Esophagus RTOG1010 “2019 Varian Plan Challenge” Model Description

Purpose:

This document describes the context in which the Esophagus RTOG1010 Model should be used, as well as how it was configured and validated. For additional information on the validation process, reference Eclipse Photon and Electron Reference Guide.

Applicability:

Note *RapidPlan knowledge-based planning and its models are not intended to replace clinical decisions, provide medical advice or endorse any particular radiation plan or treatment procedure. The patients’ medical professionals are solely responsible for and must rely on their professional clinical judgment when deciding how to plan and provide radiation therapy.*

Note *You should validate every DVH estimation model before using it clinically. This applies to any model, whether Varian provided, peer provided or the models you create yourself.*

- This model is designed to be used for RapidArc treatment plans with four coplanar arcs for esophagus targets based on a superset of RTOG1010 protocol dosimetric goals.

- Unlike the original RTOG1010 protocol which called for two sperate treatment plans (Initial to 45Gy and Boost to 50.4Gy), this model treats the entire Initial PTV target to 50.4Gy while differentially dosing portions of the target that overlap with the heart to 47.88Gy (SIB) and respecting max dose constraint to the heart

- The model estimates the DVH for HEART, KIDNEY_TOTAL, LIVER, LUNG_TOTAL-PTV, PTV03Ring, SPINAL CORD and SPINAL CORD PV

- The model is intended to be used in conjunction with a **MU objective** with a relative **strength of 70 and minimum and maximum MU of 600 and 2000, respectively**. MU objective must be added manually.

- The “Intermediate Dose” function of the Photon Optimizer is utilized and Eclipse v15.5+ calculation options: **Convergence Mode: Extended** and MR return: **MR3**

- The Esophagus RTOG1010 model was created using the guidelines described below.

Note *The performance of the Esophagus RTOG1010 model may vary depending on the contouring and planning guidelines. Each site should validate the model with institution-specific contouring and planning guidelines before clinical use.*

Target and OAR contouring and planning guidelines:

The Esophagus RTOG1010 model was created using the following guidelines. Every patient must have a planning CT. The CT simulation scan must encompass the entire thorax to include the most superior aspect of the lung. For best results the inferior aspect should include the entire liver and kidneys. Axial slice thickness should not exceed 2.5mm and smaller axial cuts are recommended.

The planning target volumes (PTV) and the organs at risk (OARs) are contoured on the planning CT.

Target contouring guidelines:

Target name	Guidelines
PTV	Planning target as defined in RTOG1010 for the initial 45Gy plan (treated to 50.4Gy in this model)
PTVnoHeart	PTV excluding the heart

OAR contouring guidelines:

OAR name	Guidelines
Heart	Entire Heart including pericardium as per RTOG atlas guidelines
Kidneys	Both Kidneys in one structure
SpinalCanal	Superior aspect to begin at the distal edge of the brainstem through inferior aspect of the image set, entire canal space (often labeled as “cord”)
SpinalCanalPRV	SpinalCanal+5mm uniform expansion
Liver	Entire liver as per RTOG atlas guidelines
Lungs-PTV	Both bilateral lungs in on structure excluding PTV

Required optimization structure contouring guidelines:

Optimization structure	Guidelines
PTV03Ring	A shell structure created with the “Extract Wall” tool in Eclipse. Based on PTV Inner wall: -.3cm Outer wall: 1.3cm

Treatment planning guidelines:

All cases used to train and to validate the model were planned using head-first supine position. A four arc VMAT technique was utilized with Halcyon 2.0 (SX2 mode with 5mm effective MLC) with four full coplanar arcs with respective collimator positions 315/0/45/90 set for each arc. Each arc was positioned at a single isocenter located in the center of the target. Halcyon has no jaws and full field MLC modulation so this beam geometry is easy to setup.

Additional validation testing was done with this model using TrueBeam. The best results were usually achieved with a two collimator position 4 total arc coplanar plan. Two full arcs with collimators of 330/30 or 315/45 were utilized with each arc having jaw settings such that the entire target was always exposed by one of the X jaws (X1) with the other X jaw (X2) within 15cm. That arc was then mirrored with the carriage shifted to the other side of the field so the entire target was always covered by the opposite X jaw (X2) and the other X jaw (X1) was moved to be within 15cm. Care was taken to ensure at least 1-2cm of exposed overlap existed in the center of the field between each carriage shifted mirrored arc. That process was repeated for the other mirrored arc pair at the complementary collimator rotation angle. For all TrueBeam plans the jaw settings were verified by a beams eye view (BEV) evaluation of each control point in the arc rotation, ensuring one side or the other of each carriage shifted arc pair's aperture covered the target and between both had sufficient overlap. In our testing the TrueBeam plans following this approach scored very near to the equivalent 4 arc Halcyon reference plan.

The following dose prescription and planning guidelines were used for the cases to train and validate the model.

Target:

PTV	50.4Gy in 28 fractions to the portion not overlapping with the heart
	47.88Gy in 28 fractions to the portion overlapping with the heat (SIB)
PTVnoHeart coverage	D100% at 95-97%
plan normalization	as needed

OARs/Scorecard:

Planning objectives for OARs are taken from a superset of RTOG 1010 protocol guidelines. The following chart explains the planning goals in scorecard format. See references below for full details on RTOG 1010 or Annex A for specific OAR sparing goals with nonlinear scoring functions.

