"That's Not Achievable": Evaluation of a Commercial Pre-Plan Feasibility Tool Using TG-218 & TG-219 QA Metrics

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

PURPOSE

To evaluate whether commercial feasibility tools can predict treatment plan achievability and performance against TG-218–recommended measurement-based IMRT QA criteria and TG-219 secondary dose calculation agreement.

Fig. 1 Schematic diagram showing the necessary inputs needed for Sun Nuclear's Pre-Plan Feasibility & Plan AI tools. Once run, the feasibility tool can inform the team of any suggested planning goal modifications before planning and Plan AI can provide both planning goal modification and criteria to export back to the treatment planning system (TPS)

MATERIALS

- Pre-Plan Feasibility: Uses geometry-based analysis of the spatial relationship between the target and surrounding organs at risk to estimate the best possible dose sparing before optimization, independent of the treatment planning system or delivery technique
  - Dependent on Physics & Geometry
  - Assumes 100% target coverage
- Plan AI: uses AI trained on high-quality clinical treatment plans to automatically generate patient-specific optimization objectives and planning strategies that guide the treatment planning system toward clinically achievable plans with minimal manual intervention
  - Dependent on Physics, Geometry and incorporates previous clinical trade-offs through machine learning
  - Does not assume 100% target coverage
  - May have biases based on plans used for model
  - Needs a model for each treatment site

METHODS

- Retrospectively selected clinical IMRT/VMAT plans were evaluated
  - Eight of ten demonstrated either failure to meet TG-218 action limits for measurement-based QA or disagreement exceeding institutional TG-219 tolerances for 3D secondary dose calculation
  - 2 plans were selected because they passed all patient-specific QA
- Plans were analyzed using Sun Nuclear Corp. software: Pre-Plan Feasibility, Plan AI, DoseCHECK, and SNC Patient/3DVH
- Pre-Plan Feasibility and Plan AI results were compared with physician-assigned planning objectives and achieved plan metrics
- Target coverage and OAR goal agreement were evaluated using 3D gamma-based dose comparison and volumetric CTV agreement.
  - Plans evaluated in SunCHECK DoseCHECK, Fraction0, SNC Patient, and 3DVH

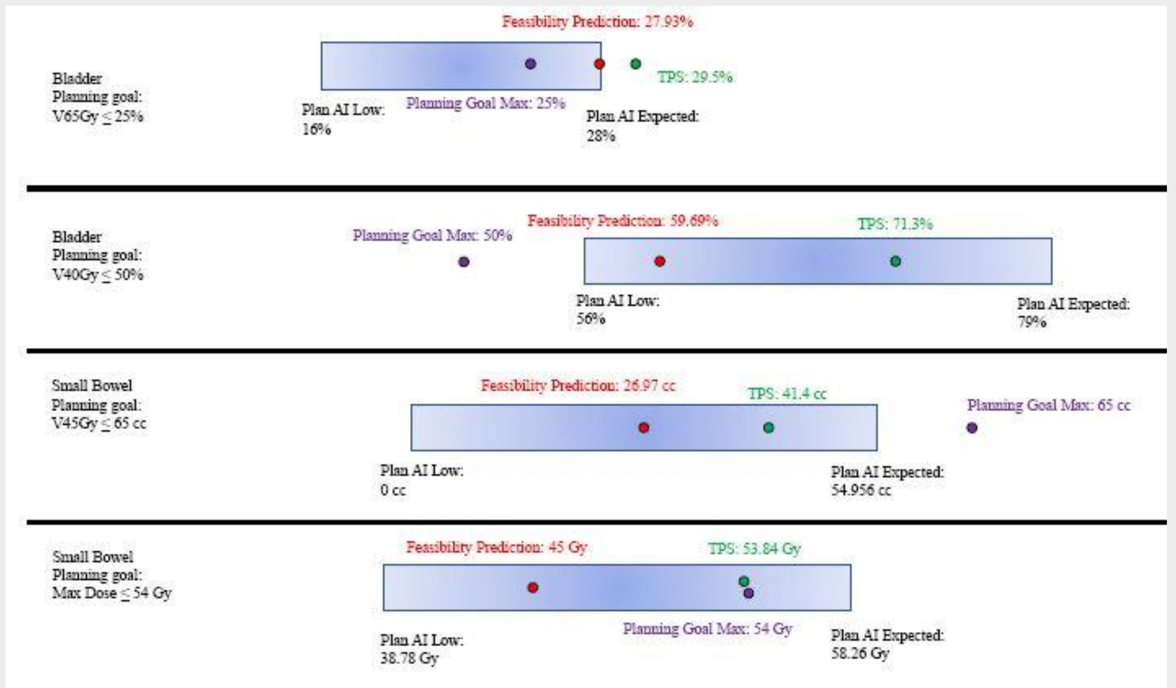

Fig. 3 Example of Pre-Plan Feasibility (red) and Plan AI (Blue range) vs. planning goal (purple) vs. achieved (green) results for one patient. Bladder planning goals were more restrictive than the feasibility and achieved TPS results. This resulted in an over modulated plan that went on to fail PSQA

