# Workflow Automation and Optimization In VMAT Treatment Planning for Cervical Cancer with Simultaneous Integrated Boost Via Scripting In a Radiotherapy Center In a Middle Income Country

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## ABSTRACT

**Purpose:** To develop and implement an Eclipse Scripting API (ESAPI) tool that automates repetitive setup tasks in VMAT treatment planning for cervical cancer (CaCU) with simultaneous integrated boost (SIB) at INCAN.
**Methods:** The institutional manual workflow was translated into modular C# scripts for optimization structures, plan and beam parameter setup, RapidPlan DVH estimation, VMAT optimization, and final dose calculation. The modules were integrated into a WPF interface using the Model–View–ViewModel pattern.
**Evaluation:** Six retrospective CaCU SIB cases were replanned with AutoPlan and compared with six institutional manual plans. Endpoints included field geometry, clinical-goal status, DVH behavior, monitor units, and active setup time.
**Main finding:** AutoPlan generated complete initial plans with comparable dosimetric behavior and reduced active setup time from 25–30 min to about 1 min 29 s. The output is intended as a standardized starting point for clinical review, not as automatic approval.

## AUTOMATED STAGES

1. Verify selected patient, course, structure set, and prescription inputs.
2. Generate auxiliary optimization structures following institutional naming rules.
3. Create VMAT plan geometry, treatment arcs, isocenter configuration, and image field.
4. Estimate DVH objectives with RapidPlan, optimize VMAT fluence, and calculate final dose.

## KEY CONTRIBUTIONS

- ESAPI-based automation for CaCU SIB VMAT planning in Eclipse.
- Modular workflow: structures → plan setup → RapidPlan → optimization and dose.
- WPF interface enabling independent module execution or full AutoPlan execution.
- Tested on six retrospective patients, including one- and two-isocenter cases and two- or three-dose-level prescriptions.
- Emphasis on reproducible setup; final clinical review remains mandatory.

## CONTACT

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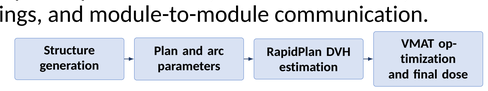
## INTRODUCTION

**Clinical problem.** Cervical cancer radiotherapy requires adequate dose delivery to pelvic target volumes and boost regions while limiting dose to bladder, rectum, bowel bag, kidneys, femoral heads, bone marrow, and spinal cord.
**Planning challenge.** VMAT with SIB combines inverse optimization, arc geometry, one- or two-isocenter selection, dose prescription, calculation models, and RapidPlan objectives. These steps are clinically standardized, but many of them are repetitive and sensitive to nomenclature or setup inconsistencies.
**Automation rationale.** ESAPI allows scripted access to Eclipse treatment-planning objects, enabling reproducible creation of auxiliary structures, beam geometry, prescription settings, DVH estimation, optimization, and final dose calculation.
**Objective.** Automate the reproducible plan setup stages so the planner can spend more time on DVH review, dose distribution assessment, and clinically meaningful optimization decisions.
**Scope of the tool.**

- Standardizes nomenclature and selected planning parameters.
- Reduces repetitive mouse-driven configuration in Eclipse.
- Preserves clinical review: dose distribution, DVH, and goals remain evaluated by the planning team.

## METHODS AND MATERIALS

**Study design.** Retrospective comparison of 12 VMAT plans: six institutional manual plans and six AutoPlan-generated plans for CaCU with SIB.
**Cases.** The evaluated series included prescriptions of 45/55 Gy, 45/57.5 Gy, and 45/55/57.5 Gy. Five patients used double-isocenter geometry and one patient used a single isocenter.
**Implementation.** The tool was written in C# using ESAPI and integrated as a WPF graphical interface. Shared XML/settings parameters preserved consistent nomenclature, prescription choices, isocenter selection, machine settings, and module-to-module communication.




**Preserved clinical logic.** Plan creation followed institutional rules for PTV selection, auxiliary optimization structures, Halcyon VMAT arc setup, daily image field creation, AAA dose calculation, and RapidPlan model-based objective estimation.
**Evaluation endpoints.** Field configuration, clinical-goal status, detailed patient-3 DVH and clinical metrics, treatment monitor units, and active setup time.
**Script outputs.** The automated sequence created a complete Eclipse plan with treatment arcs, setup imaging, prescription information, calculated dose, and optimization goals ready for clinical review.
**Quality boundary.** The workflow reduces setup variability but does not replace patient-specific QA, physician approval, or physics review.

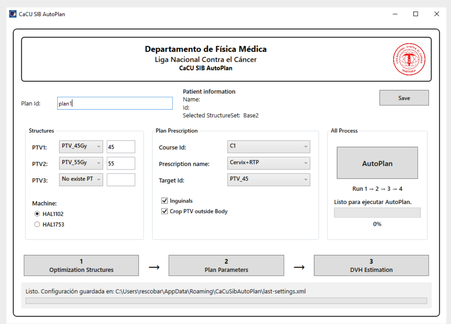



**Figure 1.** WPF interface for modular and sequential AutoPlan execution.

## RESULTS

AutoPlan produced complete VMAT plans for all six evaluated cases without manual field-by-field construction. Across the series, the automated workflow generated three more green goals and four fewer yellow goals than manual planning, with one additional red goal.

| +3 | -3.8% | 94–95% |
|---|---|---|
| additional green clinical goals | mean treatment MU reduction | active setup time reduction |

Patient 3 showed the strongest relative clinical-goal improvement: red goals decreased from 2 to 0 and green goals increased from 17 to 19. Four of six AutoPlan cases used fewer treatment monitor units than their manual counterparts.