#	METRIC ID (20 Total Metrics)	WEIGHT (150)	PERFORMANCE BINS				
[01]	Volume (%) of the PTV covered by 50.4 (Gy)	3	< 90 UNACCEPTABLE	90 MARGINAL [0]			95 IDEAL [3]
[02]	Volume (%) of the PTVnoHeart covered by 50.4 (Gy)	20	< 90 UNACCEPTABLE [0]	90 MARGINAL [5]	94 ACCEPTABLE [10]	95 GOOD [19]	97 IDEAL [20]
[03]	Volume (%) of the PTV covered by 47.88 (Gy)	2	< 95 UNACCEPTABLE [0]	95 MARGINAL [.5]	99 ACCEPTABLE [1]	9	100 IDEAL [2]
[04]	Dose (Gy) covering 0.03 (cc) of the PTV	7	> 56.95 UNACCEPTABLE	56.95 MARGINAL [0]	55.44 ACCEPTABLE [5]	53.93 GOOD [6]	52.95 IDEAL [7]
[05]	Dose (Gy) covering 0.03 (cc) of the LUNG TOTAL-PTV	6	> 56.95 UNACCEPTABLE	56.95 MARGINAL [0]	55.44 ACCEPTABLE [5]	53.93 GOOD [5.5]	52.95 IDEAL [6]
[06]	Mean dose (Gy) to the LUNG TOTAL-PTV	10	> 21 UNACCEPTABLE	21 MARGI	20 ACCEPTABLE [5]	10 GOOD [9]	5 IDEAL [10]
[07]	Volume (%) of the LUNG TOTAL-PTV covered by 30 (Gy)	7	> 25 UNACCEPTABLE	25 MARGINAL [0]	20 ACCEPTABLE [4]	10 GOOD [6]	5 IDEAL [7]
[08]	Volume (%) of the LUNG TOTAL-PTV covered by 20 (Gy)	15	> 30 UNACCEPTABLE	30 MARGINAL [0]	25 ACCEPTABLE [10]	12 GOOD [13]	7 IDEAL [15]
[09]	Volume (%) of the LUNG TOTAL-PTV covered by 10 (Gy)	7	> 50 UNACCEPTABLE	50 MARGINAL [0]	40 ACCEPTABLE [4]	15 GOOD [6]	10 IDEAL [7]
[10]	Volume (%) of the LUNG TOTAL-PTV covered by 5 (Gy)	10	> 55 UNACCEPTABLE	55 MARGINAL [0]	50 ACCEPTABLE [5]	45 GOOD [9]	20 IDEAL [10]
[11]	Dose (Gy) covering 0.03 (cc) of the HEART	5	> 52 UNACCEPTABLE	52 MARGINAL [0]	50 ACCEPTABLE [4]		40 IDEAL [5]
[12]	Mean dose (Gy) to the HEART	15	> 31 UNACCEPTABLE	31 M	30 ACCEPTABLE [5]	10 GOOD [13]	5 IDEAL [15]
[13]	Volume (%) of the HEART covered by 40 (Gy)	8	> 55 UNACCEPTABLE	55 MARGINAL [0	50 ACCEPTABLE [4]	15 GOOD [7]	5 IDEAL [8]
[14]	Dose (Gy) covering 0.03 (cc) of the KIDNEY TOT-PTV03	5	> 50 UNACCEPTABLE	50 MARGINAL [0]	45 ACCEPTABLE [3]	33 GOOD [4]	20 IDEAL [5]
[15]	Volume (%) of the KIDNEY TOTAL covered by 20 (Gy)	7	> 40 UNACCEPTABLE	40 MARGINAL [0]	30 ACCEPTABLE [5]	10 GOOD [6]	0 IDEAL [7]
[16]	Dose (Gy) covering 0.03 (cc) of the SPINAL CORD	7	> 50 UNACCEPTABLE [-150]	50 MARGINAL [0]	45 ACCEPTABLE [3]	40 GOOD [6]	20 IDEAL [7]
[17]	Mean dose (Gy) to the LIVER	5	> 25 UNACCEPTABLE	25 MARGINAL [0]	21 ACCEPTABLE [3]	15 GOOD [4]	10 IDEAL [5]
[18]	Volume (%) of the LIVER covered by 30 (Gy)	6	> 40 UNACCEPTABLE	40 MARGINAL [0]	30 ACCEPTABLE [3]	15 GOOD [5]	5 IDEAL [6]
[19]	Volume (cc) of the PTV03Ring covered by 50.4 (Gy)	5	> 10 UNACCEPTABLE	10 MARGINAL [0]	1 ACCEPTABL		0 IDEAL [5]

References for contouring, planning guidelines and further background:

RTOG-1010: A PHASE III TRIAL EVALUATING THE ADDITION OF TRASTUZUMAB TO TRIMODALITY TREATMENT OF HER2-OVEREXPRESSING ESOPHAGEAL ADENOCARCINOMA https://www.rtog.org/LinkClick.aspx?fileticket=52jdx-MJBUQ%3D&tabid=290

2019 Varian Plan Challenge: Man vs. Machine (RapidPlan Esophagus) Full details on the crowd sourced initial model training set, the recursive model creation method, scoring metric details and more see the PDF slide deck link in the bottom left corner here: http://medicalaffairs.varian.com/esophagus-vmat2

Physicians with considerable experience in treating patients under the RTOG-1010 protocol, planning goals were created to comply with these individuals' clinical preference

Structure codes:

To ensure robust structure matching between new cases and the structures defined in the model, it is recommended to use the following structure code assignment:

Structure name example	Structure name in model	Structure code(s) in model
PTV	PTV	(PTV_Int Target)
PTV-Heart	PTVnoHeart	(PTV_High)
Heart	Heart	(7088)
Kidney_Total	Kidneys	(264815)
Spinal Cord	SpinalCanal	(9680, 7647)
Spinal Cord+05	SpinalCanalPRV	(PRV)
Liver	Liver	(7197)
Lung_Total-PTV	Lungs-PTV	(68877)
PTV_Ring	PTV03Ring	(Ring)

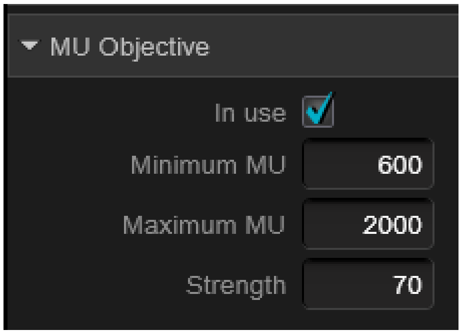
Optimization objectives and Optimization settings:

The following optimization objectives were defined in the model and will be generated when the model is applied to a new case. These objectives were created with both absolute and relative objectives being populated for all plans. This is by design and how the model was tested and is intended to be applied. Although other prescriptions/fractionation schemes were not tested, these auto-created should allow for successful plans to be created with different prescriptions as well (example: 45Gy in 25fx).