DISCUSSION

Our results demonstrate that Pre-Plan Feasibility and Plan AI alerts are not merely advisory but are clinically meaningful predictors of both optimization difficulty and QA failure (See Figs. 2, 3). Most plans with objectives aligned with Pre-Plan Feasibility and Plan AI predictions met clinical goals with lower modulation and consistently satisfied TG-218 and TG-219 criteria, whereas plans with objectives exceeding feasibility predictions failed at least one TG-218 QA metric and frequently showed reduced agreement with secondary dose calculations. Two plans were not flagged with Pre-Plan Feasibility concerns but had discrepancies on secondary or measurement QA. One was a lung with significant tissue heterogeneity variation and the other was an SIB with a sequential boost, which was flagged by Plan AI. Further work is needed to investigate those cases, but both indicated issues with target coverage, so it is likely that Pre-Plan Feasibility may be challenged by the assumption of 100% coverage. Additionally, Plan AI does not have a HAWB model, so those plans were not able to be analyzed in that software.

These findings suggest that incorporating Pre-Plan Feasibility analysis before optimization can prevent pursuit of anatomically unrealistic goals. Incorporating this with Plan AI has the potential to reduce over-modulation and undeliverable plans, and decrease late-stage QA-driven revisions. By shifting feasibility assessments upstream in the planning process, this approach has the potential to improve planning efficiency, shorten time to treatment, and increase patient access without compromising plan quality or safety.

Plan	Feasibility	PlanAI	TPS OAR Reults	Secondary Check QA: Did OAR's meet Planning Goals?	Secondary Check QA: CTV Gamma Comparison [2%/2mm]	Secondary Check QA: Gamma Comparison to TPS with Daily Correction Factor [3%/2mm]	Measurement QA: Gamma Comparison to Secondary Check Dose [3%/2mm]	Measurement QA: Did OAR's meet Planning Goals?
Prostate	Green	Green	Green	Green	Green	Green	Green	Green
Lung	Green	Green	Green	Green	Red	Green	Green	Green
Anus	Yellow	Red	Green	Green	Green	Green	Green	Green
HAWB	Yellow	No Model	Green	Green	Yellow	Green	Green	Green
HAWB	Yellow	No Model	Green	Green	Yellow	Green	Green	Green
Prostate	Green	Yellow	Yellow	Green	Yellow	Yellow	Yellow	Green
Prostate	Red	Red	Red	Red	Green	Yellow	Yellow	Red
H&N	Red	Yellow	Red	Red	Red	Green	Green	Red
HAWB	Red	No Model	Yellow	Green	Yellow	Yellow	Green	Green
HAWB	Red	No Model	Red	Red	Yellow	Yellow	Green	Green
Key (Green)	Goal > Predicted Feasibility	Goal within or greater than range	Goals All Met	Goals All Met	>95 % agreement	>95 % agreement	>95 % agreement	Goals All Met
Key (Yellow)	Goal ≤ Predicted Feasibility	Goal Low end of range	Goals Met but High Dose Optimization criteria needed		>90%, <95 % agreement	>90%, <95 % agreement	>90%, <95 % agreement	
Key (Red)	Goal < 50% Predicted Feasibility	Goal below range	Goals Not Met	Goals Not Met	<90 % agreement	<90 % agreement	<90 % agreement	Goals Not Met

Fig. 2 Each column represents a QA check in the planning process. Colors are defined by the key and indicate whether a plan passed a particular check in the process using institutional criteria informed by TG-218 and TG-219.
Note: OAR = Organ at Risk, TPS = Treatment Planning System

RESULTS

- Seven of ten plans were **flagged for OAR feasibility concerns** (See Fig. 2), 4 were flagged in Plan AI (4 could not be analyzed due to lack of model for HAWB)
  - Three plans had planning objectives consistent with feasibility predictions
  - Four plans contained planning objectives exceeding feasibility predictions by >50%
- Plans with objectives aligned with feasibility predictions met clinical goals without excessive modulation, satisfied TG-218 measurement-based QA action levels and demonstrated >90% CTV agreement with TG-219–based secondary dose calculations at a 2%/2 mm gamma criteria (all but one)
- All plans with objectives exceeding feasibility predictions either required increased modulation to meet goals or failed to meet planning objectives
- One plan was flagged with Plan AI but not with Pre-Plan Feasiblity, suggesting that Plan AI may be able to predict potential issues resulting in target coverage concerns more so than Feasibility.

