

Plan2Plan:

Using ESAPI to Automate the Plan Checking of Copied Brachytherapy Plans

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Purpose

In brachytherapy, it is common for the same plan to be used for multiple fractions (e.g. 26Gy/2# Prostate Monotherapy); this requires a plan to be copied. It is then possible for a plan to be inadvertently edited, without changing the f2 copy. To mitigate the possibility of this error, plan checkers would manually compare plans, which would contain roughly 20 catheters, each with many dwell positions.

In response to a near-miss incident, commissioning of in-house software was necessary to improve checking efficiency and patient safety.

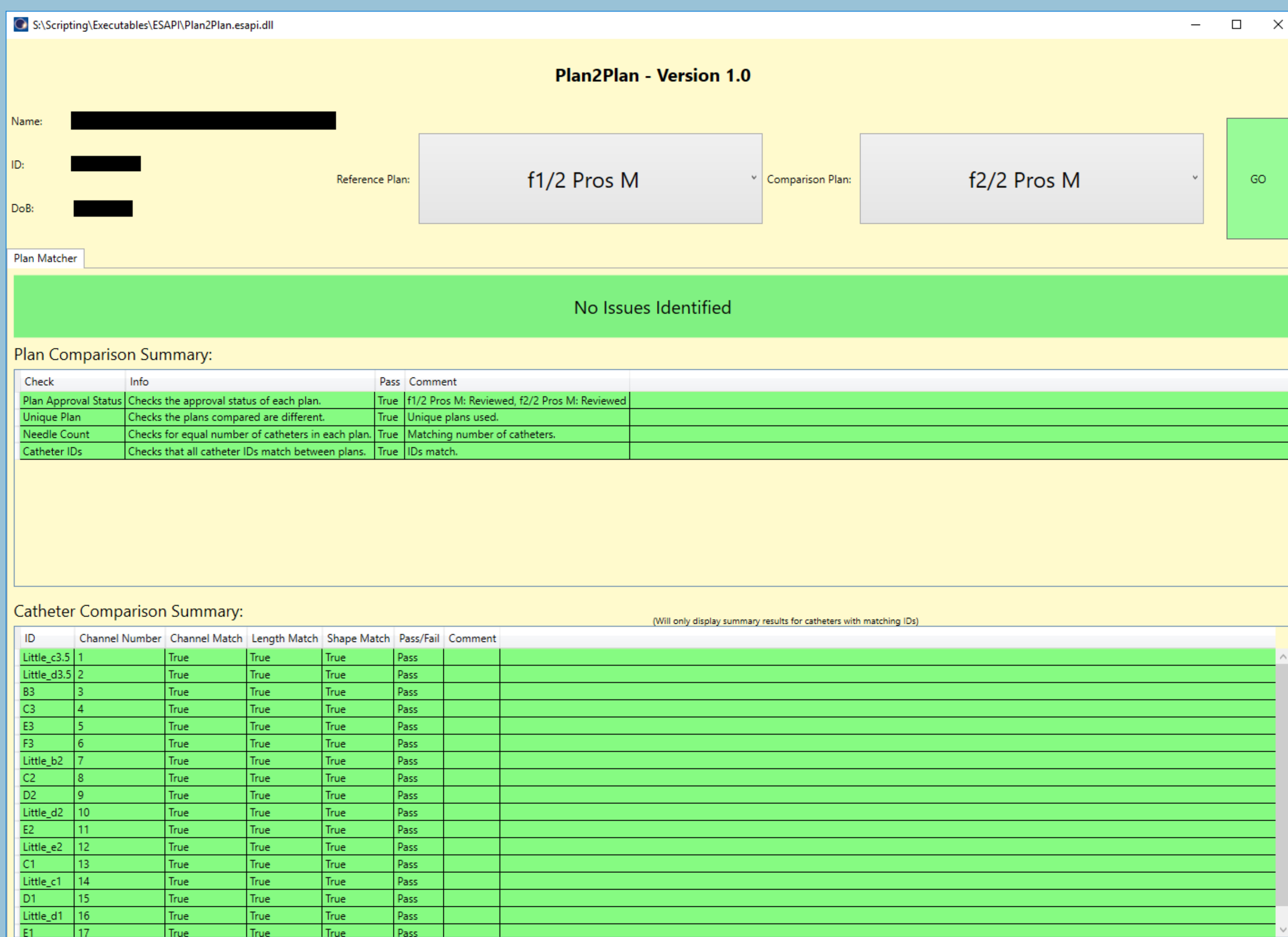
Using ESAPI (Eclipse Scripting API), a binary plug-in application was created that runs within BrachyVision to directly compare two plans and their associated objects. Using this application at the plan approval stage indicates to the checker whether the plans are matching in all aspects, or whether changes have been made to the catheters.