Yes	PTV	(PTV_Intermediate)					
	Lower		100.0	95.2	%	150	X
Yes	PTVnoHeart	(PTV_High)					
	Upper		0.0	103.1	%	175	X
	Lower		100.0	101.8	%	145	X
	Heart	(7088)					
	Upper		0.0	48.200	Gy	195	X
	Upper		0.0	95.7	%	190	X
	Mean			5.000	Gy	0	X
	Line (preferring target)		Generated	Generated		95	X
	Kidneys	(264815)					
	Upper		0.0	42.000	Gy	105	X
	Upper		0.0	83.5	%	100	X
	Line (preferring target)		Generated	Generated		75	X
	Liver	(7197)					
	Mean			10.000	Gy	25	X
	Line (preferring target)		Generated	Generated		65	X
	Lungs-PTV	(68877)					
	Upper		0.0	48.000	Gy	105	X
	Upper		0.0	95.5	%	100	X
	Upper		19.0	29.000	Gy	105	X
	Upper		19.0	59.6	%	100	X
	Upper		24.0	19.250	Gy	105	X
	Upper		24.0	38.2	%	100	X
	Upper		39.0	9.500	Gy	105	X
	Upper		39.0	18.9	%	100	X
	Upper		45.0	3.500	Gy	195	X
	Upper		45.0	6.9	%	190	X
	Line (preferring target)		Generated	Generated		98	X
	PTV03Ring	(Ring)					
	Upper		0.0	49.200	Gy	180	X
	Upper		0.0	97.8	%	175	X
	SpinalCanal	(9680, 7647)					
	Upper		0.0	38.000	Gy	105	X
	Upper		0.0	75.5	%	100	X
	SpinalCanalPRV05	(PRV)					
	Upper		0.0	43.000	Gy	105	X
	Upper		0.0	85.5	%	100	X

Applying the model will also utilize the Automatic NTO.

MU objective is also recommended for planning with the following parameters **(must be added manually each time this model is applied to a patient)**:



Model Training:

This Esophagus RTOG1010 model was trained with 39 cases. Each original case was submitted via a public planning competition with the rules stating all cases should be planned in Eclipse, only use coplanar beams with a maximum of either nine static gantry fields or four VMAT arcs (partial or full). All cases were planned to 50.4Gy in 1.8Gy fractions High energy plans were prohibited.

A small number of the originally submitted plans had either extremely poor plan quality or obvious wrong structures – those cases had their structures corrected and new manual plans created to be used in the creation of the initial model. A recursive method of model creation was utilized to generate a RapidPlan model with very consistent, high quality plans developed with tight DVH prediction bands allowing for aggressive OAR optimization objectives to be used especially on the heart and lungs.

The recursive model creation process is summarized below:

First, an initial RapidPlan model is created from the 39 manually planned originally submitted cases (with a small number needing corrections before they could be used). Then, that model is used to re-plan all the cases in that training set. All replanned cases were done using a 4 arc coplanar arrangement on Halcyon as described above. Differing combinations of auto-created optimization objective priorities are systematically used. The best scoring plan from each method is selected for each patient and those plans become the training set for the final model, and a final set of automatic objectives are then established for this final model. One RapidPlan model created from another initial/parent model, a la the recursive method.

See Annex C for a chart showing the originally submitted plan scores and the scores from the plans created from the initial model various objective priority versions from which the final model was trained within the recursive model creation method.

Model Validation:

This Esophagus RTOG model was validated using all 39 cases from which it was derived. The results of that testing can be seen in a chart in Annex D.

Additional validation was done using 5 cases obtained from another, outside institution. All cases had scores which would be expected from the internal validation results / scores.

Since finalizing this model it also has been tested on a number of cases from multiple institutions and the resulting plans were judged to have clinically satisfactory results, with scores all within the expected range.

Finally, it should be noted since this provided model only has 39 cases in its training set, the green/orange match indicators which appear when the model is applied to new patients may display more orange structures than would be common with models created from larger training sets.

Annex Directory

Annex A: **Charts of Scorecard metrics with nonlinear scoring functions**

Annex B: **Example Scorecard** from an external validation case

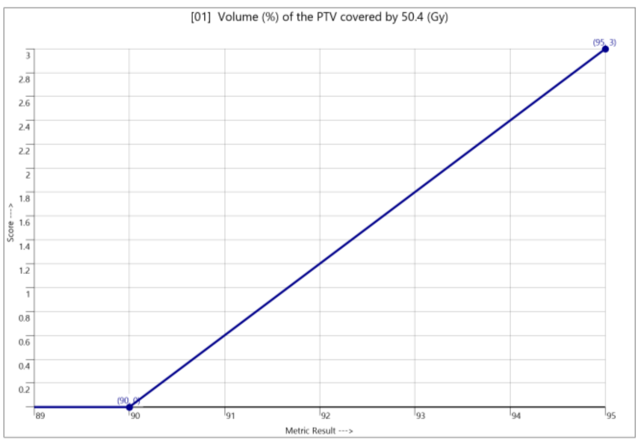
Annex C: **Originally submitted plan scores and the scores from the plans created from the initial model** with various objective priority versions

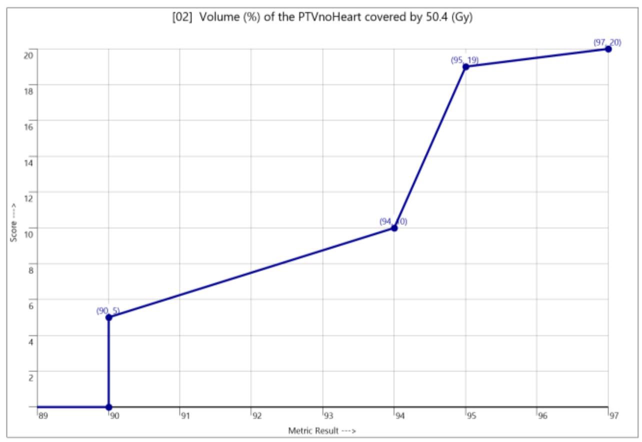
Annex D: **Scores achieved by the final model** compared with the original manually planned unmodified training set cases

