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# XSD-XST-BC Strategy Document

## MISSION

The mission of the Beam line Controls (BC) group within XSD is to develop software and electronic hardware for synchrotron radiation beam lines that serves the common needs of APS researchers, and to implement that software for the APS beam lines. Our commitment, to maximize the measurement efficiency of the beam lines we serve, shapes the culture and character of our group and how we behave and make decisions. Through collaboration with APS researchers, we design, develop, deploy, and maintain control system software and hardware that capture and create economies of scale and keep the APS at the forefront of science.

## VISION

The BC Group will work closely and collaboratively with the APS-Upgrade (APS-U) Project, XSD operations groups other XST technical groups to build, install, and maintain the machine and experiment process control of current and future APS beamlines, in support of XSD and APSU priorities.

## STRATEGY

The BC Group will provide direct development and support of control and experiment process systems at XSD and APS-U beamlines. EPICS is used to structure the design of the hardware control into a layered system, allowing specialized collaboration with instrument scientists and controls communities within the APS as well as at other DOES facilities and abroad. Bluesky will be used to provide beamlines with a scientific Python framework to develop experiment processes. Priority is placed with developing capabilities that capture and create economies of scale aligned with the priorities of APS, XSD, and APS-U.

Upgrades are considered as part of a continuing, incremental improvement process. The group relies on a standards-based approach, with a strong preference for open-source or commercial-off-the-shelf components where possible. The group also relies on an innovative R&D program to supply such components which are not otherwise available.

A fundamental component is the assignment of a BC staff member as liaison to each assigned XSD. The liaison acts as primary controls support contact for the beam line and coordinates team efforts to resolve problems and extend capabilities of the control system. This same strategy will be used to develop the control systems for the APS-U beam lines.

Through career development activities such as continuing education, conference attendance, participation in international controls discussions, and cross-training, the group maintains its leadership in delivering control systems for APS beam lines.

## FIVE-YEAR GOALS

- develop software and hardware to support remote operations of APS beam lines
- integrate Bluesky based data acquisition scripting and analysis pipelines into beam line controls
- make custom electronics a deliverable (much like custom software)
- support enhanced fly scanning speed, stability, precision, and frame rate.
- support the beam line needs for nanometer metrology (data-acquisition and diagnostics)
- develop and compare AI/ML algorithms (including multi-objective genetic algorithm, recurrent neural networks, convolutional neural networks) for both automated beamline alignment and on-line optimization
- transition to a field-bus based principle IOC platform
- integrate EPICS v7 in beam line controls
- promote XSD/BC beam line control system strategy

## GOALS FOR FY2022 AND FY2023

- continue operations support at all assigned beam lines while simultaneously supporting the beam lines' transition to APS-U instruments.
- area detectors: support new and upgrade existing support
- continue development of BlueSky based experiments on beam lines
    - Spectroscopy beam lines (9-BM)
    - Ptychography beam lines (2-ID-D)
    - Continue development APS-specific diffractometer geometries: psic, s2d2, sevenc
- develop and test advanced motion control in APS-U required applications
    - fast synchronization and coordination instruments
    - nanobeam-based techniques
- APS-U:
    - Continue control system installation for CHEX beam line
    - Continue to integrate RAVEN instrument controls into CHEX beam line
    - Control system installation for the ASL (25-ID) beamline.
    - Develop coordinated energy scanning with undulator, monochromator, and diffractometer
    - Control system deployment plans for the Feature Beamlines.
- integrate EPICS v7 data structures into device support as appropriate
- build machine learning (neural-network-based) surrogate models of x-ray beamlines for automated alignment algorithm development and testing

# BCDA SWOT ANALYSIS

| **Strengths** | **Weaknesses** |
|---|---|
| • Group members have strong technical skills and often share experience.<br>• Group has good working relationships with beam line staff.<br>• Group in regular contact with global EPICS support base.<br>• Reliance on standardized components (hardware, software, and plans).<br>• Group staff are available and eager to solve beam line controls problems. | • Some expertise vested with individuals.<br>• R&D program lower priority than operations support.<br>• Large installed base increases resistance to change.<br>• Coordination with other support groups.<br>• Controls roadmap for new deployment is out of date |
| **Opportunities** | **Threats** |
| • New beam lines: new technologies and ideas<br>• XST team approach to coordinate complete design team.<br>• APS scientists and user community brings new and interesting science.<br>• Global controls community shows how to implement new technologies. | • Competition for scarce resources.<br>• Some new technologies need deep knowledge & expertise.<br>• Existing technologies could reach end of life.<br>• Technological evolution.<br>• Without hardware roadmap, facility will make non-standard decisions. |