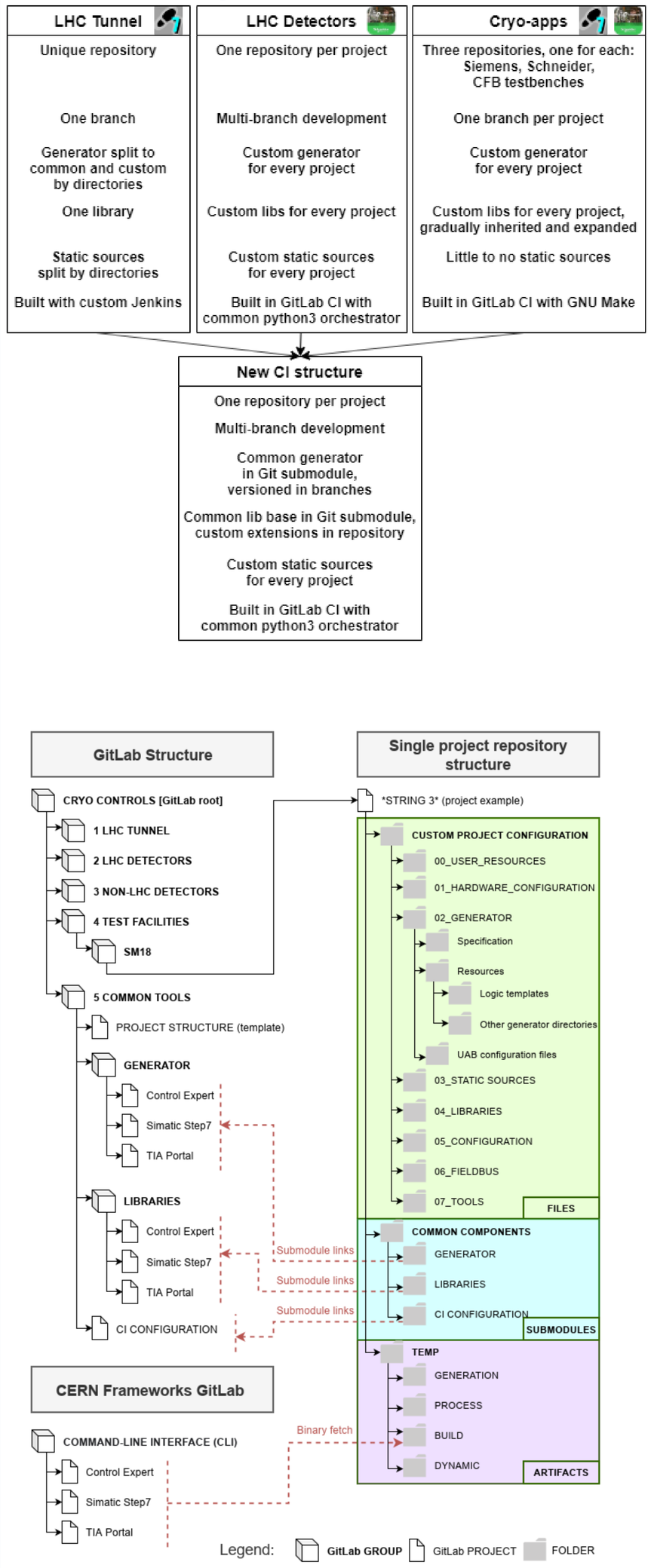
The initial CI system had limitations and couldn't efficiently handle over a hundred applications. The key lessons learned are as follows:

1. Avoid Grouping: Don't group unrelated applications in a single git project, as it can slow down operations without real benefits.
2. Share Common Parts: Shared files should be modified centrally to prevent divergence.
3. Minimize Variations: Reduce complexity by applying a consistent approach to project construction, even for seemingly unique applications.

## New CI system features

1. Spec version control: UCPC code generator uses Excel for its input specification, which offers advantages for data manipulation but poses version control challenges with Git due to its binary format. To address this, JSON files representing UNICOS objects are maintained alongside Excel, facilitating effective change tracking and Git compatibility without affecting program generation.
2. Quality Assurance tests: Pipeline includes verification tests for error detection and rectification, with two comparison jobs to ensure code integrity. Automatic comparison to the production environment streamlines manual adjustments, maintaining accuracy in the version-controlled codebase.
3. Mirror PLC validation test platform: Subpipeline scripts automate the creation of a "mirror PLCs" validation testing platform, benefiting developers and operators by ensuring correctness, relevance, and training support. The platform includes PLC and SCADA components, with automatic IP configuration, program deployment, and basic simulation, simplifying testing procedures compared to manual processes.

## New CI system structure




CERN's cryogenic process control system extensively uses continuous integration and automatic code generation. Our unified software production solution applies a shared methodology, enabling a robust and automatized global process control system generation from design to operation. The reorganization of our git repositories and the leveraging of submodules significantly improved code reuse and de-sign consistency. By transitioning to GitLab CI and Docker, the need for custom runners was reduced. Critical software tools, including the UCPC code generator and PLC CLIs, are now maintained by the CERN central control group, alleviating our operational concerns. Moreover, with the integration of mirror SCADA system into our CI ecosystem, it is possible to automatically deploy mirror builds, which streamlines validation and testing. The addition of quality assurance tests into our CI pipeline also limits the risk of errors and deployment failures. These results highlight our commitment to finding smarter and more efficient ways to reach our scientific goals.

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