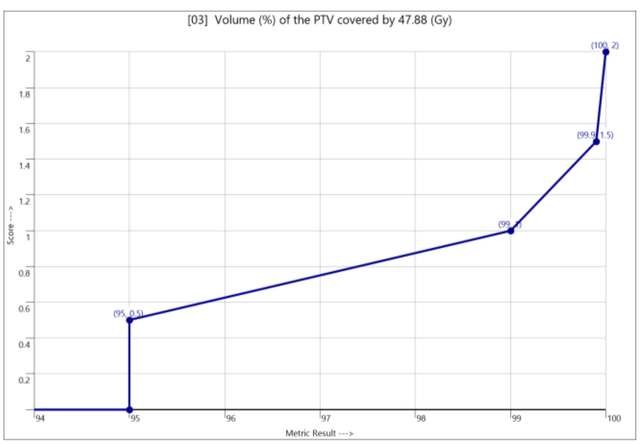
Annex E: **Acknowledgements**

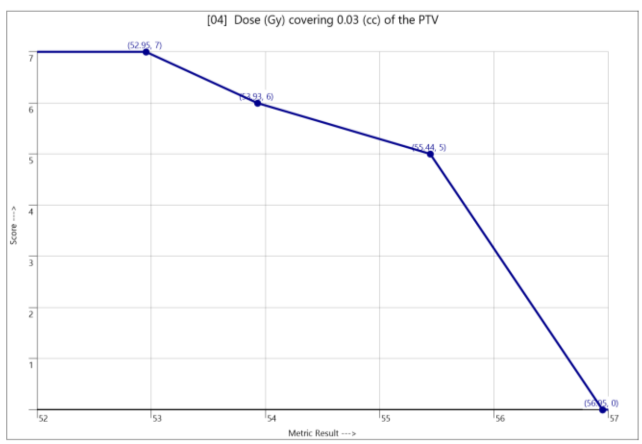
Annex F: **Release, distribution and compatibility**

Annex A: Charts of Scorecard metrics with nonlinear scoring functions

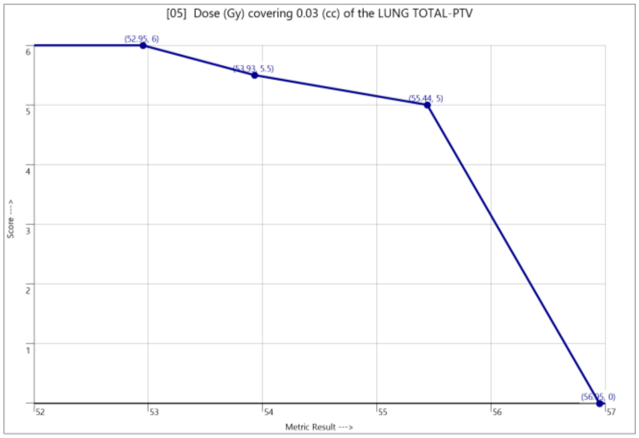




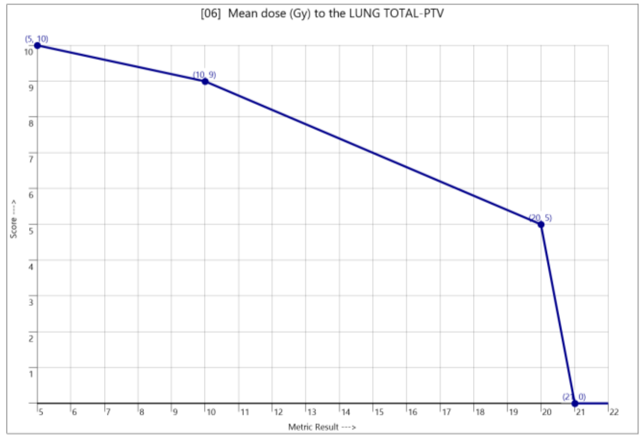




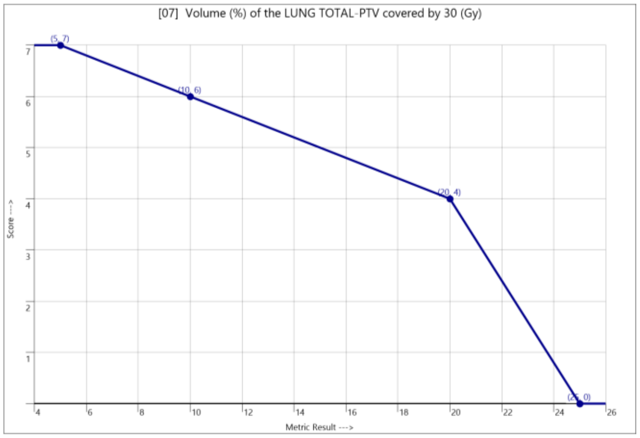
[05] Dose (Gy) covering 0.03 (cc) of the LUNG TOTAL-PTV



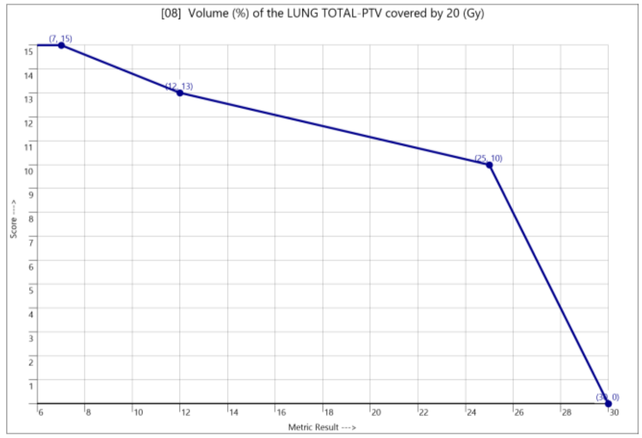
[06] Mean dose (Gy) to the LUNG TOTAL-PTV



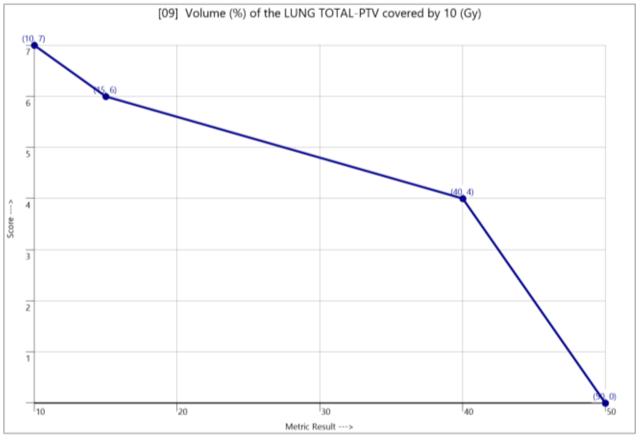
[07] Volume (%) of the LUNG TOTAL-PTV covered by 30 (Gy)