Method

The application was created using ESAPI and C#. By running as a binary in BrachyVision, plan data are directly referenced, avoiding rounding error in positional vectors. The reference plan and comparison plan are registered as dictionaries, containing catheter numbers, channel numbers, catheter node positions and dwells. The script loops iteratively over each matching catheter, comparing geometries and properties.

Overall checks are also performed, confirming both plans have been signed and that the correct number codes have been assigned. The Graphical User Interface (GUI) provides visual, traffic-light feedback, indicating which catheters are causing errors.

Test patients with induced errors were used to show the validity of the app, focusing on removing false positive results from the dataset through confusion matrix testing.



Plan2Plan - Version 1.0

Name: [Redacted]
ID: [Redacted]
DOB: [Redacted]

Reference Plan: f1/2 Pros M
Comparison Plan: f2/2 Pros M
GO

Plan Matcher

No Issues Identified

Plan Comparison Summary:

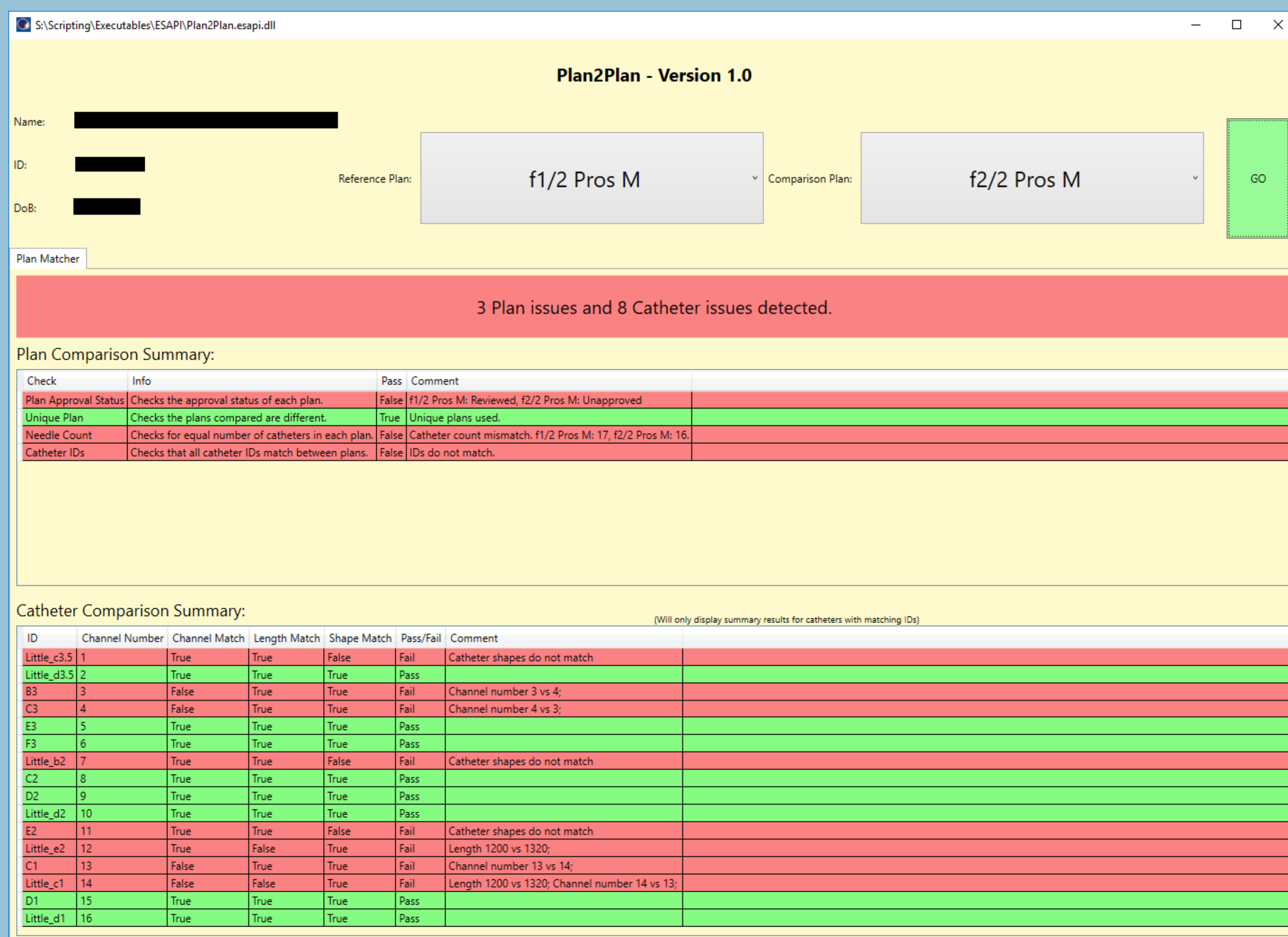
Check	Info	Pass	Comment
Plan Approval Status	Checks the approval status of each plan.	True	f1/2 Pros M: Reviewed, f2/2 Pros M: Reviewed
Unique Plan	Checks the plans compared are different.	True	Unique plans used.
Needle Count	Checks for equal number of catheters in each plan.	True	Matching number of catheters.
Catheter IDs	Checks that all catheter IDs match between plans.	True	IDs match.

