Head & Neck SIB70Gy(63Gy)56Gy Bilateral Parotid Involved (HN-SIB-BPI) Model Description

Purpose:

This document describes the context in which the Head & Neck SIB70Gy(63Gy)56Gy Bilateral Parotid Involved (HN-SIB-BPI) Model should be used, as well as how it was configured and validated. All instruction needed to use this model in your clinic can be found when you **read the first eleven pages of this document**.

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 *The performance of the HN-SIB-BPI 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.*

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.*

- HN-SIB-BPI is intended to be used for RapidArc treatment plans of 4 full arcs on Halcyon/Ethos or TrueBeam.
- HN-SIB-BPI is meant to be used for treatment plans where nodes are treated in the bilateral neck and both parotid glands are nearby or only partially overlapping a target volume. When both parotids are found on the same axial plane as the targets when primary disease is in the following anatomical regions: oral cavity, oropharynx, hypopharynx, larynx, or unknown primary. Nasopharynx primary cases are often too superior to be a good match for this model.
- HN-SIB-BPI supports two or three targets: 70Gy, (63Gy) and 56Gy treated Simultaneous Integrated Boost
- Ipsilateral and contralateral parotids need to be delineated and matched to the model accordingly.
- An associated 53 metric dosimetric scorecard should be used to evaluate plan quality and automatically generate the optimization structures needed (see page 6 for details or manual creation)
- Due to the large number of structures the "Generate Estimates and Objectives" step when applying this model can take time (10+ minutes), the system isn't locked, please be patient.
- The "**Automatic Intermediate Dose**" function of the Photon Optimizer was utilized with **MR3** return and **convergence mode: extended** selected in the calculation options which provide best results. These **settings should be changed prior to starting the optimization or plan quality will be compromised.** For increased homogeneity, **consider an additional intermediate dose optimization: "2xMR3"** with v15.6-17.0, not v18.0.
- Only users creating Halcyon plans with V18.0 of the Photon Optimizer: consider Min MU=1000 strength=70.
- The HN-SIB-BPI model was created using the guidelines described below.

Target contouring guidelines:

Standard Target Name	Example Description
GTV70	Primary tumor and involved nodes to receive 70 Gy
CTV70	GTV70 + 5-10 mm margin, excluding anatomic boundaries to tumor spread
PTV70	CTV70 + 3 mm margin (subtract 3-5 mm from skin if needed)
CTV63	• CTV70 + 5 mm • first echelon nodes • node levels including involved nodes • 2 cm inferior/superior margin for gross nodal disease covering the fat of nodal chain suspicious nodes < 1 cm + 5 mm
PTV63	• CTV630 + 3 mm margin (subtract 3-5 mm from skin if needed)
PTV56	CTV56 + 3 mm margin (subtract 3-5 mm from skin if needed)
CTV56	Lower risk nodal levels that are not first echelon nodes and are not adjacent to levels containing grossly involved nodes

All target contouring shall be in accordance to published guidelines, see https://econtour.org/references for various guidelines.

Example neck CTV56 guidelines by site and clinical node staging:

Site[a]	Nodal stage	Ipsilateral neck[b]	Contralateral neck
Squamous Cell Carcinoma	N0	Ib (for primary oral cavity extension); II-III; RPLN) for primary extension to posterior pharyngeal wall or soft palate	II-III; RPLN for primary extension to posterior pharyngeal wall or soft palate
	N1	Ib (only if primary tumor site requires); II-IV , RPLN for primary extension to posterior pharyngeal wall or soft palate	II-III; RPLN for primary extension to posterior pharyngeal wall or soft palate
	N1 node ≥ 3 cm or multiple	VI (If primary site requires) II,III,IV,V; Ib, RPLN, VI if primary site requires	II-III; RPLN for primary extension to posterior pharyngeal wall or soft palate
Oral Cavity	N0 N1,2,3, no N2c[c] N2c [C]	I-IV I-V; HLII; RPLN [C] I-V; HLII; RPLN [C]	1B: II-IV II-IV I-V; HLII; RPLN [C]
Oropharynx[d]	N0 N1,2,3 no N2c N2 [C]	II-IV; HLII; RPLN I-V; HLII; RPLN I-V; HLII; RPLN	II-IV II-IV I-v; HI-Il; RPLN
Hypopharynx[d e]	N0 N1,2,3 no N2c N2c[e]	II-IV; HLII; RPLN I-V; HLII; RPLN I-V; HLII; RPLN	Il-IV Il-IV I-V; HLII; RPLN [e]
Larynx [f]	N0 N1,2,3 no N2c N2c	II-IV I-V; HLII; RPLN I-V; HLII; RPLN	Il-IV Il-IV I-v; HLII; RPLN
Unknown Primary	N1,2,3 no N2c N2c	I-V; HLII; RPLN I-V; HLII; RPLN	No Radiotherapy (model N/A) I-V; HLII; RPLN

Abbreviations: RPLN, retropharyngeal lymph nodes; HLII, high level II; I-IV, levels la,1b, II, III, IV; I-v, levels la, Ib, II, III, IV, V; II-IV, levels II, III, IV.

[a] Medial retropharyngeal lymph nodes are omitted in all cases except nasopharynx, hypopharynx, or a tumor involving the posterior pharyngeal or oropharyngeal walls.

[b] HLll (level Il LNs above crossing of the posterior belly of the digastric and internal jugular vein) is spared for patients with one clinically N0 neck unless specifically written. la is covered electively in the case of an ipsilateral oral cavity primary or if nodal disease in 1B is present; otherwise, it is spared. If disease is present in level Il, add elective coverage of level 1B. For disease in level II, III, or IV, add elective coverage of level V.

[C] For N1 disease limited to level l, omit level V coverage; N2c disease limited to level I on contralateral side may spare contralateral V.

[d] For well-lateralized T1/2N0 tonsillar tumors (possibly including the glossotonsillar sulcus), contralateral radiation may be omitted entirely (N/A for this model); bilateral RPLN coverage should be considered for midline tumors of the posterior wall of the oropharynx and hypopharynx.

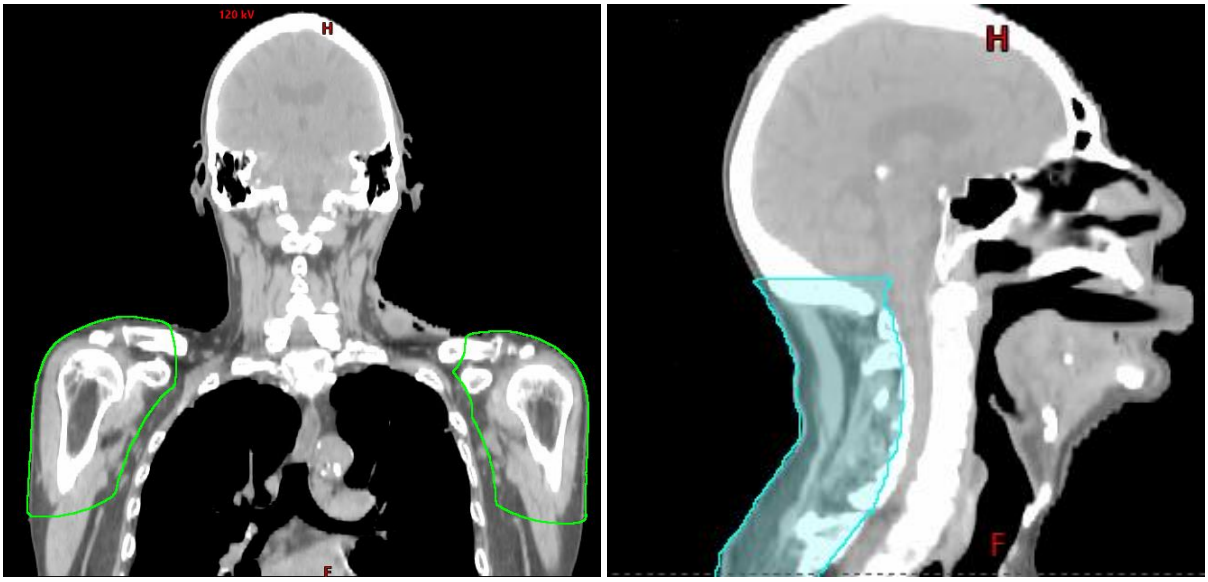
[e] For N2c disease with contralateral neck metastasis only in level Ill, IV, or V, may omit contralateral level lb.

[f] Except T1-2 carcinoma of the true vocal cord.

Organ At Risk contouring guidelines:

OAR Standard Name	Description
SpinalCord	Begins at the cranial-cervical junction (i.e., the top of the C1 vertebral body). Superior to this is brainstem and inferior to this is cord. The inferior border of the spinal cord volume will be defined at approximately T3-4 (i.e., 2-3 cm below the lowest slice level that has PTV on it.
SpinalCord_05	SpinalCord with 5 mm expansion for Planning Risk Volume (PRV)
BrachialPlexus	Use a 5-mm diameter paint tool. Start at the neural foramina from C5 to T1; this should extend from the lateral aspect of the spinal canal to the small space between the anterior and middle scalene muscles. For CT slices, where no neural foramen is present, contour only the space between the anterior and middle scalene muscles. Continue to contour the space between the anterior and middle scalene muscles; eventually the middle scalene will end in the region of the subclavian neurovascular bundle. Contour the brachial plexus as the posterior aspect of the neurovascular bundle inferiorly and laterally to one to two CT slices below the clavicular head. The first and second ribs serve as the medial limit of the OAR contour.
Brain	Interior to the skull, excluding the brainstem. The inferior border is the lower cerebellum, extending superiorly to the inner apex of the skull.
BrainStem	The most superior portion of the brainstem is approximately at the level of the top of the posterior clinoid
BrainStem_03	BrainStem with 3 mm expansion for PRV
Chiasm	Inferiorly from superior border of the sella turcica, extending superiorly 3-6 mm. The structure forms an "X" shape. The anterior region of the chiasm is located inferior to the posterior region of the chiasm.
Cochlea_R	Well visualized near the most lateral extent of the internal auditory canal. The spiral canals of the cochlea appear as small curved or round lucencies within the temporal bone. The cochlea should be defined in its entirety limited by vestibular apparatus posteriorly and middle ear laterally.
Cochlea_L	
Esophagus	Upper Cervical Esophagus, a tubular structure that starts at the bottom of pharynx (cricopharyngeal inlet) and extends to the thoracic inlet.
Eyes	Soft tissue spherical structure located within the orbital cavity.
LacrimalGlands	Structure sits superior and lateral to the globe of the eye; best generated on CT simulation image set and verified on MRI; bilateral contoured together
Larynx	Glottic and supraglottic larynx, including the tip of the epiglottis, the epiglottis, the aryepiglottic folds, arytenoids, false cords, and true cords, up to but not including the medial border of the thyroid cartilage, and including the cricoid cartilage to the inferior edge of the arytenoid cartilage, but not the hypopharynx. Posteriorly, the contour extends to the anterior edge of the pharyngeal wall.
Lens_R	Small structure on anterior border of the eye.
Lens_L	
Lips	Extends from the inferior margin of the nose to the superior edge of the mandibular body. The lateral border is at the lateral commissure. The lip contour should include the inner surface of the lips. Lips will be defined in their entirety (upper and lower).
Lungs	Low density structures, contoured together, inferiorly incomplete.
Mandible	High density bone that extends from the mental protuberance to the articulation points near the skull

