2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

A Practical Framework for Safe LINAC Coordinate System Standardization

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ABSTRACT

Linear accelerator (LINAC) coordinate system conventions have historically evolved heterogeneously, with vendors and institutions adopting mixed non-IEC standards. This lack of uniformity introduces complexity and latent risk, particularly in multi-site environments where identical treatment geometries may display different angles across the planning and delivery chain. We developed a structured framework for a controlled weekend conversion to IEC 61217 across two LINACs serving ~60 active patients. The transition was completed without clinical disruption, requiring ~35 hours of physics effort and ~25 hours of dosimetry work. No treatment errors or user-reported issues occurred post-implementation. Our experience demonstrates that IEC 61217 standardization can be achieved safely and efficiently, offering a reproducible framework for institutions seeking improved consistency and patient safety.

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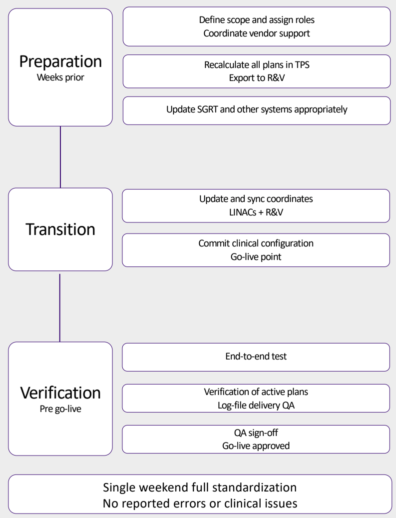
INTRODUCTION

LINAC coordinate systems govern the geometric relationship between the treatment machine, patient anatomy, and ancillary systems (e.g., TPS, R&V, SGRT). The IEC 61217[1] standard defines a unified set of coordinate systems, scale markings, and equipment movements for the full teleradiotherapy chain. However, since its original publication in 1996, adoption has remained heterogeneous, with many centers commissioned under vendor-native conventions. These legacy conventions, while internally consistent, introduce geometric ambiguity at system interfaces. This is especially consequential in multi-site settings, where identical treatment geometries may be encoded differently across the planning-to-delivery workflow, and can create latent conditions for miscommunication, complicate patient transfers, and increase training burden. AAPM TG-198[2] adopts IEC 61217 as its coordinate convention throughout, establishing it as the field's operative QA reference. Yet no published framework exists for safely converting an active clinical program to it. We report the development and execution of such a framework across a multi-LINAC program.



DISCUSSION

This work demonstrates that coordinate system conversion can be accomplished across a multi-LINAC clinical program within a single weekend and without treatment disruption. Two design decisions were central to this outcome.

First, front-loading the labor-intensive steps, including plan recalculation, naming conventions, and ancillary system updates, into the preparation phase minimized work during the transition weekend itself, reducing both time pressure and the opportunity for error at go-live. Second, distributing clearly defined tasks across the team, combined with early vendor collaboration, ensured that no single point of failure gated the conversion.

The independent verification layer proved essential to safety. Rather than relying solely on end-to-end testing, log-file delivery QA provided an automated, delivery-based check of coordinate and angular consistency. Critically, this safeguard was itself validated: by intentionally introducing a mismatched-coordinate plan, we confirmed the check would fail when it should, establishing genuine detection sensitivity rather than assumed reliability.

METHODS

A structured three-phase framework was developed for a controlled weekend conversion to IEC 61217, executed by four physicists and one dosimetrist with vendor collaboration.

Phase 1 — Preparation (weeks prior): Preparatory meetings defined conversion scope, assigned role-specific responsibilities, and coordinated vendor support. Scope explicitly included on-hold and intermittently active patients, and not only the active treatment list, to prevent post-conversion recalculation gaps. All active plans were recalculated in the TPS using the IEC 61217–compliant beam model with institution-specific naming conventions, then exported to the R&V system; the SGRT system was updated in parallel.

Phase 2 — Transition (the weekend): LINAC coordinate settings were modified and synchronized across both machines and the R&V system. The IEC 61217–configured machine was committed as the clinical configuration, marking go-live.

Phase 3 — Verification (pre–go-live): End-to-end testing spanned five workflow stages: planning, DICOM export, imaging, SGRT, and delivery. As an independent safeguard deployed for this transition, log-file-based delivery QA verified delivered-versus-planned geometry and coordinate/angle consistency. Its detection sensitivity was tested with a deliberate mismatched-coordinate plan as a positive control. Clinical go-live followed successful QA sign-off.

RESULTS

The transition was completed across two LINACs serving approximately 60 active patients over a single weekend, with no interruption to the clinical treatment schedule. All active patient plans were successfully recalculated and verified under the IEC 61217 configuration prior to go-live.

Total effort comprised approximately 35 hours of physics work, 25 hours of dosimetry, and 3 hours of engineering/R&V support, for a combined ~63 person-hours. The majority of this effort was concentrated in the preparation phase, consistent with the framework's front-loaded design; the transition weekend itself required substantially less active labor, reflecting the value of completing plan recalculation and system updates in advance.

End-to-end testing confirmed correct coordinate handling across all five workflow stages: planning, DICOM export, imaging, SGRT, and treatment delivery.

The independent log-file delivery QA performed as designed: when a deliberately mismatched-coordinate plan was introduced as a positive control, the system correctly identified the discrepancy, confirming that the safeguard had genuine detection sensitivity rather than assumed reliability. No coordinate errors were detected in any clinical patient plan.

Following go-live, no treatment errors or user-reported issues were identified during subsequent clinical operation. One canceled patient's pre-conversion plan required recalculation upon their return to treatment; the discrepancy was identified and resolved before delivery, with no patient impact.

CONCLUSIONS

Coordinate system standardization eliminates a source of geometric ambiguity that many centers have tolerated by default since initial commissioning, and our experience demonstrates it can be done safely, efficiently, and without disrupting an active clinical program. The keys were front-loaded preparation, distributed team accountability, and an independently validated verification layer. A key scoping lesson also emerged: conversion scope should encompass on-hold, canceled, and intermittently active plans, not only the active treatment list. in our experience, one canceled patient's pre-conversion plan required recalculation upon their return, and was caught before treatment with no patient impact. This phased framework scales to programs of varying size, vendor composition, and clinical complexity. Institutions operating under legacy conventions, particularly those expanding into multi-site networks or integrating new delivery platforms, are encouraged to adopt it as a starting point for achieving full IEC 61217 compliance.

REFERENCES

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