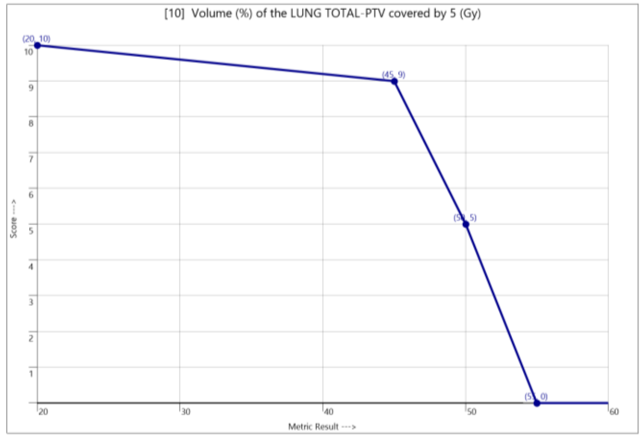
[08] Volume (%) of the LUNG TOTAL-PTV covered by 20 (Gy)



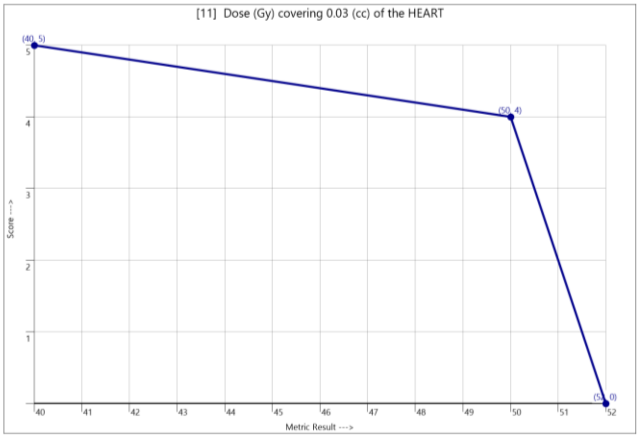
[09] Volume (%) of the LUNG TOTAL-PTV covered by 10 (Gy)



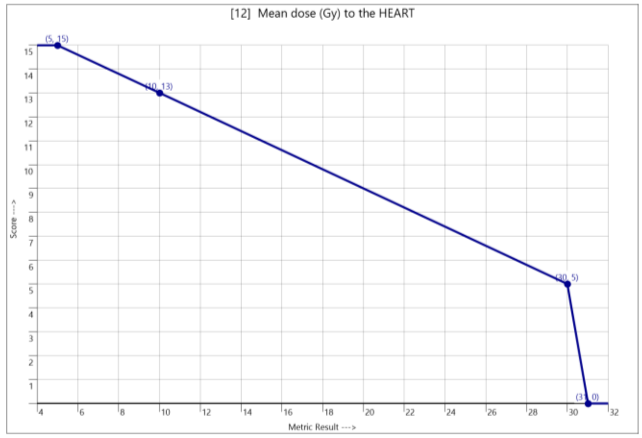
[10] Volume (%) of the LUNG TOTAL-PTV covered by 5 (Gy)



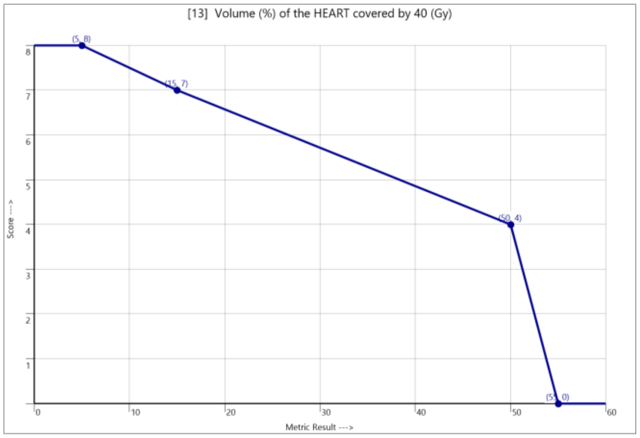
[11] Dose (Gy) covering 0.03 (cc) of the HEART



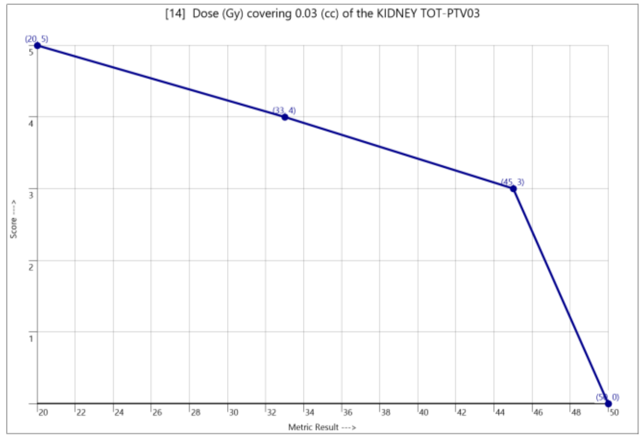
[12] Mean dose (Gy) to the HEART



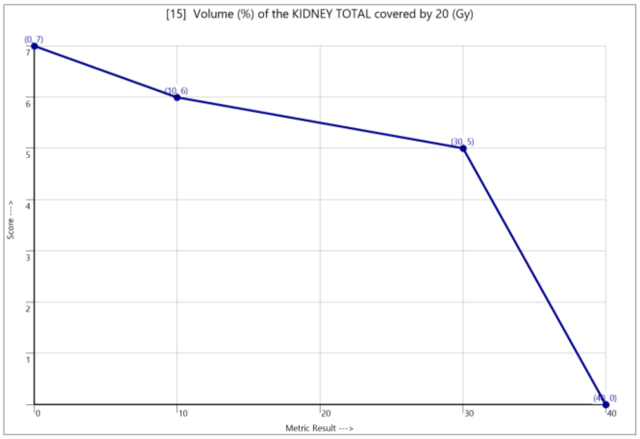
[13] Volume (%) of the HEART covered by 40 (Gy)