OpticNerve_R OpticNerve_L	Extends from the posterior eye through the skull and connects to the optic chiasm. Typically extends inferiorly from the eye and then turns superiorly once through the skull.
OralCavity	Composite structure posterior to lips consisting of the anterior 1/2 to 2/3 of the oral tongue/floor of mouth, buccal mucosa, and superiorly the palate, and inferiorly to the plane containing the tip of the mandible
Parotid_R Parotid_L Parotids ParotidIpsi ParotidContra	Defined in their entirety (superficial and deep lobes) , the parotid gland is an irregular shaped gland wedged between the ramus of the mandible and the mastoid process. The superior border is the zygomatic arch, inferiorly, the gland extends to the angle of the mandible. The anterior border is the masseter muscle; in 20% of cases the parotid gland extends anteriorly over the surface of the masseter muscle, and posteriorly, to the anterior border of the sternocleidomastoid. Laterally, it extends to the platysma and medially, to the posterior belly of the digastric muscle, styloid process and parapharyngeal space. The retromandibular vein is included. Parotid_R/L structures to be duplicated to GTV relevant ParotidIpsi and ParotidContra
PharynxConst	Superior constrictor region (level of the inferior pterygoid plates) to the cricopharyngeal inlet (inferior level of the posterior cricoid cartilage). The posterior border is the pre-vertebral muscle
Pituitary	On the sella turcica with a cranio-caudal dimension of 10–12 mm and bilaterally is bordered by cavernous sinuses. Visible on axial T1-weighted contrast-enhanced MRI. For a better delineation, coronal and sagittal images are recommended
Posterior_Neck	Extends SpinalCord_05 posteriorly, see below.
Shoulders	3D bush tool, avoids neck and 1cm margin from lungs, see below.
Submandibular_R Submandibular_L	Defined in their entirety, the submandibular glands are paired salivary glands composed of a large superficial lobe and a smaller deep process that are continuous with each other around the posterior border of the mylohyoid muscle. The superior border is the mylohyoid muscle and medial pterygoid muscle. Inferiorly, the gland abuts fatty tissue. Anteriorly, the gland is adjacent to the lateral surface of the mylohyoid muscle and posteriorly it abuts the parapharyngeal space and sternocleidomastoid. The lateral border is platysma and the mandibular surface. The medial border is the lateral surface of the mylohyoid muscle and the anterior belly of the digastric. The submandibular gland is often hypodense on CT and can be distinguished from surrounding structures.
Thyroid	Has two connected lobes and is located below the thyroid cartilage. It has considerable contrast compared to its surrounding tissues.
TMJoint	The whole joint will not be visualized on any one slice due to angulation of the neck at simulation +/- jaw opening. The joint space is convex from anterior to posterior and right to left with the joint space extending more posteriorly than anteriorly. It is for this reason that the joint space appears more prominent posteriorly rather than anteriorly
Trachea	Inferior to larynx, esophagus posterior
External	External border of the patient



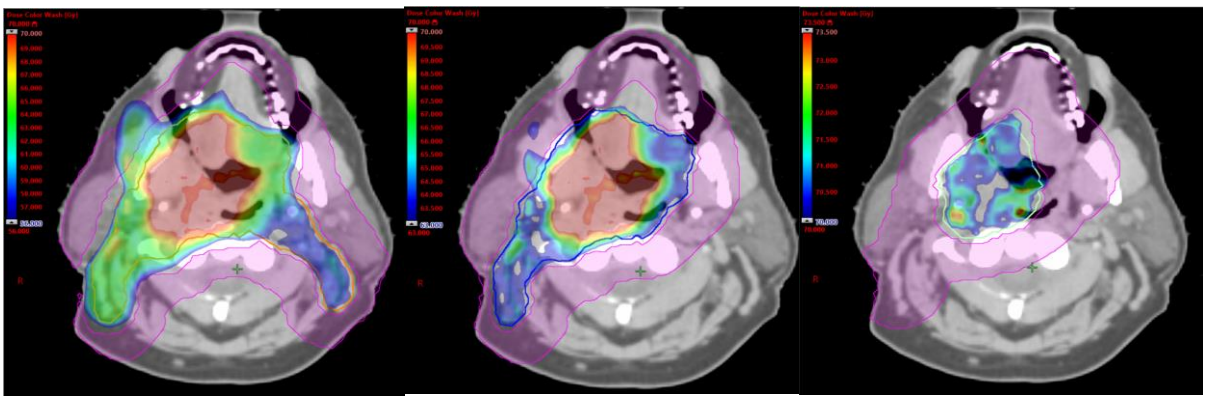
The planning target volumes (PTV) and the organs at risk (OARs) are contoured on the planning CT.

Optimization structure guidelines:*

Model Structure	Derived Boolean/Expansion
PTV_Total	{<PTV70> OR <PTV63> OR <PTV56>}
PTV70OPT	{<PTV70> SUB <BrachialPlexus>|+2mm}
PTV63OPT	{<PTV63> SUB <PTV70>|+3mm}
PTV56OPT	{<PTV56> SUB <PTV63>|+3mm SUB <PTV70>|+6mm}
RingPTV70	{<PTV70>|+30mm SUB <PTV70>|+2mm AND <BODY>}
RingPTV63	{<PTV63>|+30mm SUB <PTV63>|+2mm SUB <PTV70>|+6mm AND <BODY>}
RingPTV56	{<PTV56>|+30mm SUB <PTV56>|+2mm SUB <PTV63>|+6mm SUB <PTV70>|+9mm AND <BODY>}
PTV63-PTV70	{<PTV63> SUB <PTV70>}
PTV56-PTV63	{<PTV56> SUB <PTV63> SUB <PTV70>}
SpinalCord_05	{<SpinalCord>|+5mm}
Brainstem_03	{<Brainstem>|+3mm}
ParotdIps-PTV	{<ParotidIpsi> SUB <PTV_Total>}
ParotdCon-PTV	{<ParotidContra> SUB <PTV_Total>}
Parotids-PTV	{<ParotidContra> OR <ParotidIpsi> SUB <PTV_Total>}
PharConst-PTV	{<PharynxConst> SUB <PTV_Total>}
Mandible-PTV	{<Mandible> SUB <PTV_Total>}
OCavity-PTV	{<OralCavity> SUB <PTV_Total>}
Larynx-PTV	{<Larynx> SUB <PTV_Total>}
Thyroid-PTV	{<Thyroid> SUB <PTV_Total>}
SubmandL-PTV	{<Submandibular_L> SUB <PTV_Total>}
SubmandR-PTV	{<Submandibular_R> SUB <PTV_Total>}
Submand-PTV	{<Submandibular_R> OR <Submandibular_L> SUB <PTV_Total>}

* Optimization structures can be automatically created with ESAPI MAAS-PlanScoreCard tool or Ethos

RingPTV56 RingPTV63 RingPTV70



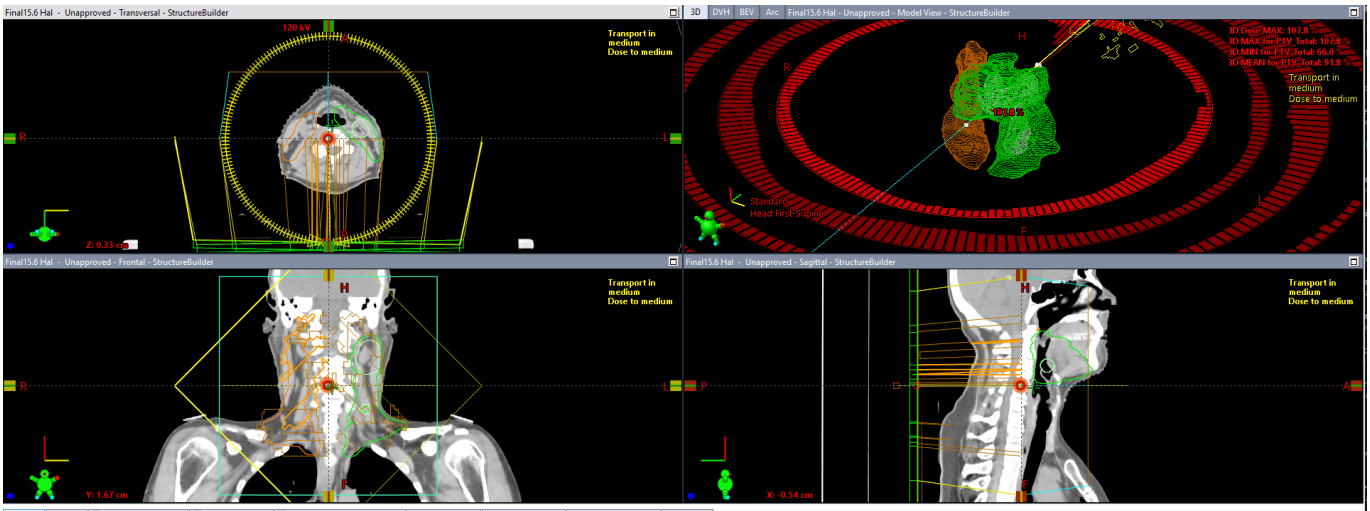
Cropped 0.2cm from PTV56, 0.6cm from PTV63, and 0.9cm from PTV70

Cropped 0.2cm from PTV63 and 0.6cm from PTV70

Cropped 0.2cm from PTV70

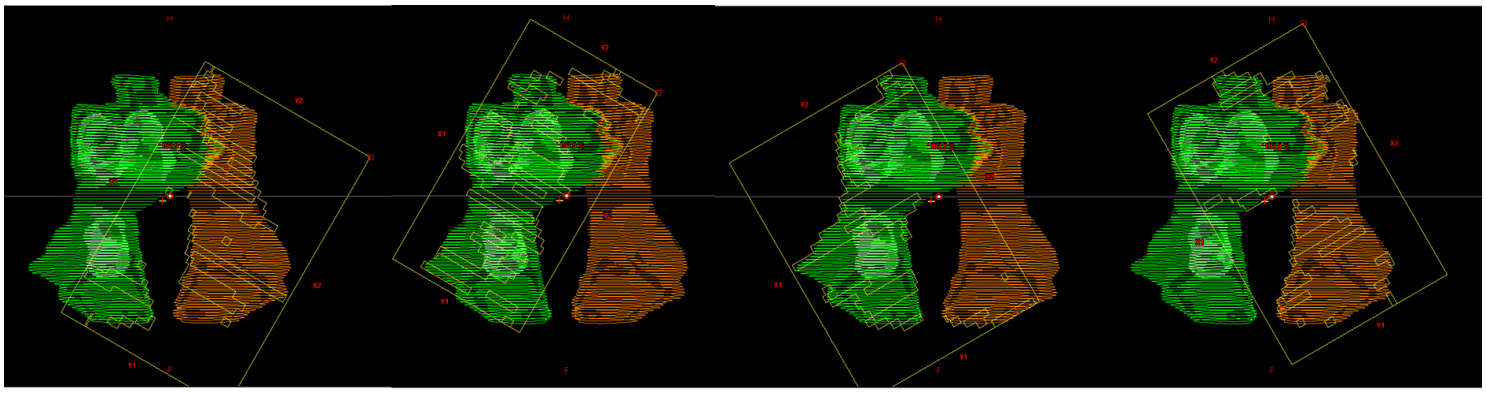
Treatment planning guidelines:

All cases used to train and to validate the model were planned using head-first supine position with head positioned in a neutral position. All patients were immobilized with an aquaplast mask. A four arc VMAT technique was utilized with four full coplanar arcs on Halcyon with MLC in SX2 mode (standard mode on all Halcyon D / Drive and above configurations). Arcs had alternating clock-wise and counter clock-wise gantry rotations with collimator positions set at 315, 0, 45 and 90. The coplanar arcs had 359.8 degrees of arc rotation for each field. Arcs were positioned at a single isocenter located in the center of the patient, laterally and the center of and within the PTVTotal in the superior-inferior direction.