Catheter Comparison Summary:

(Will only display summary results for catheters with matching IDs)

ID	Channel Number	Channel Match	Length Match	Shape Match	Pass/Fail	Comment
Little_c3.5	1	True	True	True	Pass	
Little_d3.5	2	True	True	True	Pass	
B3	3	True	True	True	Pass	
C3	4	True	True	True	Pass	
B3	5	True	True	True	Pass	
F3	6	True	True	True	Pass	
Little_b2	7	True	True	True	Pass	
C2	8	True	True	True	Pass	
D2	9	True	True	True	Pass	
Little_d2	10	True	True	True	Pass	
B2	11	True	True	True	Pass	
Little_e2	12	True	True	True	Pass	
C1	13	True	True	True	Pass	
Little_c1	14	True	True	True	Pass	
D1	15	True	True	True	Pass	
Little_d1	16	True	True	True	Pass	
B1	17	True	True	True	Pass	

Figure 1 - Example of Plan2Plan with identical, correctly copied plans.



Plan2Plan - Version 1.0

Name: [Redacted]
ID: [Redacted]
DOB: [Redacted]

Reference Plan: f1/2 Pros M
Comparison Plan: f2/2 Pros M
GO

Plan Matcher

3 Plan issues and 8 Catheter issues detected.

Plan Comparison Summary:

Check	Info	Pass	Comment
Plan Approval Status	Checks the approval status of each plan.	False	f1/2 Pros M: Reviewed, f2/2 Pros M: Unapproved
Unique Plan	Checks the plans compared are different.	True	Unique plans used.
Needle Count	Checks for equal number of catheters in each plan.	False	Catheter count mismatch: f1/2 Pros M: 17, f2/2 Pros M: 16
Catheter IDs	Checks that all catheter IDs match between plans.	False	IDs do not match.

Catheter Comparison Summary:

(Will only display summary results for catheters with matching IDs)

ID	Channel Number	Channel Match	Length Match	Shape Match	Pass/Fail	Comment
Little_c3.5	1	True	True	False	Fail	Catheter shapes do not match
Little_d3.5	2	True	True	True	Pass	
B3	3	False	True	True	Fail	Channel number 3 vs 4;
C3	4	False	True	True	Fail	Channel number 4 vs 5;
F3	5	True	True	True	Pass	
F3	6	True	True	True	Pass	
Little_b2	7	True	True	False	Fail	Catheter shapes do not match
C2	8	True	True	True	Pass	
D2	9	True	True	True	Pass	
Little_d2	10	True	True	True	Pass	
B2	11	True	True	False	Fail	Catheter shapes do not match
Little_e2	12	True	False	True	Fail	Length 1200 vs 1320;
C1	13	False	True	True	Fail	Channel number 13 vs 14;
Little_c1	14	False	False	True	Fail	Length 1200 vs 1320; Channel number 14 vs 13;
D1	15	True	True	True	Pass	
Little_d1	16	True	True	True	Pass	

Figure 2 - Example of Plan2Plan with induced errors, including geometric shifts, channel length changes and channel number changes..

Results

The Plan2Plan software was successfully deployed within the clinical work system and is quickly available for BrachyVision users. During commissioning, the detection rate was 100% for deliberately induced errors, without any false-negatives. The GUI provides immediate feedback through the comparison table, quickly alerting the user to the failing catheters.

This script reduces the operational time in plan checking, while improving patient safety by removing human error.

Conclusion

The development and implementation of the Plan2Plan ESAPI tool has effectively improved the safety of the plan checking process and removed a vulnerability in the brachytherapy planning workflow. The automation of this check removes human error and increases the speed of plan checking in multi-fraction treatments.

Plan2Plan is a good example of utilising novel technology to improve the brachytherapy workflow with bespoke solutions.

Future Work

- Use Plan2Plan to verify catheter reconstruction from a "Tracking" plan for additional certainty during planning.
- Integrating further plan checks into Plan2Plan.
- Continuing ESAPI scripting to further improve efficiency and aid in automation in the brachytherapy workflow.