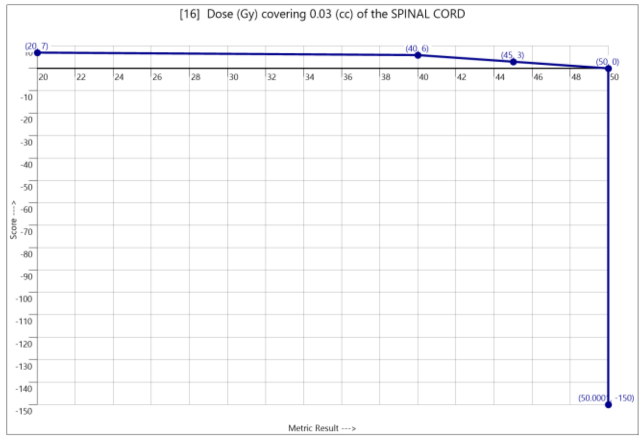
[14] Dose (Gy) covering 0.03 (cc) of the KIDNEY TOT-PTV03



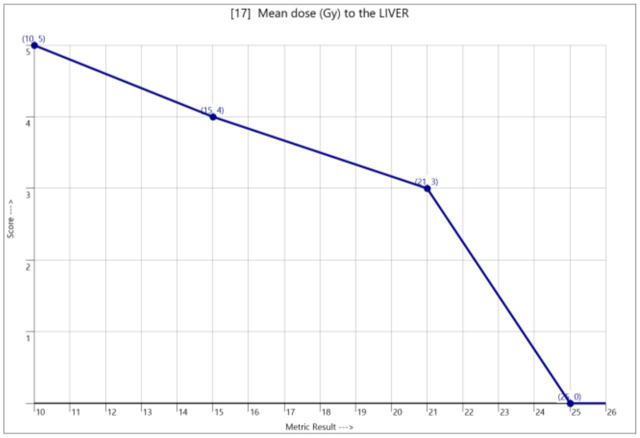
[15] Volume (%) of the KIDNEY TOTAL covered by 20 (Gy)



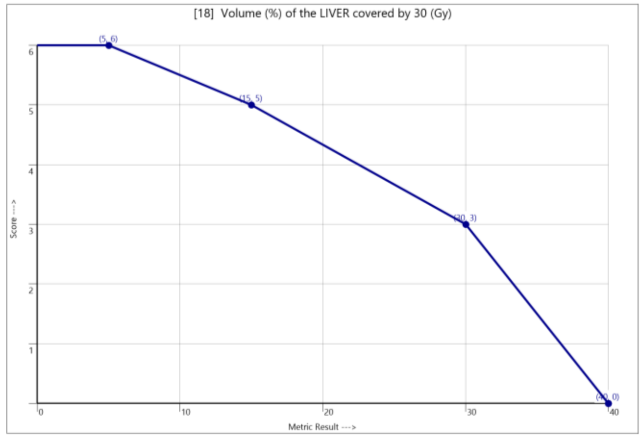
[16] Dose (Gy) covering 0.03 (cc) of the SPINAL CORD



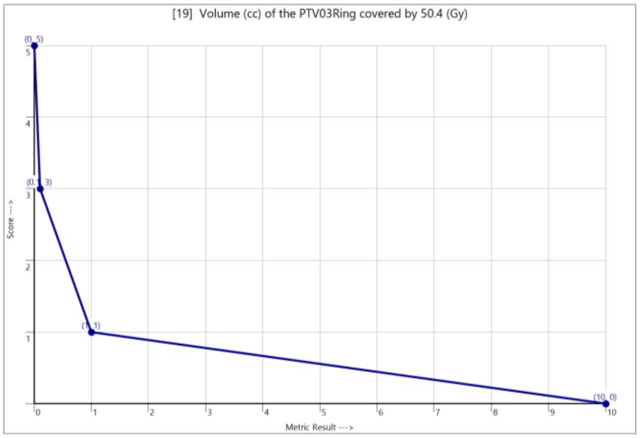
[17] Mean dose (Gy) to the LIVER



[18] Volume (%) of the LIVER covered by 30 (Gy)



[19] Volume (cc) of the PTV03Ring covered by 50.4 (Gy)



[20] Cumulative meterset over all treatment beams

Metric 20: Unscored Metric (no metric objective defined)

Annex B: **Example Scorecard** from an external validation case

Computed | Custom | Score: 132.11 / 150.00 (88%) | Edit

	Metric	Value	Objectives	Result
1	Volume (%) of the PTV covered by 50.40 (Gy)	90.890	90 95	MARGINAL (0.53)
2	Volume (%) of the PTVnoHeart covered by 50.40 (Gy)	96.678	90 94 95 97	GOOD (19.84)
3	Volume (%) of the PTV covered by 47.88 (Gy)	98.628	95 99 100	MARGINAL (0.95)
4	Dose (Gy) covering 0.03 (cc) of the PTV	53.914	52.95 53.93 55.44 56.95	GOOD (6.02)
5	Dose (Gy) covering 0.03 (cc) of the LUNG TOTAL-PTV	51.255	52.95 53.93 55.44 56.95	IDEAL (6.00)
6	Mean dose (Gy) to the LUNG TOTAL-PTV	6.878	5 10 20 21	GOOD (9.62)
7	Volume (%) of the LUNG TOTAL-PTV covered by 30.00 (Gy)	1.472	5 10 20 25	IDEAL (7.00)
8	Volume (%) of the LUNG TOTAL-PTV covered by 20.00 (Gy)	7.754	7 12 25 30	GOOD (14.70)
9	Volume (%) of the LUNG TOTAL-PTV covered by 10.00 (Gy)	27.612	10 15 40 50	ACCEPTABLE (4.99)
10	Volume (%) of the LUNG TOTAL-PTV covered by 5.00 (Gy)	39.442	20 45 50 55	GOOD (9.22)
11	Dose (Gy) covering 0.03 (cc) of the HEART	50.855	40 50 52	MARGINAL (2.29)
12	Mean dose (Gy) to the HEART	16.709	5 10 30 31	ACCEPTABLE (10.32)
13	Volume (%) of the HEART covered by 40.00 (Gy)	6.128	5 15 50 55	GOOD (7.89)
14	Dose (Gy) covering 0.03 (cc) of the KIDNEY TOTAL	21.555	20 33 45 50	GOOD (4.88)
15	Volume (%) of the KIDNEY TOTAL covered by 20.00 (Gy)	0.061	0 10 30 40	GOOD (6.99)
16	Dose (Gy) covering 0.03 (cc) of the SPINAL CORD	31.862	20 40 45 50	GOOD (6.41)
17	Mean dose (Gy) to the LIVER	13.928	10 15 21 25	GOOD (4.21)
18	Volume (%) of the LIVER covered by 30.00 (Gy)	8.433	5 15 30 40	GOOD (5.66)
19	Volume (cc) of the PTV03Ring covered by 50.40 (Gy)	0.021	00 1 10	GOOD (4.59)
20	Cumulative meterset	659.513		