Group	Field ID	Technique	Machine/Energy	MLC	Field Weight	Scale	Gantry Rtn [deg]	Coll Rtn [deg]	X [cm]	Y [cm]	Z [cm]	Calculated SSD [cm]	MU	Ref. D [Gy]
I	kVCBCT	Static-I	RDS3 Ti kV - 6X-FFF		0.000	IEC61217	0.0	0.0	-0.54	1.67	0.33	92.4		
I	Field 1	Arc Therapy-I	RDS3 Ti kV - 6X-FFF	VMAT	1.293	IEC61217	181.0 CW 179.0	315.0	-0.54	1.67	0.33	87.7	258.7	
I	Field 2	Arc Therapy-I	RDS3 Ti kV - 6X-FFF	VMAT	2.326	IEC61217	179.0 CCW 181.0	45.0	-0.54	1.67	0.33	87.7	465.2	
I	Field 3	Arc Therapy-I	RDS3 Ti kV - 6X-FFF	VMAT	1.574	IEC61217	181.0 CW 179.0	0.0	-0.54	1.67	0.33	87.7	314.8	
I	Field 4	Arc Therapy-I	RDS3 Ti kV - 6X-FFF	VMAT	0.630	IEC61217	179.0 CCW 181.0	90.0	-0.54	1.67	0.33	87.7	126.1	

When utilizing this model for TrueBeam, two arcs with alternating gantry rotations (CW and CCW) and collimator positions set at 30° and 330° (or less for taller/wider targets, ex: 20° and 340°) are recommended to start. Then, each arc is to be duplicated (copy+paste) with carriages split to create four arcs with jaws defined such that each covers the X1 or X2 side, this so-called "flip flop" method is seen below. The split arc apertures should overlap, but always ensure M120 /HD-MLC VMAT plans, total X jaw span does not exceed 15.0cm.



Full model validation results for TrueBeam (M120 MLC), including a quantification of the relative dosimetric performance of both Truebeam and Halcyon delivery methods are provided later in this document.

Target Clinical Goals

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

Standard Target Name	Dose [Gy]	Fraction Size [Gy]	# of fractions	Dose specification technique
PTV70 / PTV70opt	70	2.0	35	>=95% of PTV should receive >=70 Gy
PTV63 / PTV63opt	63	1.8	35	>=95% of PTV should receive >=63Gy
PTV56 /PTV56opt	56	1.6	35	>=95% of PTV should receive >=56Gy

This model is compatible (trained and validated) with two or three dose levels, always PTV70 and PTV56 while the intermediated dose level, PTV63, is optional. Other fractionation regimens may work, however, this model has not been tested at other prescriptions. Use caution if scaling this model by a significant amount.

OAR Clinical Goals:

Name of Structure	Dosimetric parameter	Goal	Variation Acceptable
PTV70 or PTV70opt	D95%[Gy]	70	> 68.6 and < = 71.4
	D99%[Gy]	> = 66.5	> = 63
	D0.03cc[Gy]	< = 77	< = 80.5
PTV63	D95%[Gy]	> = 63	> = 59.8
PTV56	D95%[Gy]	> = 56	> = 53.2
SpinalCord_05	D0.03cc[Gy]	< = 50	< = 52
SpinalCord	D0.03cc[Gy]	< = 45	< = 48
BrainStem_03	D0.03cc[Gy]	< = 52	< = 54
Esophagus	Mean [Gy]	< = 30	< = 35
	V54 [%]	< = 15	< = 20
BrachialPlexus_R/L	D0.03cc[Gy]	< = 66	< = 72
Parotid_R/L (at least one gland)	Mean[Gy]	< = 26	< = 35Gy Uninvolved Ipsilateral
Larynx (uninvolved)	Mean[Gy]	< = 40	N/A
Pharynx (uninvolved)	Mean[Gy]	< = 45	N/A
OralCavity (uninvolved)	Mean[Gy]	< = 35	N/A
Lips	Mean[Gy]	< = 20	< = 30
Submandular_R/L (contralateral)	Mean[Gy]	< = 39	N/A
Cochlea_R/L	Mean[Gy]	< = 35	N/A
Mandible	D0.03cc[Gy]	< = 73.5	N/A

References for contouring and planning guidelines:

Brouwer et al **CT-based delineation of organs at risk in the head and neck region: DAHANCA, EORTC, GORTEC, HKNPCSG, NCIC CTG, NCRI, NRG Oncologyand TROG consensus guidelines**
http://dx.doi.org/10.1016/j.radonc.2015.07.041
(https://www.eortc.org/app/uploads/2018/02/Atlas-HN.pdf)

NRG-HN001, NRG-HN004, NRG-HN008
https://www.nrgoncology.org/

Washington University Head & Neck Model Description
Varian Provided DVH Estimation Model PI 009977-003-C

Dosimetric Scorecard overview-points only:

Summary of 53 metric dosimetric 260 point scorecard, based on various clinical goal sets, guided this work.

Metric Id	Structure Id	Metric	Max Score
0	PTV70OPT	Volume at 70Gy [%]	20
1	PTV70OPT	Dose at 99.5% [Gy]	1.5
2	PTV70OPT	Dose at 0.03CC [Gy]	10
3	PTV63	Volume at 63Gy [%]	17
4	PTV63	Dose at 99.5% [Gy]	1.5
5	PTV63-PTV70	Volume at 66.15Gy [%]	8
6	PTV56	Volume at 56Gy [%]	15
7	PTV56	Dose at 99.5% [Gy]	1.5
8	PTV56-PTV63	Volume at 58.8Gy [%]	8
9	SpinalCord_05	Dose at 0.03CC [Gy]	6.5
10	SpinalCord_05	Volume at 40Gy [%]	2
11	SpinalCord_05	Volume at 30Gy [%]	2
12	Brainstem_03	Dose at 0.03CC [Gy]	4
13	Brain	Dose at 0.03CC [Gy]	2
14	Brain	Volume at 50Gy [CC]	3
15	Pituitary	MeanDose [Gy]	1
16	Chiasm	Dose at 0.03CC [Gy]	3
17	OpticNerve_L	Dose at 0.03CC [Gy]	3
18	OpticNerve_R	Dose at 0.03CC [Gy]	3
19	LacrimalGlands	MeanDose [Gy]	3
20	Cochlea_R	Volume at 40Gy [%]	3
21	Cochlea_L	Volume at 40Gy [%]	3
22	Lens_R	Dose at 0.03CC [Gy]	2.5
23	Lens_L	Dose at 0.03CC [Gy]	2.5
24	Eye_R	Dose at 0.03CC [Gy]	2
25	Eye_R	MeanDose [Gy]	2
26	Eye_L	Dose at 0.03CC [Gy]	2
27	Eye_L	MeanDose [Gy]	2

Metric Id	Structure Id	Metric	Max Score
28	Lips	MeanDose [Gy]	7
29	ParotdIps-PTV	MeanDose [Gy]	12
30	ParotdCon-PTV	MeanDose [Gy]	15
31	PharConst-PTV	MeanDose [Gy]	5
32	Mandible-PTV	Volume at 70Gy [%]	5
33	Mandible-PTV	Volume at 60Gy [%]	2
34	Mandible-PTV	Volume at 50Gy [%]	2
35	Esophagus	MeanDose [Gy]	4
36	Esophagus	Dose at 0.03CC [Gy]	3
37	OCavity-PTV	MeanDose [Gy]	6
38	OCavity-PTV	Dose at 0.03CC [Gy]	2
39	Larynx-PTV	MeanDose [Gy]	7
40	Thyroid-PTV	MeanDose [Gy]	2
41	BrachialPlexus_L	Dose at 0.1CC [Gy]	4
42	BrachialPlexus_R	Dose at 0.1CC [Gy]	4
43	SubmandL-PTV	MeanDose [Gy]	9.25
44	SubmandR-PTV	MeanDose [Gy]	9.25
45	TMJoint	Dose at 0.03CC [Gy]	2
46	RingPTV70	Dose at 0.03CC [Gy]	5
47	RingPTV63	Dose at 0.03CC [Gy]	5
48	RingPTV56	Dose at 0.03CC [Gy]	5
49	Posterior_Neck	Volume at 35Gy [%]	5
50	Trachea	MeanDose [Gy]	2.5
51	Lungs	Volume at 20Gy [CC]	2
52	Shoulders	MeanDose [Gy]	1

