# Requirements for High-Level Applications Infrastructure for Development and Production

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History of Changes

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1 High-Level Applications (HLAs) at TRIUMF

At present TRIUMF users and operators use a number of high-level applications (written in different languages, having rather complicated graphics user interfaces, employing multiple cores for fast calculations), to carry out tasks related to delivering ion beams with required characteristics and to process data from TRIUMF’s EPICS-based and legacy cyclotron control systems. Some applications have been developed by the EPICS community, some at another laboratory, and some at TRIUMF. These applications run on different production computers and are developed on different machines. This model no longer satisfies the TRIUMF’s needs because of the growing number of applications, the long times required for data visualization and processing on current machines, the lack of real-time visualization of beam properties obtained after processing by HLAs and so on. There is a need to improve the efficiency of developing, running, and maintaining HLAs at TRIUMF.

2 Requirements for infrastructure

Typically, each high-level application is unique, developed for some particular task. Thus, initial development, installation, adaptation for other tasks is always a challenge. HLA development infrastructure must help to solve these tasks with minimum time for development. Duplication and “re-inventing the wheel” must be avoided. All development tasks should be solved on development server hladevel.

Running HLAs in production, which use real data must provide matching between the delay for data acquisition from control systems (which is typically on the order of 0.5 second) and the delay for processing data and their visualization. Starting HLAs on production server should be done in the most convenient manner. Such tasks should be solved on production server hlaprod.

Very important part of HLA development is writing and maintaining documentations for each project. Writing documentation should be organized in the most convenient manner. The documentation should be available both for developers and users with minimum time spent for navigation and search. The information about present state of different TRIUMF beam lines should be easily available for all TRIUMF personnel. Such tasks should be solved on the web server hlaweb.

HLA infrastructure should provide redundancy for running services in case of hardware failures of hlaweb and hlaprod. This redundancy must be provided by installation of exactly the same software on all servers and having exactly the same hardware.

More detailed requirements for each part of HLA infrastructure are described in the next sections.
2.1 Common requirements for HLA Development, Production, and Public web servers (hladevel, hlaprod, and hlaweb)

RS 1. The machines shall be powerful servers with at least 2 CPUs, 16 cores, and memory no less than 128 G. They shall be capable to run the existing HLAs and anticipated growth of HLAs for the next 5 years.

Rationale: Many modern tools and application require lots of resources. Several application instances can run at the same time for different users. To avoid long response times it is necessary to have powerful servers

RS 2. All cores shall be accessible. Virtual machines, which give limitation for usage of cores shall not be used.

Rationale: To run HLA as fast as possible it is necessary to develop the codes with parallel execution on all cores (openMP technology). This has become a standard: openMP support is nowadays part of Linux distributions.

RS 3. Development, testing, and running of applications require access to real EPICS data from TRIUMF’s control systems.

Rationale: Most of the development and testing will be done with local development Soft IOCs, but HLAs need real EPICS data both in development and production environment

RS 4. For the present list of HLAs the readback update period for input EPICS data shall be no longer than 0.5 second. This period doesn’t require any changes to existing control systems. However, in the future, shorter update period may be requested for some HLAs.

Rationale: HLAs are used at run time. Any significant delays for readbacks can lead to incorrect settings of beam parameters for HLAs.

RS 5. HLAs shall be isolated from Control systems as much as possible to avoid unpredictable influences on running systems

Rationale: Control systems shall be protected as much as possible from HLA glitches

RS 6. All servers shall be identical.

Rationale: Applications are developed and built on the development machine before being deployed on the production server. Using identical hardware and software for both eliminates difficulties in copying built or installed applications from the development server to the production server.

RS 7. A modern reliable operating system (OS) which has good support from TRIUMF System Administrators and the world community shall be installed on HLA servers. OS shall be easily maintained and able to accommodate EPICS tools and applications that are necessary for HLA development and running.

Rationale: Administration of OS, installation of necessary applications shall require minimum time.
**RS 8.** Full support of all necessary EPICS components shall be provided by the HLA System and Application Administrator.

_**Rationale:**_ Control systems use EPICS for ISAC and E-Linac. Some HLAs use EPICS Channel Access (CA). Also Matlab applications using Matlab Channel Access (MCA) are in use at TRIUMF.