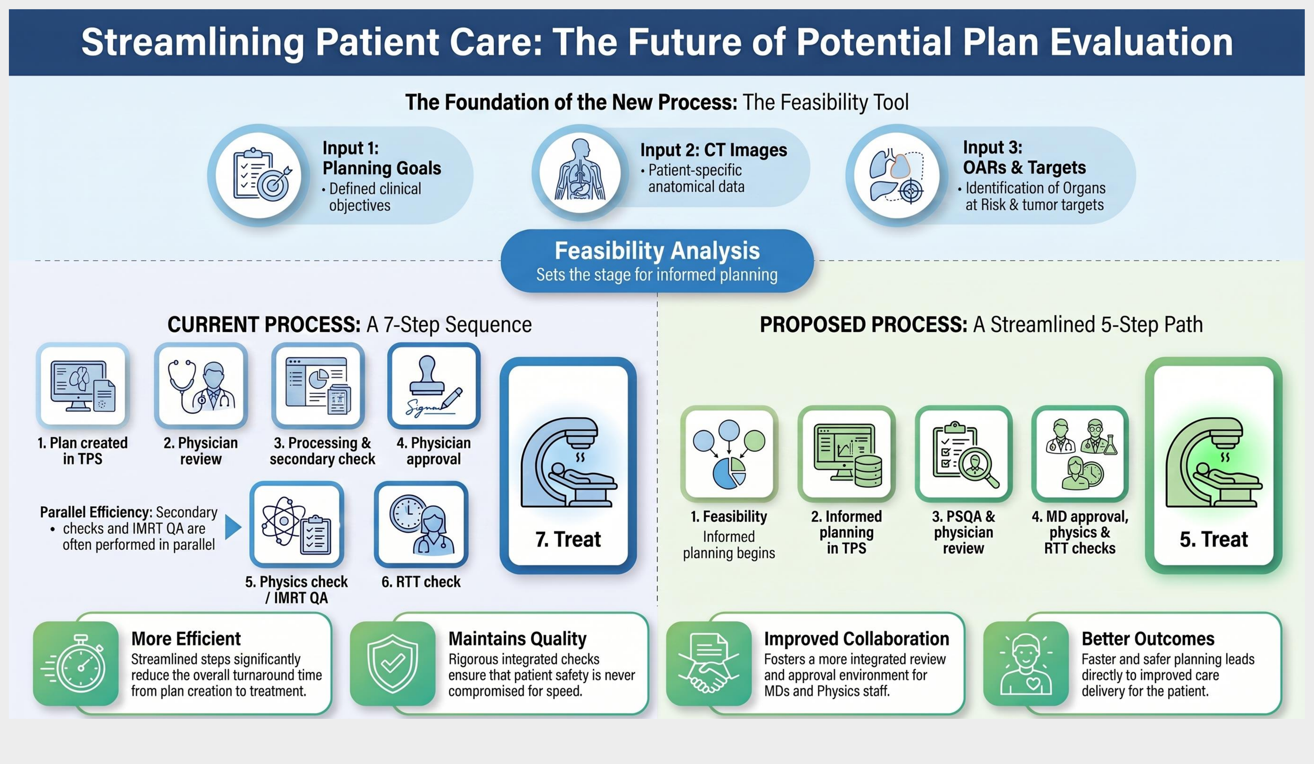

Fig. 4 Schematic showing a proposed new IMRT work-flow incorporating the feasibility tool. The benefit of using the feasibility tool is to prevent PSQA failures that would result in re-planning, thus improving planning efficiency.

CONCLUSIONS

- Pre-plan Feasibility and Plan AI predictions correlated with both TG-218 measurement-based QA performance and TG-219 secondary dose calculation agreement.
- Incorporation of feasibility analysis **prior to optimization** may reduce unnecessary plan modulation, improve planning efficiency, and decrease late-stage QA-driven plan revisions (See Fig. 4).
- Future work will look at best methods for combining Pre-Plan Feasibility and Plan AI to best improve planning efficiency and results

REFERENCES

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