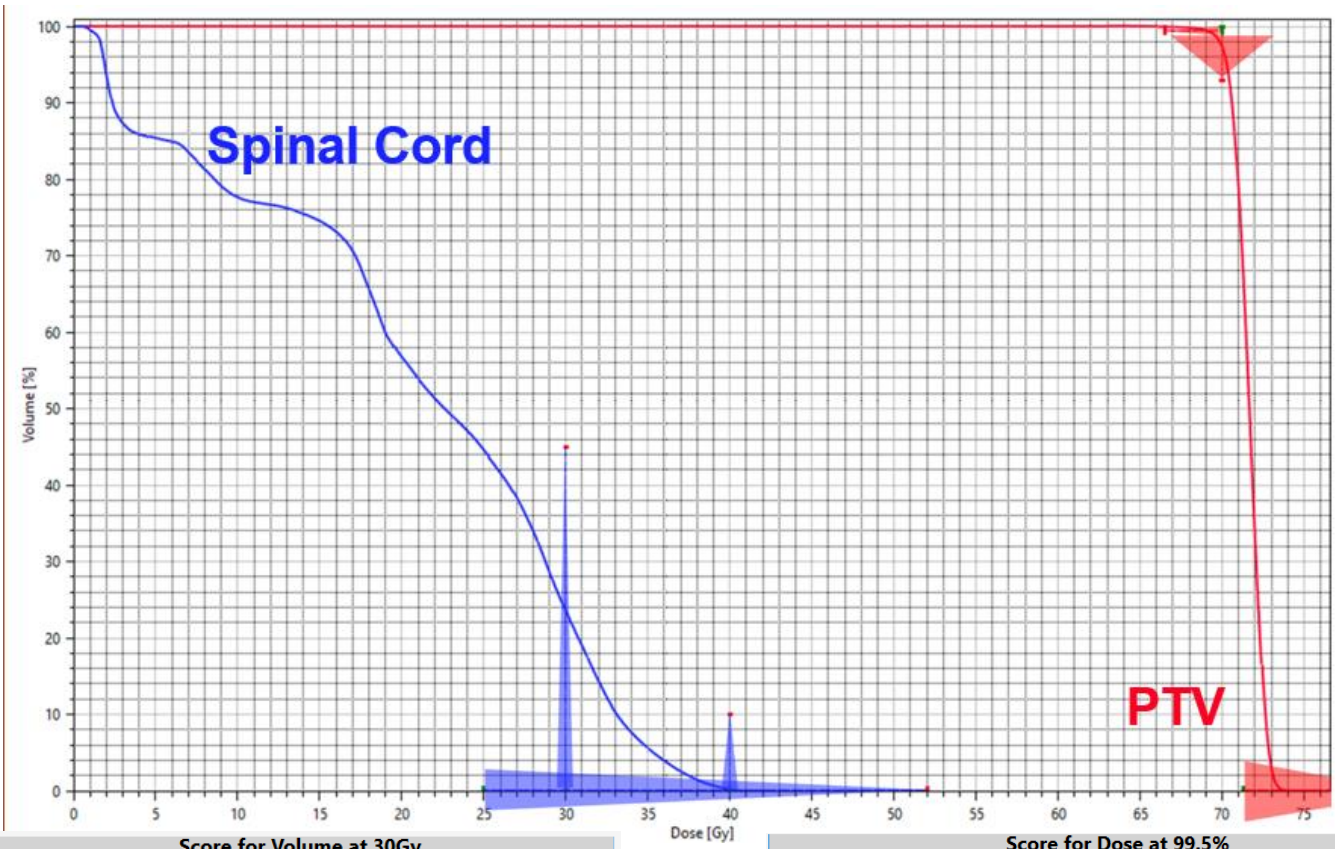
In general, how points are assigned between the various competing metrics on a dosimetric scorecard represents the physician's preference insofar as relative weighting, this weighting is a second order prioritization. Each function spans a DVH value range of two or more values (ranges not pictured, see next page), the starting, failing value (0 points) through the maximum, but often purposely unachievable, point value. The zero value represents a failure and is the first order priority. Optional intermediate point values can be added in between the failing point and the end of the aspirational range, covering the piecewise linear function shape and providing multiple levels of reasonably expected DVH values. Ideally, most maximum values are not achievable so as to continue to quantify additional improvement in already "very good" treatment plans. Care must be taken when attempting such a precise articulation of clinical intent. The full dosimetric scorecard provides a singular objective measure of dosimetric plan quality for a specific intent from which the RapidPlan optimization objective tuning can be manually iterated upon. This laborious model tuning process can prove worthwhile when such a RapidPlan model is deployed in a clinic and works as a single button press auto planning solution of high quality (as defined by it's associated dosimetric scorecard).

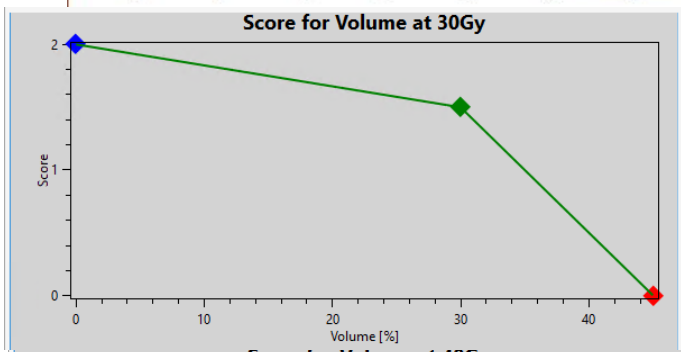
Example metrics for two structures are shown on the next page. For a full view of this dosimetric score card, see Annex C or download the scorecard json online here:

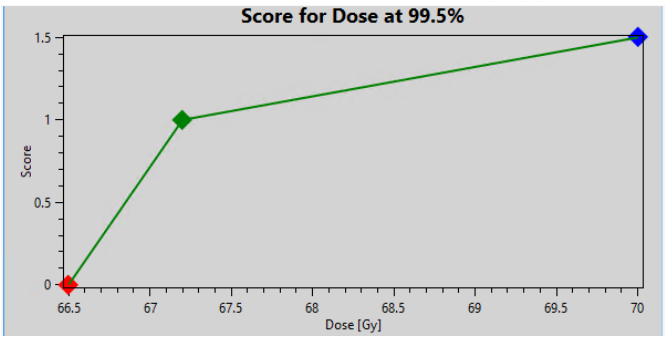
https://medicalaffairs.varian.com/hn-sib-bpi-rapidplan-vmat2

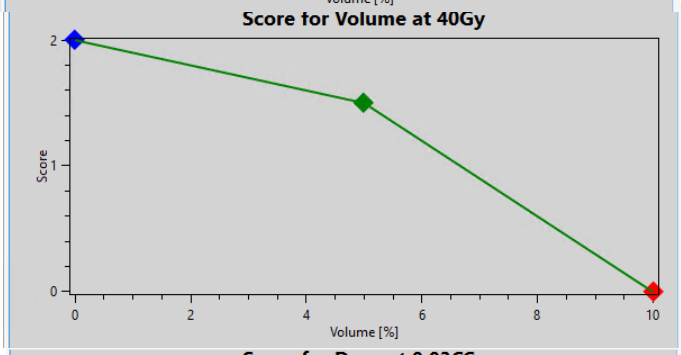
Dosimetric Scorecard selected piecewise linear metrics plotted on DVH:

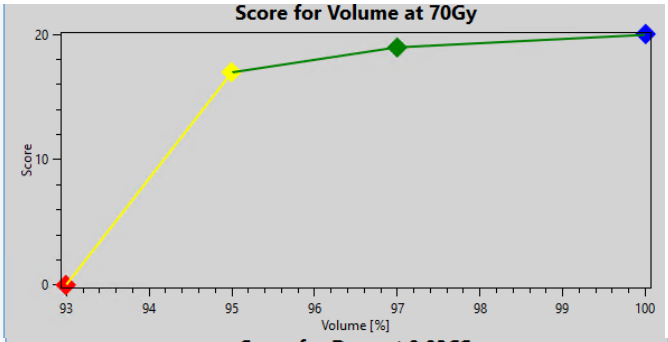
Volume at Dose (vertical) and Dose at Volume (horizontal) lines *with expansions to represent increasing score*

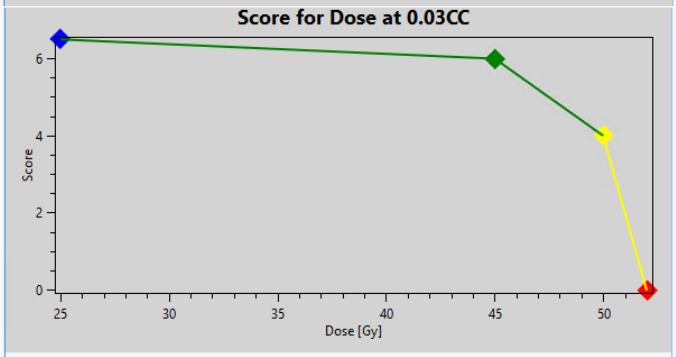


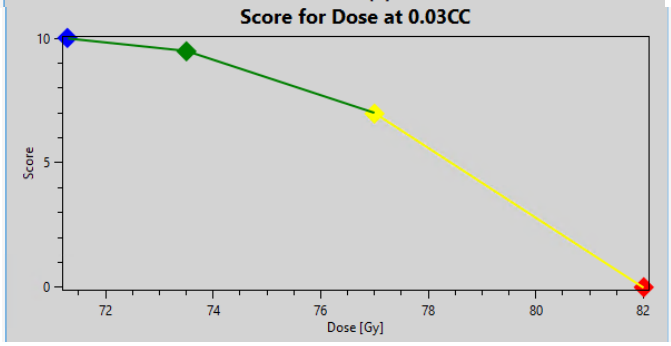












Structure codes:

Recommended structure code assignment:

PTV70/PTV70OPT	PTV_High (99VMS STRUCTCODE)
PTV63/PTV63OPT	PTV_Intermediate (99VMS STRUCTCODE)
PTV56/PTV56OPT	PTV_Low (99VMS_STRUCTCODE)
Brain	50801 (FMA)
Brainstem	79876 (FMA)
Brainstem_03	79876 (FMA)
Pituitary	13889 (FMA)
Chiasm	62045 (FMA)
Cochlea_L	60203 (FMA)
Cochlea_R	60202 (FMA)
Lens_L	58243 (FMA)
Lens_R	58242 (FMA)
Esophagus	7131 (FMA)
Eye (R+L Separate)	12514 (FMA) and 12515 (FMA)
Lacrimal Glands (R+L Separate)	59103 (FMA) and 59102 (FMA)
Larynx	55097 (FMA)
Lips	59815 (FMA)
Mandible	52748 (FMA)
Rings	NS_Ring (99VMS_STRUCTCODE)
Shoulders	Control (99VMS STRUCTCODE)
Posterior_Neck	PRV (99VMS STRUCTCODE)
Lungs	68877 (FMA)
OpticNerve_R	50875 (FMA)
OpticNerve_L	50878 (FMA)
OralCavity	20292 (FMA)
Parotids	59797 (FMA) and 59798 (FMA)
PharynxConst	54966 (FMA)
Thyroid	9603 (FMA)
TMJoint	54834 (FMA) and 54833 (FMA)
Trachea	7394 (FMA)
SpinalCord	7647 (FMA)
SpinalCord_05	PRV (99VMS_STRUCTCODE)
Submandibulars	59802 (FMA) and 59803 (FMA)
BrachialPlexus (R+L Separate)	45245 (FMA) and 45244 (FMA)

Optimization objectives:

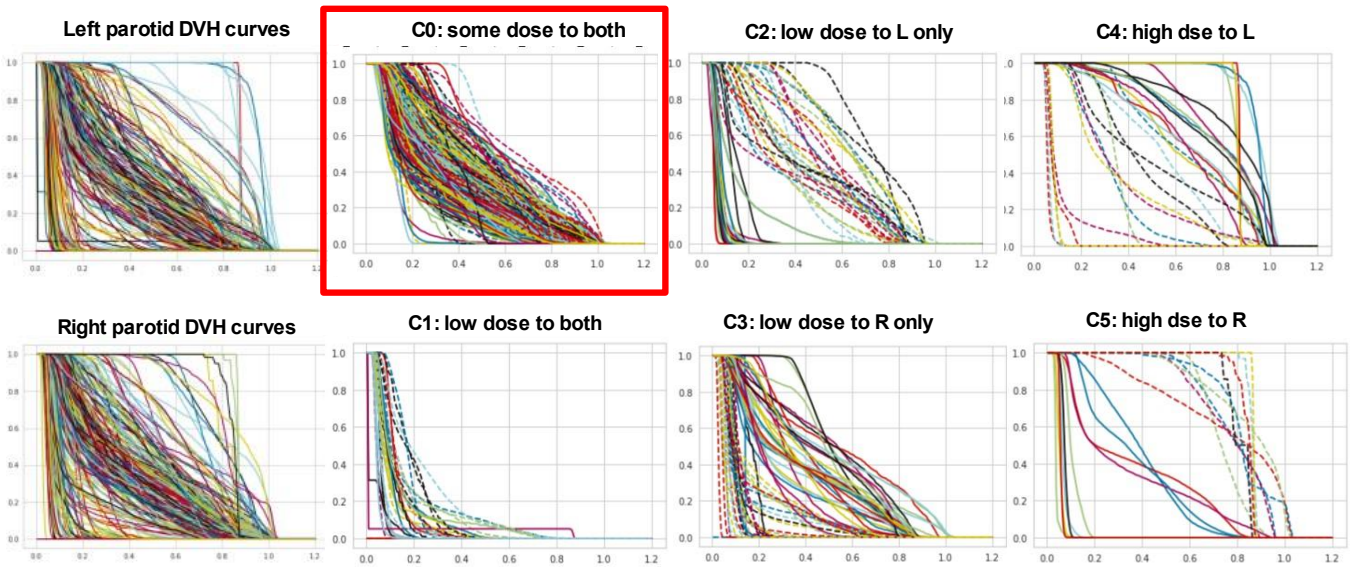
The following optimization objectives were defined in the model and will be generated when the model is applied to a new case:

Target	ID		Vol [%]	Dose	Priority	gEUD a
Yes	PTV56	(PTV_Low)				
	Lower		100.0	101.0 %	300	
Yes	PTV56OPT	(PTV_Low)				
	Upper		0.0	105.0 %	180	
Yes	PTV63	(PTV_Intermediate)				
	Lower		100.0	101.0 %	300	
Yes	PTV63OPT	(PTV_Intermediate)				
	Upper		0.0	105.0 %	180	
Yes	PTV70OPT	(PTV_High)				
	Upper		0.0	103.5 %	315	
	Lower		100.0	101.0 %	300	
	BrachialPlexus	(5906, 45245, 45244)				
	Upper		0.0	63.000 Gy	200	
	Upper		5.0	56.000 Gy	65	
	Line (preferring OAR)		Generated	Generated	60	
	Brain	(50801)				
	Upper (fixed vol., generated dose)		0.0	Generated	100	
	BrainStem	(79876)				
	Upper (fixed vol., generated dose)		0.0	Generated	150	
	Line (preferring OAR)		Generated	Generated	50	
	BrainStem_03	(79876)				
	Upper (fixed vol., generated dose)		0.0	Generated	125	
	Line (preferring OAR)		Generated	Generated	Generated	
	Chiasm	(62045)				
	Upper		0.0	45.000 Gy	200	
	Upper (fixed vol., generated dose)		0.0	Generated	40	
	Cochlea_L	(60203)				
	Mean			Generated	80	
	Line (preferring target)		Generated	Generated	65	
	Cochlea_R	(60202)				
	Mean			Generated	80	
	Line (preferring target)		Generated	Generated	65	
	Esophagus	(7131)				
	Upper (fixed dose, generated vol.)		Generated	45.000 Gy	50	
	Upper (fixed dose, generated vol.)		Generated	35.000 Gy	50	
	Upper (fixed vol., generated dose)		0.0	Generated	90	
	Mean			Generated	70	
	Line (preferring target)		Generated	Generated	60	
	Eyes	(264089, 12515, 12514)				
	Line (preferring target)		Generated	Generated	100	
	LacrimalGlands	(59103, 59102)				
	Line (preferring target)		Generated	Generated	40	
	Larynx	(55097)				
	Mean			Generated	75	
	Line (preferring target)		Generated	Generated	60	
	Larynx-PTV	(55097)				
	Mean			Generated	85	
	Line (preferring target)		Generated	Generated	90	
	Lens_L	(58243)				
	Upper (fixed vol., generated dose)		0.0	Generated	80	
	Lens_R	(58242)				
	Upper (fixed vol., generated dose)		0.0	Generated	80	
	Lips	(59815)				
	Mean			Generated	70	
	Line (preferring target)		Generated	Generated	65	
	Lungs	(68877)				
	Line (preferring target)		Generated	Generated	48	
	Mandible	(52748)				
	Upper (fixed vol., generated dose)		0.0	Generated	120	
	Line (preferring target)		Generated	Generated	60	
	Mandible-PTV	(52748)				
	Upper (fixed vol., generated dose)		1.0	Generated	130	
	Upper gEUD			Generated	60	12.0
	Line (preferring target)		Generated	Generated	70	
	OCavity-PTV	(20292)				
	Upper (fixed dose, generated vol.)		Generated	35.000 Gy	50	
	Upper (fixed dose, generated vol.)		Generated	45.000 Gy	50	
	Line (preferring target)		Generated	Generated	60	
	Trachea	(7394)				
	Mean			Generated	62	
	Line (preferring target)		Generated	Generated	55	

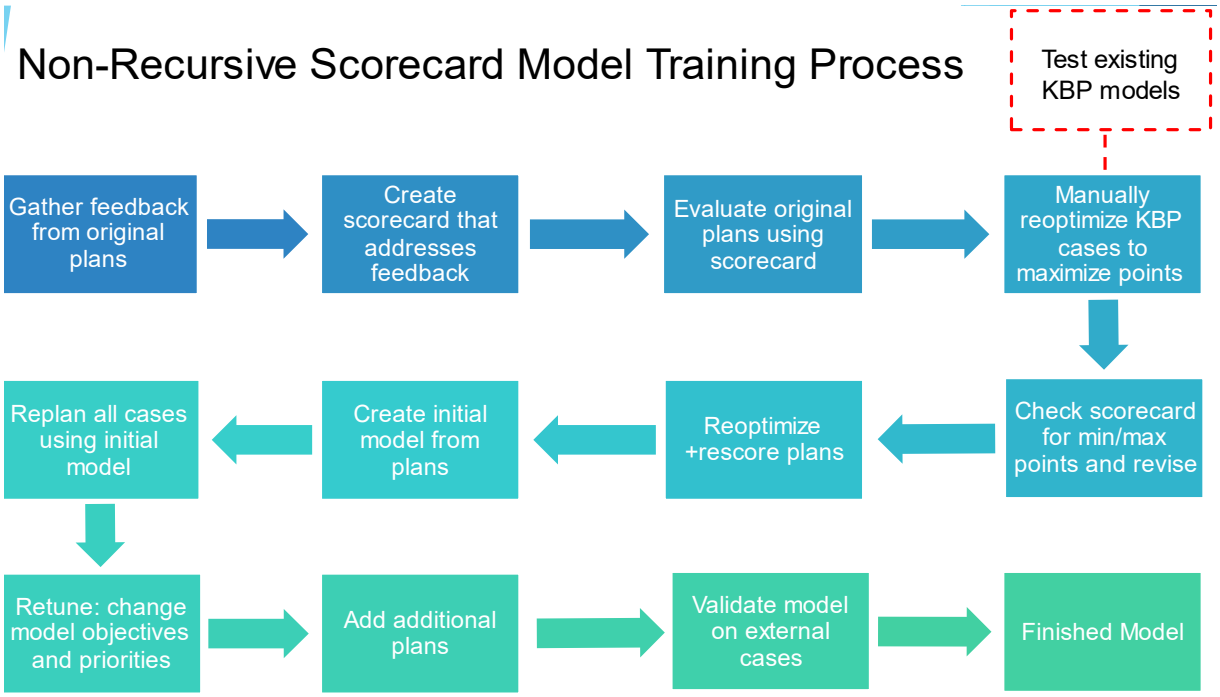
Target	ID		Vol [%]	Dose	Priority	gEUD a
	OpticNerve_L	(50878)				
	Upper		0.0	45.000 Gy	200	
	Upper (fixed vol., generated dose)		0.0	Generated	45	
	OpticNerve_R	(50875)				
	Upper		0.0	45.000 Gy	200	
	Upper (fixed vol., generated dose)		0.0	Generated	45	
	OralCavity	(20292)				
	Upper (fixed dose, generated vol.)		Generated	35.000 Gy	65	
	Mean			Generated	80	
	Line (preferring target)		Generated	Generated	75	
	ParotidCon-PTV	(Parotids)				
	Mean			Generated	65	
	Line (preferring target)		Generated	Generated	70	
	ParotidIps-PTV	(Parotids)				
	Mean			Generated	55	
	Line (preferring target)		Generated	Generated	60	
	Parotids	(Parotids, 59798, 59797)				
	Mean			Generated	100	
	Line (preferring target)		Generated	Generated	90	
	Parotids-PTV	(PRV)				
	Upper (fixed dose, generated vol.)		Generated	19.000 Gy	50	
	Upper (fixed dose, generated vol.)		Generated	9.000 Gy	50	
	Mean			Generated	80	
	Line (preferring target)		Generated	Generated	100	
	PharConst-PTV	(46688)				
	Mean			Generated	90	
	Line (preferring target)		Generated	Generated	80	
	PharynxConst	4966, 46621, 46622, 46623)				
	Mean			Generated	75	
	Line (preferring target)		Generated	Generated	78	
	Pituitary	(13889)				
	Line (preferring target)		Generated	Generated	45	
	Posterior_Neck	(Control)				
	Upper (fixed dose, generated vol.)		Generated	35.000 Gy	62	
	Mean			Generated	65	
	Line (preferring target)		Generated	Generated	70	
	RingPTV56	(Ring)				
	Upper		0.0	53.200 Gy	250	
	RingPTV63	(Ring)				
	Upper		0.0	59.850 Gy	250	
	RingPTV70	(Ring)				
	Upper		0.0	66.500 Gy	250	
	Shoulders	(NormalTissue)				
	Upper (fixed vol., generated dose)		0.0	Generated	100	
	Line (preferring target)		Generated	Generated	55	
	SpinalCord	(7647)				
	Upper (fixed vol., generated dose)		0.0	Generated	200	
	Line (preferring OAR)		Generated	Generated	50	
	SpinalCord_05	(7647)				
	Upper (fixed dose, generated vol.)		Generated	40.000 Gy	60	
	Upper (fixed dose, generated vol.)		Generated	30.000 Gy	55	
	Upper (fixed vol., generated dose)		0.0	Generated	200	
	Line (preferring OAR)		Generated	Generated	50	
	Submandibular	mandibular, 59803, 59802)				
	Mean			Generated	75	
	Line (preferring target)		Generated	Generated	70	
	SubmandL-PTV	(59803)				
	Mean			Generated	65	
	Line (preferring target)		Generated	Generated	60	
	Submand-PTV	(Submandibular)				
	Mean			Generated	90	
	Line (preferring target)		Generated	Generated	85	
	SubmandR-PTV	(59802)				
	Mean			Generated	65	
	Line (preferring target)		Generated	Generated	60	
	Thyroid	(9603)				
	Mean			Generated	48	
	Line (preferring target)		Generated	Generated	50	
	Thyroid-PTV	(9603)				
	Mean			Generated	45	
	TMJoint	(54834, 54833)				
	Upper (fixed vol., generated dose)		0.0	Generated	100	
	Line (preferring target)		Generated	Generated	40	

Model Training:

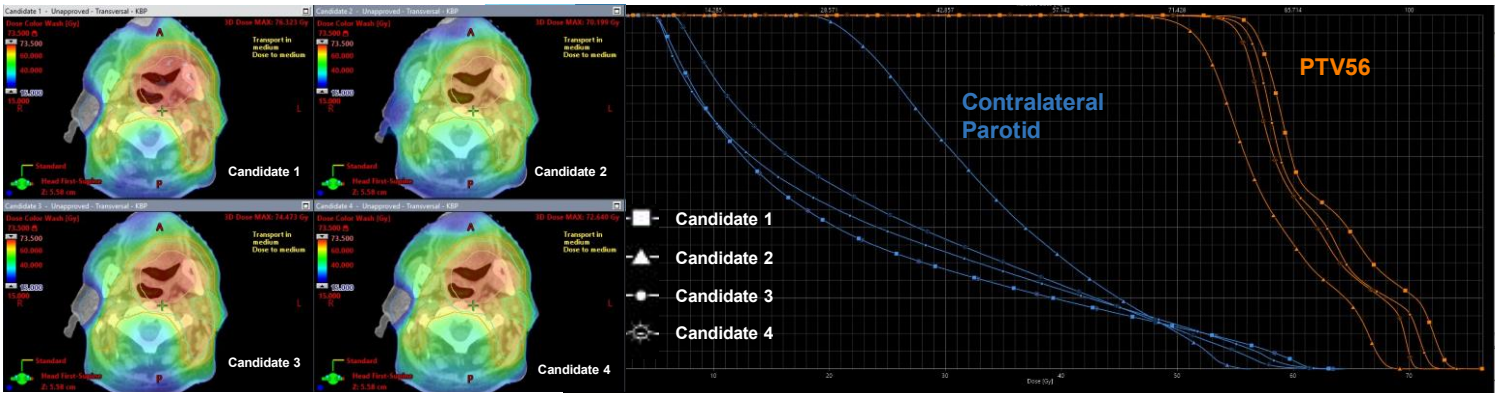
This Head & Neck SIB70Gy(63Gy)56Gy Bilateral Parotid Involved (HN-SIB-BPI) Model (HNSIB-BPI) model was originally trained with a select 27 case dataset from a single institution. Those cases were selected from a large dataset filtered to only bilateral parotid involvement. These so called "Cluster 0" cases were identified in an AI clustering exercise when this larger cohort was already being used to train an AI 3D dose prediction model.



Those Bilateral parotid involvement cases initially identified were further filtered to include only cases with 3 target dose levels, leaving only 27 cases in the initial training set. Rather than employing the usual recursive model creating training set, whereby an initial model is first created to generate training set cases for a final model – this time an existing RapidPlan models, both public and private were tested to create useful starting doses (clinical doses are too inconsistent and are therefore not used) and a dosimetric scorecard was developed to quantify improvement throughout the process, summarized below.

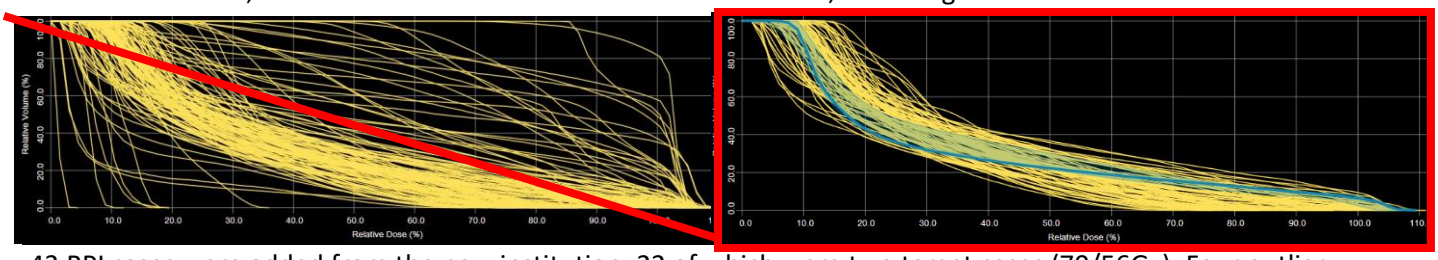


After creating doses with four existing candidate head and neck RapidPlan models, the one most matching this model's desired dosimetric performance was selected: Candidate 1. Qualitative isodose, selected PTV + OAR DVH analysis and quantitative dosimetric scorecard results: 181.82(1); 138.51(2); 161.09(3) and 144.00(4) agreed.

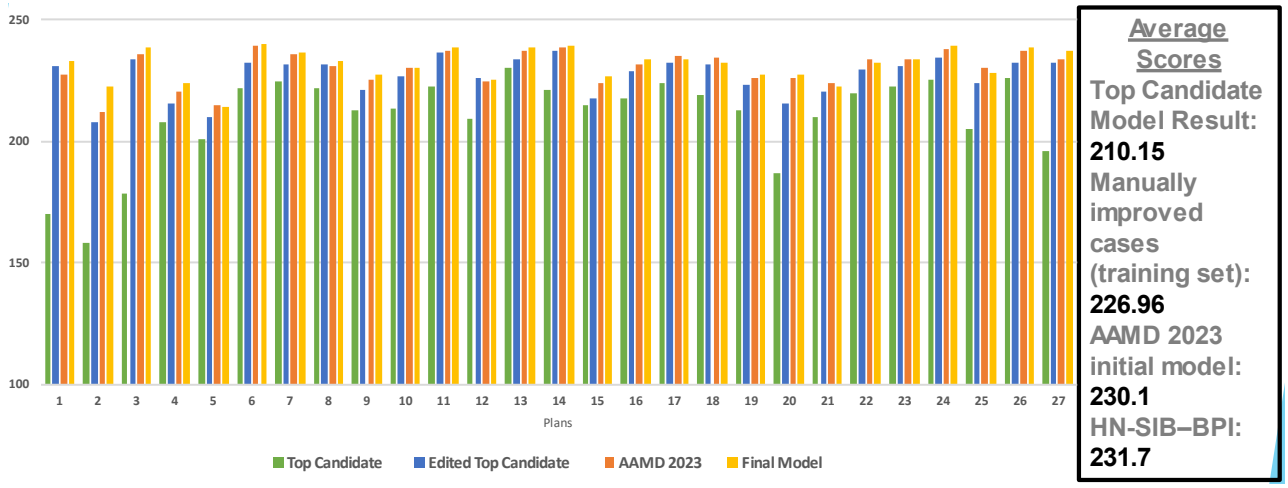


All 27 training set cases were planned with the candidate 1 model and scored -- there was room for improvement. Each of those resulting cases were manually improved, adding ring structures/conformality and increasing OAR sparing and target coverage where possible. Those manually improved 27 plans became the training set for the initial model. After analysis, tuning and retuning of the automatically created optimization objectives, early results were shown at the AAMD 2023 annual meeting: https://medicalaffairs.varian.com/download/Handouts_-_Taking_Knowledge_Based_Planning_to_the_Next_Level_Modern_Tools_to_Build_Better_Models_Faster.pdf.

Certain structures were not getting reasonable DVH prediction with some validation patients, so additional training set cases were needed. Another institution offered additional cases to improve the model from their own in-progress RapidPlan model. Their head and neck model's parotid DVH model configuration workspace looked like the below-left, then limited to cases with bilateral involvement, below-right.



43 BPI cases were added from the new institution, 22 of which were two target cases (70/56Gy). Four outlier cases were omitted for a total of 66 cases in the final model. Both optimization objective and NTO priorities were further tuned. The resulting final HN-SIB-BPI features more robust DVH estimations for a broader variety of cases.



Model Validation:

In addition to the initial 27 case training set, model tuning and validation shown above, this HN-SIB-BPI model was validated using eight external validation cases: four with 3 targets + four with 2 targets on both Halcyon and TrueBeam. Below dosimetric scorecard results quantify performance on validation cases while changing beam energy between flat and FFF and examine performance with current algorithms with Enhanced Leaf modeling compared with older algorithms with more primitive Dosimetric Leaf Gap based leaf tip modeling

3 Target 260 totalpoints 4 arcs Validation cases (HN-BPI-SIB)								
	Halcyon				TrueBeam			
	Opt. + Calc. Non ELM (V17)		*Opt. + Calc. ELM (V18)*		Opt. + Calc. Non ELM (V17)		Opt. + Calc. ELM (V18)	
	HN-SIB-BPI		*HN-SIB-BPI*		HN-SIB-BPI		HN-SIB-BPI	
Case	Score	MU	*Score*	*MU*	Score	MU	Score	MU
HN37	221.09	1039	*213.44*	*789.5*	224.94	1050	226.67	943
HN31	235.03	1095	*232.47*	*785.6*	234.29	1094	235.06	911
HN46	209.6	1008	*202.22*	*770.9*	208.75	992	206.79	905
HN38	219.8	1020	*212.58*	*880.5*	220.05	1020	220.97	890
Average	**221.38**	**1040.5**	***215.1775***	***806.625***	**222.0075**	**1039**	**222.3725**	**912.25**

3 Target 260 totalpoints 4 arcs Validation cases (HN-BPI-SIB) Lower MU Objective (1100min at Priority 70)								
	Halcyon				TrueBeam			
	Opt. + Calc. Non ELM (V17)		Opt. + Calc. ELM (V18)		*Opt. + Calc. Non ELM (V17)*		*Opt. + Calc. ELM (V18)*	
	HN-SIB-BPI		HN-SIB-BPI		*HN-SIB-BPI*		*HN-SIB-BPI*	
Case	*Score*	*MU*	Score	MU	*Score*	*MU*	*Score*	*MU*
HN37	*223.63*	*1,582.10*	224.71	1,269.50	*227.05*	*1365*	*227.26*	*1370*
HN31	*233.75*	*1,442.60*	234.65	1,188.10	*234.41*	*1346*	*235.46*	*1,459*
HN46	*206.8*	*1,463.60*	206.59	1069.5	*209.79*	*1232*	*209.28*	*1276*
HN38	*225.72*	*1,663.10*	218.11	1325.7	*220.59*	*1379*	*220.23*	*1390*
Average	***222.475***	***1537.85***	**221.015**	**1213.2**	***222.96***	***1330.5***	***223.0575***	***1373.75***

2 Target 228.5 total 4 arcs Validation (6XFFF vs 6X)														
	Halcyon						TrueBeam							
	Non ELM (V17)		*ELM (V18)*		ELM (V18.MU1000)		Opt. + Calc. Non ELM (V17)				Opt. + Calc. ELM (V18)			
	6X-FFF	6X-FFF	*6X-FFF*	*6X-FFF*	6X-FFF	6X-FFF	6X-FFF		6X		6X-FFF		6X	
Case	Score	MU	*Score*	*MU*	Score	MU	Score	MU	Score	MU	Score	MU	Score	MU
C05_119	180.41	1009	*171.6*	*741.7*	182.55	1219	188.41	1841	183.95	1344	174.11	1302	183.52	1124
C05_143	180.76	968.1	*191.6*	*750.2*	196.44	1145.7	200.77	1384	200.48	1367	201.14	1340	197.81	1144
C05_169	209.53	1031.2	*209.2*	*848.6*	208.43	1113.9	207.8	1470	208.42	1195	207.47	1460	209.01	1213
C05_019	213.65	958.6	*213*	*817.4*	214.25	1050	211.97	1585	213.98	1301	215.04	1604	214.45	931
Average	**196.0875**	**991.725**	***196.3***	***789.48***	**200.42**	**1132.15**	**202.24**	**1570**	**201.71**	**1301.8**	**199.44**	**1426.5**	**201.2**	**1103**

This HN-SIB-BPI RapidPlan model validation demonstrates excellent performance on both Halcyon and TrueBeam with both v17 and v18 algorithms with Enhanced Leaf modeling. Version 18 of the Photon Optimizer seems to have been tuned to result in more efficient, lower MU plans. This tuning results in generally equivalent quality TrueBeam plans with fewer MU when measured by the relevant dosimetric scorecard. However, Halcyon plans from V18 Photon Optimizer have reduced monitor units and score lower than v17 Photon Optimizer unless utilizing the minimum MU objective during optimization (recommend MinMU 1000 strength 70). Columns in italics indicate suboptimal result. All TrueBeam plans and Halcyon v17 PO plan increase MU without increasing score, thus enabling minimum MU objective is only recommended for Halcyon plans with Photon Optimizer v18.0. See Annex A for further testing of this phenomenon indicating the V18 Photon Optimizer when creating Halcyon plans does not add enough MU during Intermediate Dose Optimizations producing plans with compromised dosimetric performance. A work around is adding more MU during initial optimization in v18.0 for Halcyon.