**RS 9.** The HLA servers shall be maintained by HLA System and Application Administrator.

_**Rationale:**_ HLAs are outside the scope of the Controls and Core Networking and Computing groups, therefore HLA servers must be administered and maintained by HLA personnel.

**RS 10.** The HLA servers shall be installed in a clean, non-dusty, air-conditioned area and shall be installed in a rack to be easily accessible and maintainable. Sufficient space for future expansion should be provided. The servers shall be on uninterruptible power.

_**Rationale:**_ HLAs development is on a very fast development track. The installation space for HLA servers must provide enough room for the addition of new powerful servers in 5 years.

### 2.2 Development, building and installation of HLAs on development server hladevel

**RS 11.** A common set of tools for modeling, code development and version control shall be used.

_**Rationale:**_ Having a common set of modeling and development tools establishes a “common culture” of developers. Having as many as possible developers “under one roof” provides their mutual exchangeability.

**RS 12.** Development shall be organized as “project-based”, not “home directory-based”. There shall be “common” directories as well (common for all projects).

_**Rationale:**_ It is much easier to maintain applications organized in tree-like project-based directory structure, which is accessible by any developer.

**RS 13.** The development machine shall be accessible by developers only from inside TRIUMF in secure manner. The development server shall be secured against external attacks.

_**Rationale:**_ The possibility of direct access to the development machine by hackers must be excluded because the development machine has access to the HLA production server, which, in turn, has access to TRIUMF’s control systems.

**RS 14.** Web applications should be developed and tested on development machine like any stand-alone applications.

_**Rationale:**_ Development machine is used for development both non-web and web application.
RS 15. Version control system shall be installed. It shall be widely adopted, powerful and easy to use. The installation should comply to TRIUMF intellectual property rules.

**Rationale:** Version control system allows better management of source code than timestamp-based or rename-based versioning.

RS 16. A Universal Modeling Language (UML) tool should be installed and used for system and code design

**Rationale:** The rule “first model, then code” must be standard practice for software development.

RS 17. A set of basic programming languages should be supported: Python, Perl, C/C++, Java, Matlab. Support for any other languages and application is provided on “as needed” basis.

**Rationale:** HLA's may be written in different languages. It is necessary to support a multi-language environment.

RS 18. The projects, information/documentation and data trees shall be backed up both locally and to a remote location once a day

**Rationale:** Loss of codes, documentation and data must be avoided.

2.3 **Running HLAs in Production environment on hlaprod**

RS 19. HLAs on Production machines get/set EPICS data from/to TRIUMF’s control systems. For the present list of HLAs setting of PVs shall be with delay on the order of 0.5 second. Such delay doesn’t require any changes to existing control systems. However, in the future, shorter delay may be requested for some HLAs.

**Rationale:** EPICS data are an input and output for HLAs. EPICS PV setpoints are used to control different parameters of the beams and physical equipments. Any significant delays can lead to incorrect settings of beam parameters by HLAs

RS 20. Operators and users, who use HLAs shall be able to connect to the production HLA server without entering the password by using SSH keys.

**Rationale:** HLAs must start automatically on the HLA production server without requiring every operator and user to know account specific password. This improves both the efficiency of operation and network security

RS 21. HLA shall be started by operators and users in the most convenient manner. Documentation for each HLA shall be easily accessible.

**Rationale:** Operators and users should focus on their tasks, starting and running of HLA shall require minimum learning time.
2.4 Public web server hlaweb for development of information web pages and documentation and publishing live EPICS data

RS 22. A web server shall be set up for writing information web pages and documentation and running web application with read-only access to EPICS data. Necessary tools shall be installed to write and update web pages with minimal effort.

Rationale: The organization of information in hierarchical is a proven method of maintaining easily maintainable and navigable documentation. Practice shows that if the system is too onerous documentation is maintained very poorly.

RS 23. Connections to the public web server shall be allowed but all connections from the public web server to any computers at TRIUMF shall be disabled.

Rationale: This must be done for security reasons: hlaweb is “completely open” to the public Internet: it is accessible via ssh and http from anywhere. If a hacker were to gain control of hlaweb he/she must not be able to go further into the TRIUMF network and control systems.

2.5 HLA development by temporary personnel (postdocs and students)

RS 24. HLA infrastructure shall accommodate temporary and short term developers

Rationale: Prevent loss of effort.