

Script-Aided Automated TPS Testing

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07/30/2018



Outline

- Motivation of automation and standardization of TPS testing
- General concept and proposed approach
- Introduction of automated commissioning tests suite (ACTS)
- Conclusions



Background—TPS Commissioning and QA

Conventional concept of TPS commissioning and QA (TG106, TG53, MPPG 5.a)

- Machine configuration in TPS
- Beam modeling in TPS
- TPS functionality test
- Planning and dose calculation
- End to end test
- Routine TPS QA

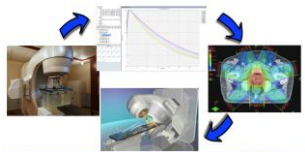


Image courtesy Dr. Amy Wheeler



Background—issues with conventional process

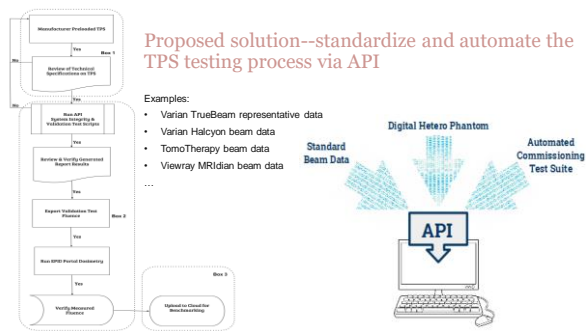
- Error prone process
- ❖ WHO report (3125 radiation incidences 1976-2007 and 24% incidences are related to commissioning errors)
- ❖ IROC report 2013 and 2016
 - 30% failed the +/- 5% criteria (2013)
 - 23% failed the +/- 5% criteria (2016)
- Reason: Errors in beam data input; Inadequate MLC modeling; Inadequate beam modeling
- Labor intensive and time consuming
- Lack of standardization and benchmarking



Table 1. Institutional percentage pass rates for overall and individual criteria

Criteria	Overall pass ^a	TLD pass	Quanta pass ^b
7% TLD, 7% ± 0.5 mm	90 ± 2	93 ± 2	92 ± 2
9% TLD, 7% ± 0.5 mm	77 ± 1	80 ± 1	78 ± 2
9% TLD, 9% ± 0.5 mm	70 ± 4	80 ± 3	74 ± 1
9% TLD, 9% ± 0.5 mm	65 ± 4	87 ± 4	76 ± 2
9% TLD, 9% ± 0.7 mm	37 ± 4	89 ± 4	81 ± 4

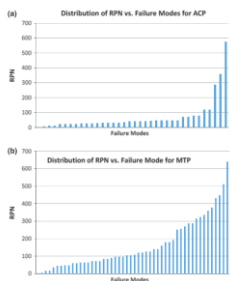
Med Phys. 2016 Dec;43(12):6491.



Risk analysis Manual vs Auto process

- A digital phantom and corresponding automated tests that can be readily used for commissioning, benchmarking, and continued testing is a valuable tool for an RT department.
- The prospective FME A methodology applied to the proposed automated TPS commissioning test suite suggest that errors will be reduced as a result of fewer potential failure modes.

	# of Failure Modes	RPN _{man}	RPN _{auto}
Manual Test Procedure	47	151	640
Automated Commissioning Process	36	73	576



Med Phys. 2017 Sep;44(9):4415-4425. doi: 10.1002/imp.12278



Automated and standardized TPS testing suite

Aim: To develop a software platform

which:

- Automate the testing process with API
- Standardize the test and expectations for test results
- Reduce the subjectivity of the TPS commissioning and QA process
- Output test results to an easily readable format allowing for benchmarking

Approaches: Follow MPPG5.a & TG53 and automate/standardize as many tests as possible.

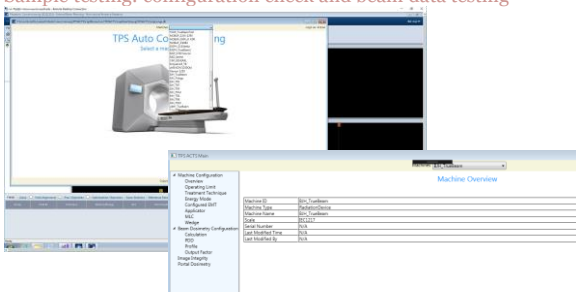
Sample: Automated Commissioning Tests Suite (ACTS)

- Treatment machine and beam modeling check
- Image dataset and digital phantom integrity check
- Radiation plan dosimetry check
- Plan specific quality assurance