Annex Directory

Annex A: Validation Results

A1: V17/V18 Photon Optimizer MU investigation with Halcyon on 3 target validation set

Case	V17 PO and AXB								
	MR3x0			MR3x1			MR3x2		
Case	Score	MU	Norm%	Score	MU	Norm%	Score	MU	Norm%
HN37	190.64	696.7	92.8	217.75	1060.2	99.8	224.08	1105.9	100.2
HN31	209.4	635.9	95.9	232.62	959.5	99.8	234.59	1100.5	100.5
HN46	182.38	730.8	92.5	206.72	883.5	99.9	207.33	997.5	100.2
HN38	195.15	712.1	93.4	222.47	1020	100.1	223.18	1183.7	100.4
Average	**194.39**	**693.88**	**93.65**	**219.89**	**980.80**	**99.90**	**222.30**	**1096.90**	**100.33**

	V17 PO and AXB then recalced with V18 AXB								
	MR3x0			MR3x1			MR3x2		
Case	Score	MU	Norm%	Score	MU	Norm%	Score	MU	Norm%
HN37	189.34	697.9	92.7	218.33	969.2	99.9	222.95	1103.6	100.2
HN31	210.29	707.6	96	231.42	958.3	100	231.71	1093.9	100.7
HN46	171.39	728.1	92.8	205.66	882.8	100	206.36	995.6	100.4
HN38	190.94	712.2	93.4	222.31	1021.1	100.4	223.72	1180.1	100.1
Average	**190.49**	**711.45**	**93.73**	**219.43**	**957.85**	**100.08**	**221.19**	**1093.30**	**100.35**

Case	V18 PO and AXB								
	MR3x0			MR3x1			MR3x2		
	Score	MU	Norm%	Score	MU	Norm%	Score	MU	Norm%
HN37	196.63	688.1	95.3	218.51	774.1	100	217.49	804.4	100.2
HN31	215.59	721.9	95.5	223.82	773.1	100.7	231.41	821.6	100.7
HN46	192.42	724.1	94.9	202.83	768.3	100	203.3	801.9	100.3
HN38	198.09	708.2	95.3	207.45	826.6	98.8	203.57	885.6	100.3
Average	**200.68**	**710.58**	**95.25**	**213.15**	**785.53**	**99.88**	**213.94**	**828.38**	**100.38**

	V18 PO and AXB then recalced with V17 AXB								
	MR3x0			MR3x1			MR3x2		
Case	Score	MU	Norm%	Score	MU	Norm%	Score	MU	Norm%
HN37	197.52	687.6	94.4	217.06	774.1	100	215.88	805	100
HN31	215.12	721.6	94.9	221.01	774.9	100.4	227.44	823.6	100.4
HN46	191.42	723.5	94.1	203.14	768.3	100	203.4	803.3	100.1
HN38	190.39	733.2	92	207.07	826.8	100.1	210.56	891.3	100
Average	**198.61**	**716.48**	**93.85**	**212.07**	**786.03**	**100.13**	**214.32**	**830.80**	**100.13**

Case	V18 PO and AXB - Lower MU Objective (1000 & Priority 70)								
	MR3x0			MR3x1			MR3x2		
	Score	MU	Norm%	Score	MU	Norm%	Score	MU	Norm%
HN37	198.49	1025.9	95.1	223.43	1092.9	100	221.77	1143.8	100.1
HN31	213.8	1032.5	94.8	233.78	1108.2	99.9	234.64	1165.2	100
HN46	192.96	1060.9	94.3	201.45	1093.5	99.1	208.87	1143.6	100.2
HN38	191.53	1091.9	92.2	212.34	1164.8	98.6	217.08	1223	99.9
Average	**199.20**	**1052.80**	**94.10**	**217.75**	**1114.85**	**99.40**	**220.59**	**1168.90**	**100.05**

When V18.0 PO is used with Halcyon, MUs are always low and score suffers unless utilizing lower MU objective. All plans normalized to max score. MR3 return used for intermediate dose (MR3x1), MR3x2 restarts optimizer with current dose.

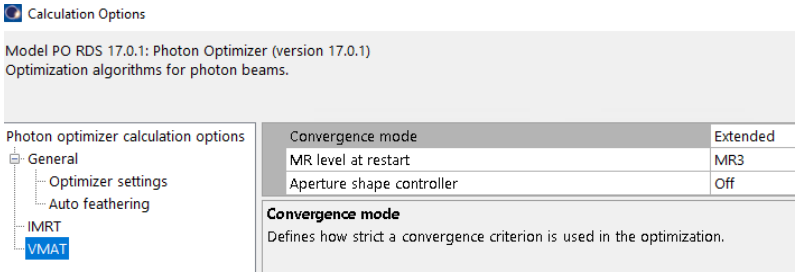
Annex A: Validation Results

A2: Convergence Mode: Off, On, Extended TrueBeam 6X v18 PO AXB MR3 Intermediate dose

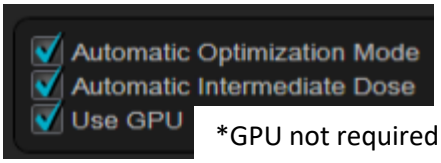
(v18 algorithms, adjusting convergence mode, MR3 return)

Case C05_019 validation with TrueBeam

Use intermediate dose with MR3 return, adjusting convergence mode:

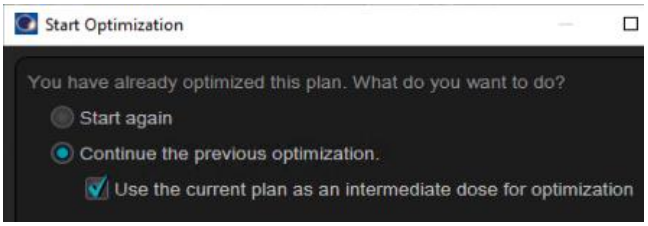


MR3x1= "Automatic Intermediate dose"

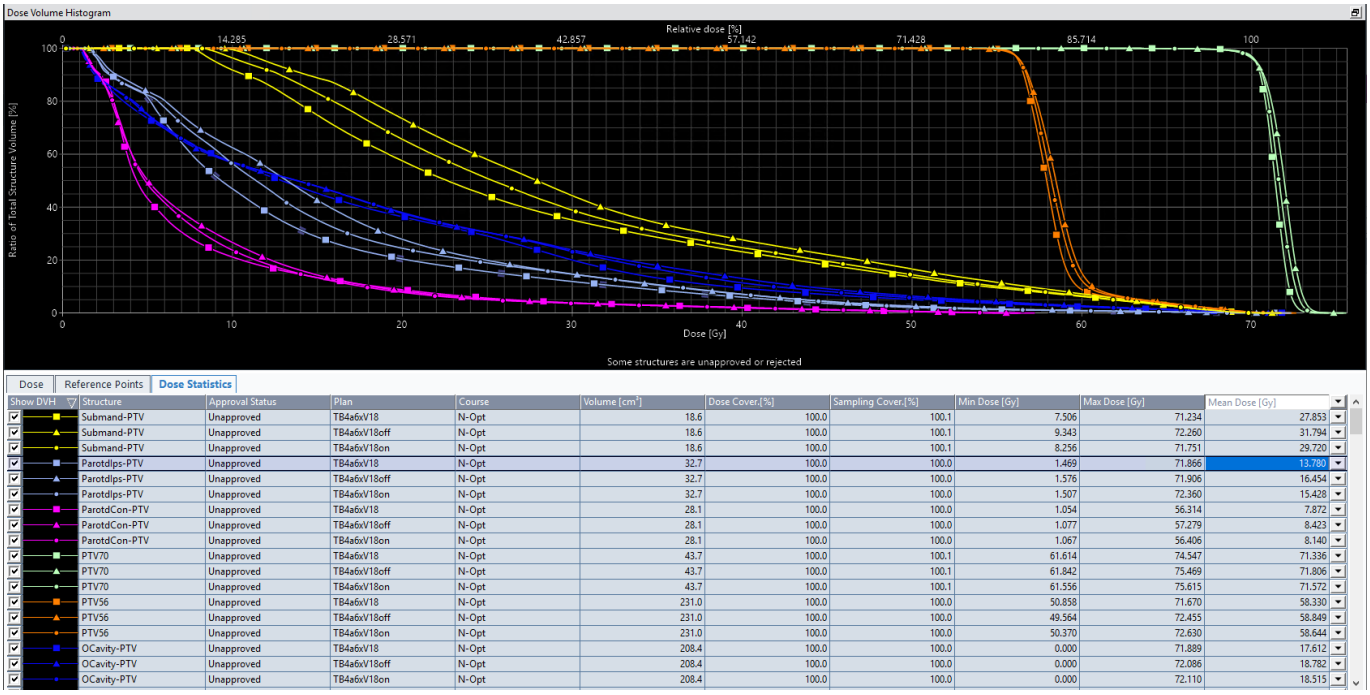


*GPU not required

MR3x2= multiple Intermediate dose optimizations, "current plan as an intermediate dose…"



2 Target 228.5 total 4 arcs Convergence Mode TrueBeam								
	TrueBeam v18(ELM) M120 with MR3 Intermediate							
	MR3 x1						MR3x2	
	Off		On		Extended		Extended	
Case	Score	MU	Score	MU	Score	MU	Score	MU
C05_019	207.15	789	210.7	832	214.45	931	213.96	1019