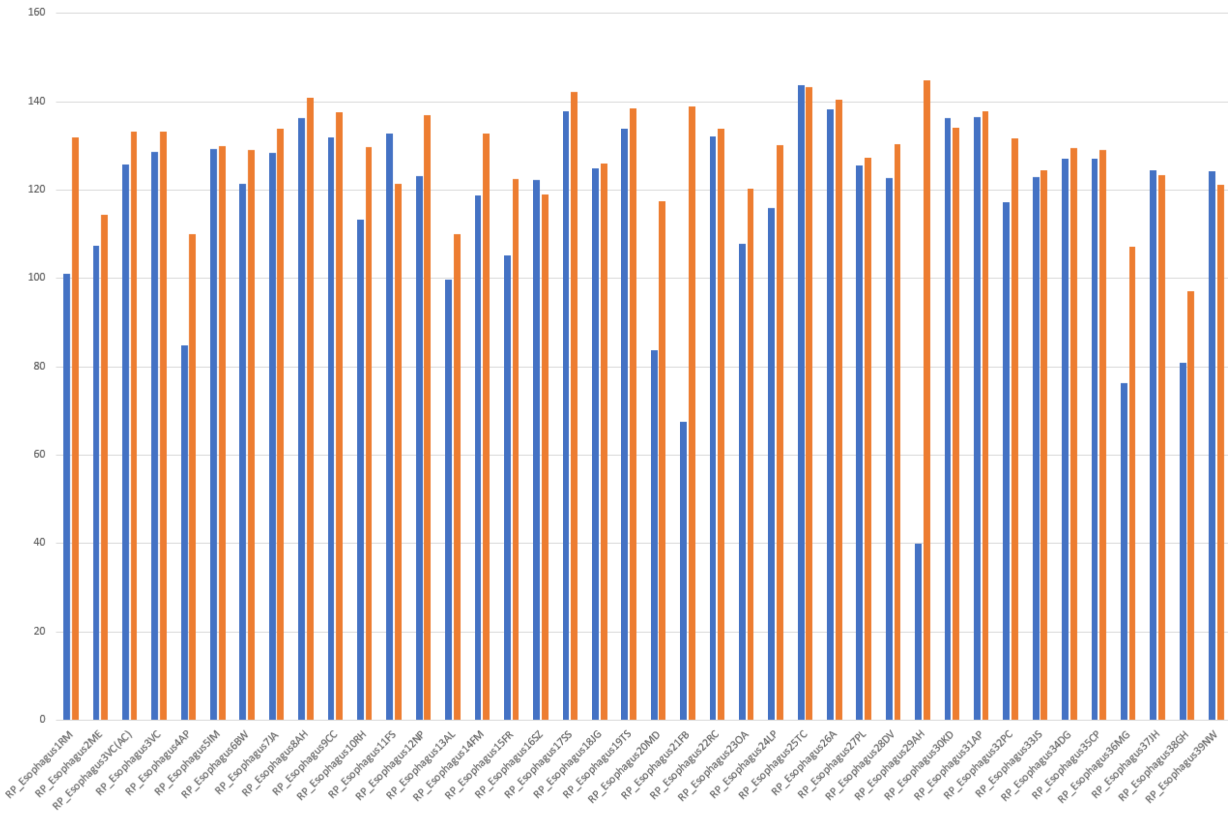
Annex C: **Originally submitted plan scores and the scores from the plans created from the initial model** with various objective priority versions