**Table 1.** Global comparison between institutional manual plans and AutoPlan.

| Metric | Manual | AutoPlan | Change |
|---|---|---|---|
| Evaluated plans | 6 | 6 | 12 total |
| Clinical goals: green | 100 | 103 | +3 |
| Clinical goals: yellow | 33 | 29 | -4 |
| Clinical goals: red | 14 | 15 | +1 |
| Mean treatment MU | 1026.8 | 987.6 | -39.1 (-3.8%) |
| Active setup time | 25–30 min | 1 min 29 s | 94–95% reduction |
| Cases with lower MU | – | 4/6 | no systematic MU increase |

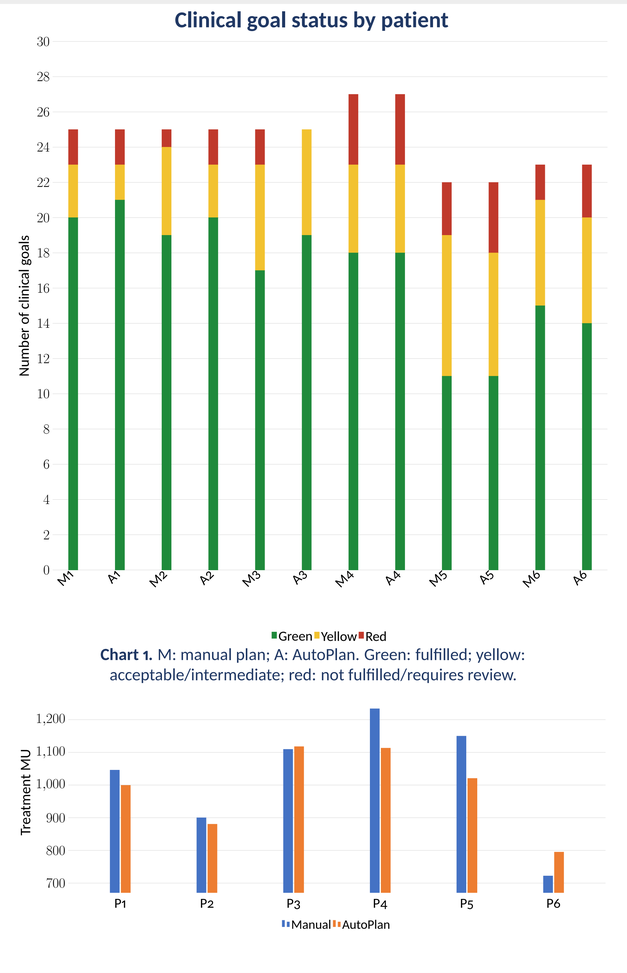



**Chart 1.** M: manual plan; A: AutoPlan. Green: fulfilled; yellow: acceptable/intermediate; red: not fulfilled/requires review.

**Figure 2.** Clinical goals and monitor units comparison.

## DISCUSSION

AutoPlan did not simply copy the manual beam geometry; it constructed the plan from scripted rules. In patient 3, for example, the manual plan used four arcs and AutoPlan generated five arcs, while treatment MU remained almost equivalent (+0.7%).
The clinical-goal analysis was mixed but favorable for an initial automated plan. The tool increased the total number of green goals, reduced yellow goals, and maintained monitor units within a clinically comparable range. The additional red goal in the global summary indicates that automated planning still requires planner review and local clinical judgment.
Patient 3 illustrates the potential of the workflow: AutoPlan preserved target coverage, reduced hot-spot metrics in `PTV_45Gy` and `PTV_55Gy`, lowered `Bone_Marrow` mean dose by 1.82 Gy, reduced `Bowel_Bag` $V_{46\,\mathrm{Gy}}$ by 7.346 cm$^3$, and improved femoral head metrics.

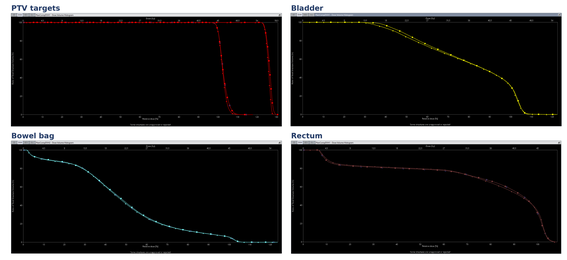



**Figure 3.** Patient-3 DVH comparison for targets and selected organs at risk.
Source: Eclipse, Varian Medical Systems

**Interpretation.** The main benefit is workflow standardization: the script rapidly creates a clinically familiar plan setup, after which the dosimetrist can focus on optimization trade-offs rather than repetitive configuration.
**Limitations.** The series is retrospective and small; results depend on structure quality, correct input selection, institutional naming, and the RapidPlan model. Expanded validation is required before routine clinical deployment.

## CONCLUSIONS

**AutoPlan automated the repetitive configuration stages of VMAT planning for CaCU with SIB and generated complete initial plans for all six retrospective cases.**

- The automated plans were dosimetrically comparable to institutional manual plans, with a slight increase in green goals and a modest mean MU reduction.
- Active setup time decreased from approximately 25–30 min to 89 s, shifting planner effort toward plan review, and clinical decision-making.
- The workflow supports one- and two-isocenter scenarios and two- or three-level SIB prescriptions used in the institutional CaCU workflow.
- The tool should be used as a standardized starting point, not as automatic clinical approval; final validation must include physician, dosimetrist, and physicist review.
- Future work should expand validation and tune RapidPlan/optimization priorities for kidneys, rectum, bowel bag, bone marrow, and spinal cord.

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