Automation in Treatment Planning QA
Toward Self-driving Patient Care

Kelly C Younge PhD, DABR
Physics chart review effectiveness

- The physics plan check has the potential to be one of the most effective checks

Physics chart review effectiveness

- Processes that rely on human intervention are inherently less effective

Automated Plan Checking in Radiotherapy

- Automation and safety barriers are the most effective safety methods for reducing errors (SINA, 2012)
- Specific aspects of the physics plan evaluation are ideally suited for such automation
- Already investigated / implemented by many institutions

Background and history of Plan Checker Tool

• 2013, In-house → Commercial planning system
  – Track errors via in-house incident learning system
  – Gathered information on treatment unit delays
    • Hand-offs, interruptions and non-standard work can lead to problems
    • Prescription mismatches, missing imaging fields, incorrect field names
Dosimetry and Physics Check Elements

- Is the site correct? Laterality?
- Are the documents approved?
- Any mistakes / omissions on the planning directive?
- OARs correct? Approved? Any missing? Stray points?
- Margins correct?
- ITV needed? Correct and documented?
- Correct dataset used? Named correctly?
- Registration required? Is there more than one? Was it used appropriately?
- Is the imaging good enough for what is needed?
- Orientation documented correctly?
- Has the patient had previous treatment? Reports uploaded into documentation?
- Is a physics consult needed? How about reference images?
- Did SBRT rounds get completed?
- Anything on the directive not make sense?
- Does the plan meet the physician-defined planning goals?
- Could the plan be improved with a different geometry / modality?
- Is the dose prescription correct?
- Is the course named correctly? How about the plan?

Plan normalization ok?
- Calculation model correct? How about the calculation resolution?
- Fields named correctly? In the right order? Shaped correctly?
- EDW used appropriately?
- How about FiF? Does the unmerged plan match the merged plan? Are the MU correct? Enough time to complete the field?
- Does the Mobius document correctly reflect the segments?
- Appropriate energy used?

- Is the optimization designed to meet the SBRT goals?
- Is the planning process correct? Is the calculation right order? Right field? Right dose?
- Is the log/sum file correct? Is it ready for EDW?
- Does the plan have a cutout? Is it the correct size? Was the right applicator used? Does it have the correct code?
- Were the optimization objectives designed correctly?
- Optimized with the correct resolution?
- All the field dose rates correct?
- Tolerance tables added and correct?
- Plan scheduling completed? Are the imaging templates attached?
- Has the plan been reviewed by the physician? Planning approved? Clinical consultant?

- Is the plan linked to it?
- Do the patients have DRRs? Are they the right size?
- Do they match anatomy?
- In the right direction? What about the angle of the SSD?
- Correct labelling VM, IM, FiF, SB structures? Clearance? Did it have a clearance?
- Does the patient have a CIED? Are the questionnaires done?
- Is the carepath correct?
- Should the plan be treatment approved? Did I remember to do this?
- Do I need to follow up on anything after QA?

Is this the best treatment plan?
What about the physics?
Background and history of Plan Checker Tool

• Used data from treatment units and incident learning system to identify QA elements for automatic, semi-automatic, and manual checks

• Initiated collaboration with Memorial Sloan Kettering Cancer Center in 2014

# Plan Checker Tool Interface

## Stage 1: Prior to planning

<table>
<thead>
<tr>
<th>Item</th>
<th>St.</th>
<th>Results</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check laterality and treatment site</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Verify course has ICD10 diagnosis code</td>
<td></td>
<td>![X] <a href="image">No diagnosis code attached.</a></td>
<td>This is a note.</td>
</tr>
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<td></td>
</tr>
<tr>
<td>Check dataset names against standards</td>
<td>![✓]</td>
<td>Structure Image Id: '20141120LTARM' Created on 20141120 checked.</td>
<td></td>
</tr>
<tr>
<td>Check image registration (if applicable)</td>
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<tr>
<td>Report patient orientation from CT dataset</td>
<td>![✓]</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
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## Current patient / plan

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Plan Checker Tool Interface

### Select Body Site
- Default
- SRS
- Sim on Set

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Checks organized by stages

First stage
Plan Checker Tool Interface

Functional subunits (checkers)
Plan Checker Tool Interface

Select Body Site
- Default
- SRS
- Sim on Set

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**Plan Checker Tool Interface**

Graphical depiction of results / checker status

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</tr>
<tr>
<td>Verify number of CT slices against move sheet</td>
<td>Number of CT slices in planning dataset '20141120LTARM' is '144'</td>
</tr>
<tr>
<td>Verify 3D vs IMRT Carepath</td>
<td>This is a VMAT plan but may be on a 3D carepath. Please confirm carepath is correct</td>
</tr>
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</table>
Automation considerations

• ILS-driven data is a must
• Error messaging – is it clear enough for easy / fast interpretation?
• False flags and complacency – will the user read all of the output?
• Communication with team members
## Error messaging