1	Patient ID	submitted plan typ	special note	Score of submitted pla	score of manual repla	RapidPlan V1	Rapidplan V1a	RapidPlan V1b	RapidPlan V1c	RapidPlan V1d	RapidPlan V1e	RapidPlan V1f	Score of RapidPlan V2	Score of RapidPlan2a	2a after c
2	RP_Esophagus1RM	9 field IMRT		101.12					114.86		127.61			131.51	
3	RP_Esophagus2ME	2 part arcs	tall challenging PTV	107.3					104.29 heart/lung failed		115.23 Ring	112 PRVring/heart failed		113.85 Ring	
4	RP_Esophagus3VC(AC)	4 arcs NC	Noncoplanar Vladimir	125.67					120.82			130.21 duplicate patient		131.4	
5	RP_Esophagus3VC	4 full arcs		128.67								130.21 duplicate patient		131.4	
6	RP_Esophagus4AP	5 field IMRT	15x tall challenging PT	84.83		106.03						109.57		108.08 ring/heart failec	111.84
7	RP_Esophagus5IM		missingCT	129.23											
8	RP_Esophagus6BW	2 full arcs	optimized on wrong PT	121.36								126.94		127.31	
9	RP_Esophagus7JA	8 field IMRT	name was John Dickma	128.34					134.26					127.43	
10	RP_Esophagus8AH	3 full arcs		136.22					138.47					138.77	
11	RP_Esophagus9CC			131.95					134.56					136.14	
12	RP_Esophagus10RH	2 full arcs NC	non coplanar	113.21					128.15					129.41	
13	RP_Esophagus11FS	10 field IMRT	15x	132.75						110.17		121.52	120.92		
14	RP_Esophagus12NP	4 full arcs		123.05						127.69					
15	RP_Esophagus13AL	10 field IMRT	name was Klaus Weste	99.61						101.68			109.79		10X(norm)
16	RP_Esophagus14FM	1 full arc	1 arc	118.67						131.64					
17	RP_Esophagus15FR	3 full arcs	10x	105.26						119.97					
18	RP_Esophagus16SZ	10 field IMRT NC	InitMrem:Heart Non c	122.31						114.22 dmax 55.22		116.79 PTV50.40/ dmax54.78	118.25/all passed	118.49 passed	
19	RP_Esophagus17SS	2 full arcs	FinMrem:Heart	137.79						140.75			141.51		
20	RP_Esophagus18JG	3 320* arcs	FinMrem:Lung-PTV10x	124.86						126.49			125.75		127.57
21	RP_Esophagus19TS	3 part arcs		133.95						131.28		135.16			
22	RP_Esophagus20MD		FinMrem:Heart,Lungs-	83.7						105.52		119.11 PTV50.40	113.49 PTV50.40		
23	RP_Esophagus21FB	1 full arc		67.49	137.68	135.3						139.22			13X(norm)
24	RP_Esophagus22RC	4arc coplanar	InitMrem:Lungs-PTV M	132.14						130.77		132.86	130.77		
25	RP_Esophagus23OA		InitMrem:Lungs-PTV**	107.71						115.79 heart/lung failed	109.47	119.32			
26	RP_Esophagus24LP			116.02						129.27					
27	RP_Esophagus25TC		FinMrem:Heart	143.83							143.13	144.12			
28	RP_Esophagus26A		DICOM structure assoc	138.16									139.49		
29	RP_Esophagus27PL	InitMrem:PTV03Ring		125.56						127.81					
30	RP_Esophagus28DV			122.81		126.36				130.49					
31	RP_Esophagus29AH		FinMrem:Heart superi	40						142.97				145.2	
32	RP_Esophagus30KD	4arc noncoplanar	FinMrem:Liver	136.19						132.53		134.61		133.44	
33	RP_Esophagus31AP			136.5						137.26				135.88	
34	RP_Esophagus32PC		1arc	117.24						131.95 PTV50.40				131.04PTV5040	
35	RP_Esophagus33JS			122.99						126.05					
36	RP_Esophagus34DG		dose will not import	127.02						129.71PTV50.40				129.12PTV50.40	
37	RP_Esophagus35CP			127.05						127.93			128		
38	RP_Esophagus36MG	2 isocenter	InitMrem:Lungs-PTV, P	76.38	107.36					101.75		95.28Ring	105.9 LungV5	106.92	
39	RP_Esophagus37JH		removed agressivly spa	124.41						121.92		122.68	124.06		
40	RP_Esophagus38GH		FinMrem:Lungs-PTVno	80.96					97.45LungV5fail	85.91LungV5HeartDmax		96Ring	93.28HeartDmax,Ring		
41	RP_Esophagus39NW	9field IMRT coplan	FinMrem:Kidney_Total	124.32				110.57HeartDmax		120.16 PTV50.40		119.96	119.2PTV5040		

Highest scoring plans in green were used as training set for final model. A small number of manually created plans outscored initial model attempts and were used in the training set for the final model.

Annex D: **Scores achieved by the final model** compared with the original manually planned unmodified training set cases

Plan ID	submitted	FinalModel
RP_Esophagus1RM	101.12	131.92
RP_Esophagus2ME	107.3	114.31
RP_Esophagus3VC(AC)	125.67	133.31
RP_Esophagus3VC	128.67	133.31
RP_Esophagus4AP	84.83	110
RP_Esophagus5IM	129.23	130
RP_Esophagus6BW	121.36	128.95
RP_Esophagus7JA	128.34	133.98
RP_Esophagus8AH	136.22	140.85
RP_Esophagus9CC	131.95	137.7
RP_Esophagus10RH	113.21	129.7
RP_Esophagus11FS	132.75	121.41
RP_Esophagus12NP	123.05	136.9
RP_Esophagus13AL	99.61	110
RP_Esophagus14FM	118.67	132.85
RP_Esophagus15FR	105.26	122.47
RP_Esophagus16SZ	122.31	118.9
RP_Esophagus17SS	137.79	142.23
RP_Esophagus18JG	124.86	126
RP_Esophagus19TS	133.95	138.45
RP_Esophagus20MD	83.7	117.52
RP_Esophagus21FB	67.49	139
RP_Esophagus22RC	132.14	133.77
RP_Esophagus23OA	107.71	120.36
RP_Esophagus24LP	116.02	130.14
RP_Esophagus25TC	143.83	143.36
RP_Esophagus26A	138.16	140.38
RP_Esophagus27PL	125.56	127.35
RP_Esophagus28DV	122.81	130.42
RP_Esophagus29AH	40	144.91
RP_Esophagus30KD	136.19	134.06
RP_Esophagus31AP	136.5	137.88
RP_Esophagus32PC	117.24	131.61
RP_Esophagus33JS	122.99	124.39
RP_Esophagus34DG	127.02	129.48
RP_Esophagus35CP	127.05	129.03
RP_Esophagus36MG	76.38	107.16
RP_Esophagus37JH	124.41	123.37
RP_Esophagus38GH	80.96	97.13
RP_Esophagus39NW	124.32	121.28
average	116.4158	128.396



Annex E: Acknowledgements

Manual plans created by 2019 Varian Plan Challenge participants

Manual replans of extremely poor / incomplete submissions by Belinda Thibodaux, CMD and Lesley Rosa, CMD

Model generated plans created and priorities tuned by Anthony Magliari, CMD and Belinda Thibodaux, CMD

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Clinical Description document created by Anthony Magliari, CMD

RapidPlan Model created in Eclipse v15.6, Varian Medical Systems

Scorecards created with ProKnow

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Ben Nelms PhD, Drew Bullock CMD, Karen Kigin, Theodore Hong, MD and Andy Su, MD

Annex F: Release, distribution and compatibility

This RapidPlan model is free to use, Eclipse RapidPlan license required

This RapidPlan model is to be distributed exclusively via the links found on the Varian marketplace (www.myvarian.com > resources > Marketplace) or at http://medicalaffairs.varian.com / http://medicalaffairs.varian.com/esophagus-vmat2 . Please do not re-distribute this model as number of downloads will be tracked from the links above and used to judge the success of this project.

This RapidPlan model was created and tested with Eclipse v15.6 but should also be compatible with Eclipse v15.5. Unfortunately, previous v13.X Eclipse will need to be upgraded before utilizing this model.