Washington University School of Medicine in St. Louis

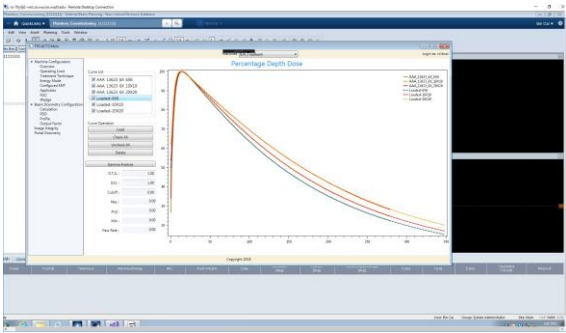
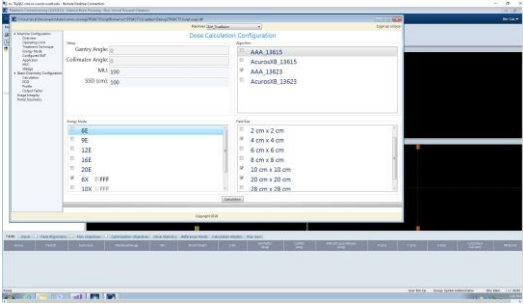
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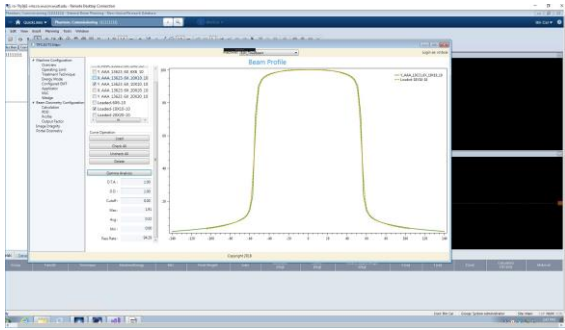
Sample testing: configuration check and beam data testing



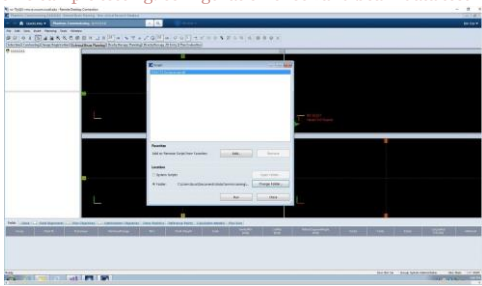
Parameter Name	Parameter Value	Minimum	Maximum	Limit Function
Technique	Technique	1	1	0
Source-to-Surface Distance (SSD)	100	95	105	0
Energy	6	20	20	0
Beam-on Time	1	0.001	99.999	0
Machine Head Position	0	-10	10	0
Machine Bed Position	0	-10	10	0
Machine Gantry Angle	0	175	175	0
Machine Collimator Angle	0	0	360	0
Machine Couch X Position	0	-65	65	0
Machine Couch Y Position	0	-65	65	0
Machine Couch Z Position	0	-65	65	0
Machine Table Height	0	0	0	0
Machine Table Roll	0	0	0	0
Machine Table Pitch	0	0	0	0
Machine Table X Position	0	0	0	0
Machine Table Y Position	0	0	0	0
Machine Table Z Position	0	0	0	0
Machine Table Roll	0	0	0	0
Machine Table Pitch	0	0	0	0
Machine Table X Position	0	0	0	0
Machine Table Y Position	0	0	0	0
Machine Table Z Position	0	0	0	0

Sample testing: configuration check and beam data testing



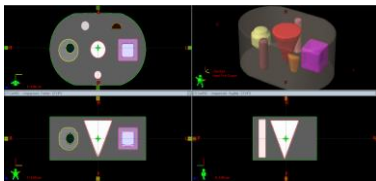


Demo sample testing: configuration check and beam data testing



Sample testing: image integrity check with digital phantom

- Imported pre-designed images and structure set
- Measurement on dataset to determined the integrity
- Point HU, HU intensity profile, volume, dimension, orientation



Sample testing: plan dosimetry check

- Auto-planning script to generate pre-defined 3D and IMRT plans
- Dose information are checked (point dose, DVH,3D dose)



Analysis, report and benchmarking

- Analysis:
 - Automated comparison with baseline or reference data
 - Least human involvement
 - Quantifiable results
- Report:
 - Color-coded pass or fail
 - Exportable data (as baseline) for future routine or incidental QA
- Benchmarking:
 - Data and results can be uploaded to a central location (via cloud) for benchmarking with data from other centers

Conclusions

- The conventional TPS commissioning and testing approaches are often error-prone, labor-intensive and time-consuming.
- Automated TPS testing have advantages to reduce risks based on FMEA analysis.
- An automated test suite (ACTS) is designed and sample TPS tests are implemented as feasibility study.
- Future work focuses on the full implementation of a comprehensive TPS testing based on MPPG5.a.



Acknowledgements

- WashU Team
- Sasa Mutic
- Bin Cai
- Bruce Gu
- Douglas Caruthers
- Amy Wexler (U Missouri)
- Murty Goddu
- Jason LaBrash
- Varian support
- Wayne Keranen
- Keith Stinson
- Dezhi Liu
- Bruno Canamasas





Thank you !

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