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<tr>
<td>Verify field names</td>
<td>Flagged</td>
<td>'CW_T90' does not follow standard naming convention.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'CW' 'CCW' follow standard naming convention.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'CW' 'CCW' 'CW_T90' are labeled with the correct direction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'kV AP' 'kV RLAT' 'CBCT' follow standard naming convention.</td>
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## Error messaging

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</tr>
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'CW_T90' should be 'CW_T45'
## False flags

| Report patient orientation from CT dataset | Image orientation: HeadFirstSupine  
Treatment orientation: HeadFirstSupine  
Automatic Checks passed |
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**Checker that consistently flagged for a subset of plans that have a correct Care Path**
Plan construction issue (163)

- Incorrect laterality / tx site (1)
- Problem with imaging (14)
- Problem with image dataset (6)
- Treatment plan unacceptable (92)
- Misc. plan quality (56)
Dosimetry and Physics Check Elements

- Is the site correct? Laterality?
- Are the documents approved?
- Any mistakes / omissions on the planning directive?
- OARs correct? Approved? Any missing? Stray points?
- Margins correct?
- ITV needed? Correct and documented?
- Correct dataset used? Named correctly?
- Registration required? Is there more than one? Was it used appropriately?
- Is the imaging good enough for what it was used for?
- Orientation documented correctly?
- Has the patient had previous treatment? Have the records been uploaded into documents?
- Is a physics consult needed? How about an NTCP consult?
- Did SBRT rounds get completed?
- Anything on the directive not make sense?
- Does the plan meet the physician-defined planning goals?
- Could the plan be improved with a different geometry / modality?
- Is the dose prescription correct?
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- Plan normalization ok?
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- Fields named correctly? In the right order? Shaped correctly?
- EDW used appropriately?
- How about FiF? Does the unmerged plan match the merged plan? Are the MU correct? Enough time to complete the field?
- Does the Mobius document correctly reflect the segments?
- Appropriate energy used?
- Is the modulation going to be ok? Do I trust the dose? Does QA have a good chance of passing? Is the field width ok? Should jaw tracking be on?
- How does the fluence look? Is it deliverable?
- Will the treatment clear? Will the imaging fields clear?
- Should it be on a different machine?
- Is different imaging needed?
- Is the origin in the right place?
- Is there more than one iso? Is that documented clearly?
- Do all the parameters in Prescribe Treatment match the plan?
- Is the reference point in the right spot? Does it have the right dose limits?
- Does the plan have bolus? Is the structure there? Is it attached to the fields? Is it attached to any fields it shouldn't be attached to? Is it documented on the setup sheet?
- Does the plan have a tray? Is it the correct one? Does it have the correct code?

- Does the plan have a cutout? Is it the correct size? Was the right applicator used? Does it have the correct code?
- Were the optimization objectives designed correctly? Optimized with the correct resolution?
- All the field dose rates correct?
- Tolerance tables added and correct?
- Plan scheduling completed? Are the imaging templates attached?
- Has the plan been reviewed by the physician? Planning approved by the dosimetrist?
- Is the prescription approved? Is the plan linked to it?
- Do all the necessary fields have DRRs? Are they the right DRRs? Do the DRRs have match anatomy?
- Are the moves correct? In the right direction? What about the SSD and the gantry angle of the SSD?
- Does the plan have the correct labelling VM, IM, FiF, SB
- Did Mobius report any problems? Clearance? Did it have a structure to calc dose to or a norm point? Is it uploaded and approved?
- Do any of the setup fields have MLCs?
- Are any of the scheduled machines going to be a problem?
- Are all the instructions to the therapists clear?
- Any patient alerts needed?
- Does the patient have a CIED? Are the questionnaires done?
- Is the carepath correct?
- Should the plan be treatment approved? Did I remember to do this?
- Do I need to follow up on anything after QA?
Dosimetry and Physics Check Elements

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- Is the modulation going to be ok? Do I trust the dose? Does QA have a good chance of passing? Is the field width ok?
- Should jaw tracking be on?
- How does the fluence look? Is it deliverable?
- Are all the correct documents there? IGRT? Setup sheet?
- Move sheet? Calypso? SBRT IGRT?
- Will the treatment clear? Will the imaging fields clear?
- Should it be on a different machine?
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- Is the origin in the right place?
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- Does the patient have a CIED? Are the questionnaires done?
- Is the carepath correct?
- Should the plan be treatment approved? Did I remember to do this?
- Do I need to follow up on anything after QA?
Clinical Results

- Treatment unit delays (due to upstream errors) reduced from ~20/month to <5
- Certain categories of errors greatly reduced

Days Since Last Occurrence

- Imaging clearance: 513
- Link to script: 453
- Incorrect setup fields: 187
- Incorrect plan status: 150
- Incorrect field name: 140
- Treatment field clearance: 110
• Remove the human element by implementing automation and hard safety barriers
• Many aspects of treatment plan QA are ideally suited for automation
• Automation allows team members to focus their expertise
• Prioritization of automation should be driven by ILS and other data-tracking efforts

Conclusion