Show DVH	Structure	Approval Status	Plan	Course	Volume [cm³]	Dose Cover.[%]	Sampling Cover.[%]	Min Dose [Gy]	Max Dose [Gy]	Mean Dose [Gy]
✓	Submand-PTV	Unapproved	TB4a6xV18	N-Opt	18.6	100.0	100.1	7.506	71.234	27.853
✓	Submand-PTV	Unapproved	TB4a6xV18off	N-Opt	18.6	100.0	100.1	9.343	72.260	31.794
✓	Submand-PTV	Unapproved	TB4a6xV18on	N-Opt	18.6	100.0	100.1	8.256	71.751	29.720
✓	Parotdlps-PTV	Unapproved	TB4a6xV18	N-Opt	32.7	100.0	100.0	1.469	71.866	13.780
✓	Parotdlps-PTV	Unapproved	TB4a6xV18off	N-Opt	32.7	100.0	100.0	1.576	71.906	16.454
✓	Parotdlps-PTV	Unapproved	TB4a6xV18on	N-Opt	32.7	100.0	100.0	1.507	72.360	15.428
✓	ParotdCon-PTV	Unapproved	TB4a6xV18	N-Opt	28.1	100.0	100.0	1.054	56.314	7.872
✓	ParotdCon-PTV	Unapproved	TB4a6xV18off	N-Opt	28.1	100.0	100.0	1.077	57.279	8.423
✓	ParotdCon-PTV	Unapproved	TB4a6xV18on	N-Opt	28.1	100.0	100.0	1.067	56.406	8.140
✓	PTV70	Unapproved	TB4a6xV18	N-Opt	43.7	100.0	100.1	61.614	74.547	71.336
✓	PTV70	Unapproved	TB4a6xV18off	N-Opt	43.7	100.0	100.1	61.842	75.469	71.806
✓	PTV70	Unapproved	TB4a6xV18on	N-Opt	43.7	100.0	100.1	61.556	75.615	71.572
✓	PTV56	Unapproved	TB4a6xV18	N-Opt	231.0	100.0	100.0	50.858	71.670	58.330
✓	PTV56	Unapproved	TB4a6xV18off	N-Opt	231.0	100.0	100.0	49.564	72.455	58.849
✓	PTV56	Unapproved	TB4a6xV18on	N-Opt	231.0	100.0	100.0	50.370	72.630	58.644
✓	OCavity-PTV	Unapproved	TB4a6xV18	N-Opt	208.4	100.0	100.0	0.000	71.889	17.612
✓	OCavity-PTV	Unapproved	TB4a6xV18off	N-Opt	208.4	100.0	100.0	0.000	72.086	18.782
✓	OCavity-PTV	Unapproved	TB4a6xV18on	N-Opt	208.4	100.0	100.0	0.000	72.110	18.515

Squares=Photon Optimizer convergence mode extended MR3 return. V18.0 Photon Optimizer, no MR3x2 benefit, prior preELM versions demonstrate enhanced target homogeneity with additional Intermediate Dose (TrueBeam).

Annex A: Validation Results

A3: HD-MLC vs M120 MLC comparison V17/V18

2 Target 228.5 total 4 arcs HDMLC vs M120 Truebeam 6X-FFF								
	TrueBeam							
	Opt. + Calc. Non ELM (V17)				Opt. + Calc. ELM (V18)			
	HD-MLC		M120		HDMLC		M120	
Case	Score	MU	Score	MU	Score	MU	Score	MU
C05_169	208.73	1548	207.8	1470	207.76	1481	209.01	1460

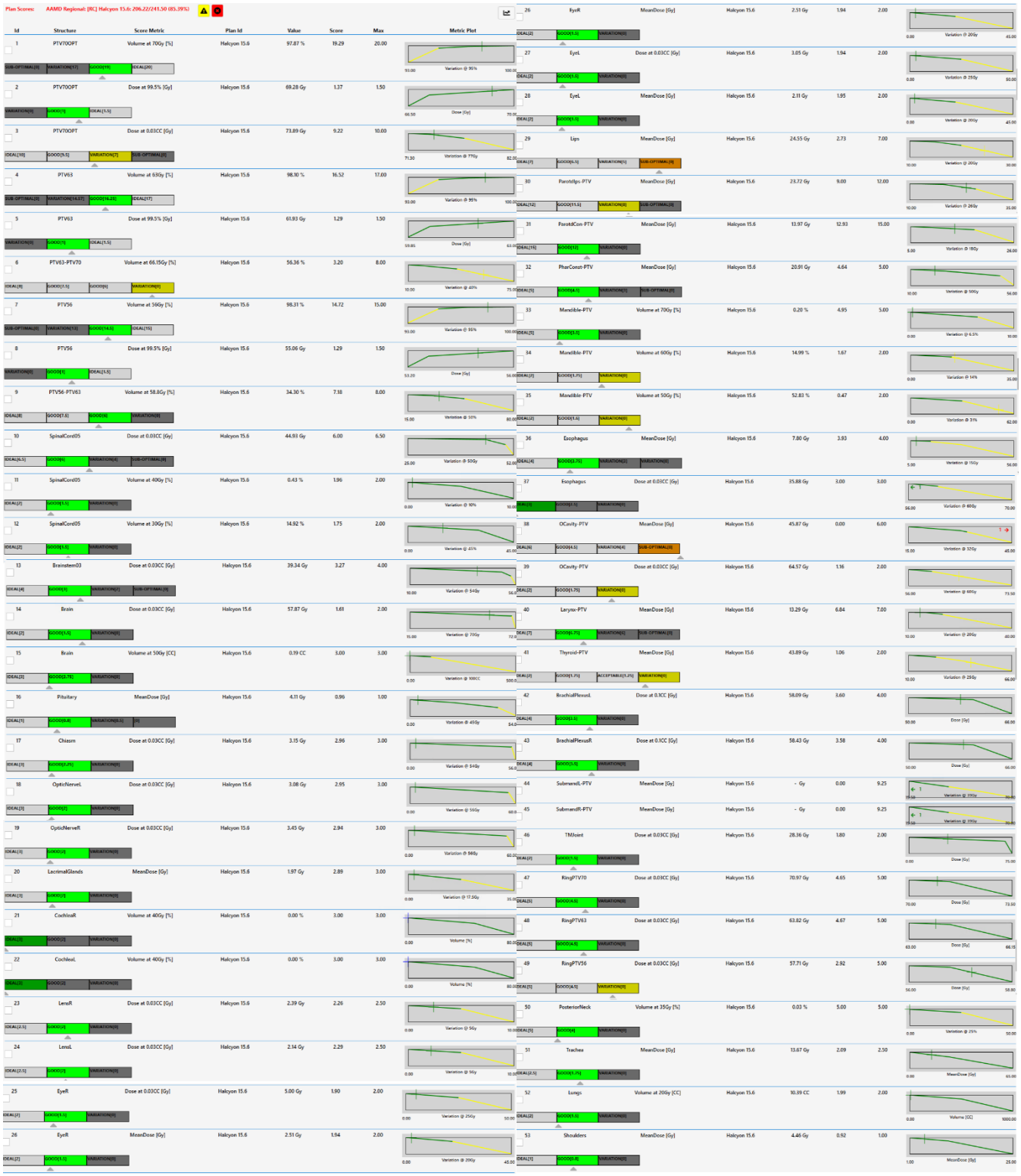
Annex B: Comparison to previous Candidate #1 RapidPlan model: MU/score on Halcyon

3 Target 260 total points 4 arcs Validation cases
(HN-SIB-BPI vs previous Candidate 1 RP model)

	Halcyon			
	Opt. + Calc. Non ELM (V17)			
	HN-SIB-BPI		Candidate1	
Case	Score	MU	Score	MU
HN37	221.09	1039	204.45	884
HN31	235.03	1095	207.8	981
HN46	209.6	1008	183.32	1050
HN38	219.8	1020	180.79	966
Average	**221.38**	**1040.5**	**194.09**	**970.25**

Annex C: **Dosimetric scorecard** details and **PlansScoreCard** ESAPI tool

C1 Full Scorecard for HN-SIB-BPI 3 targets 260 point total (missing OARs, complete overlap)



Plan Scores: AAMD Regional: [RC] Halcyon 15.6: 206.22/241.50 (85.39%)

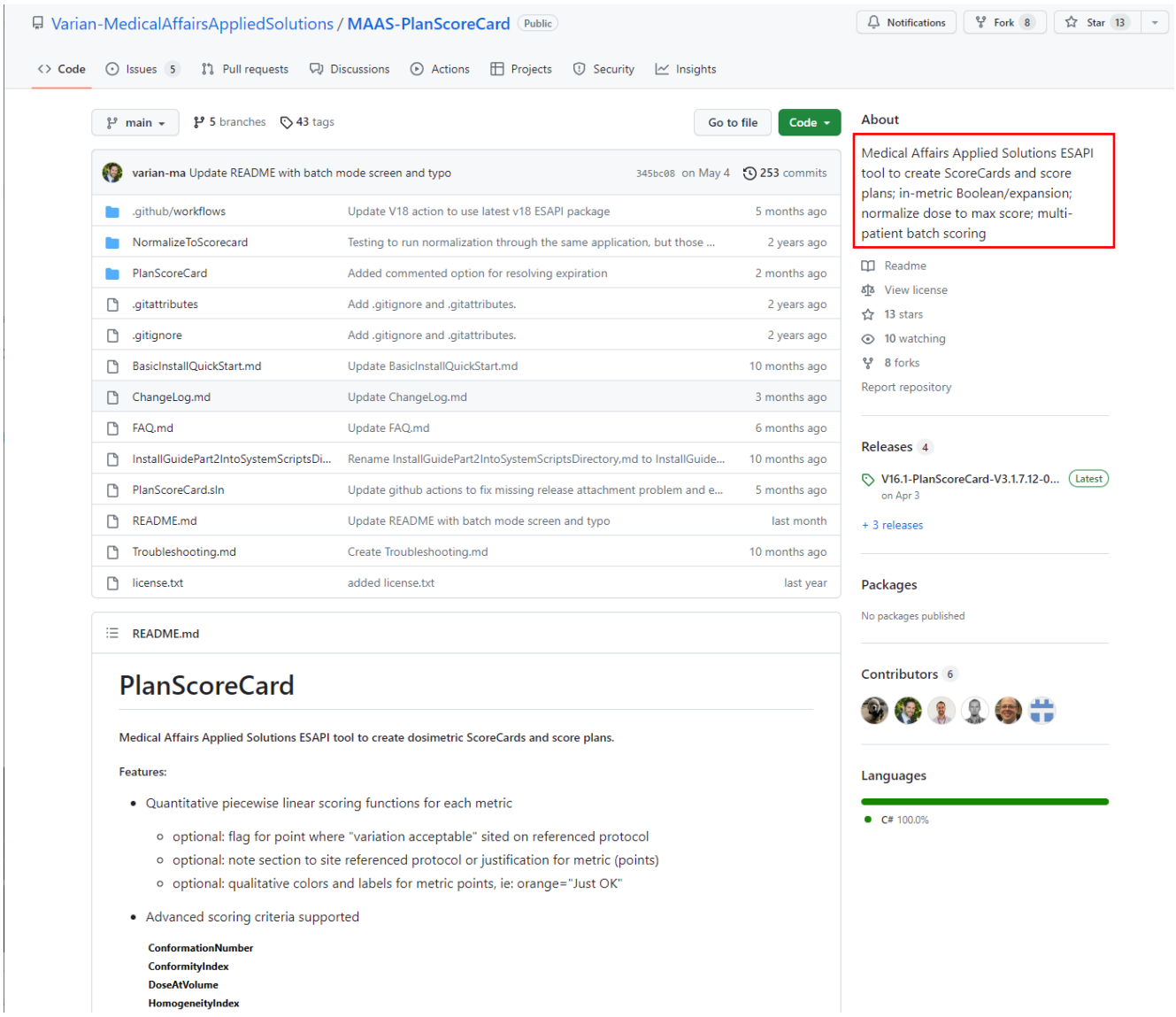
Id	Structure	Score Metric	Plan Id	Value	Score	Max
1	PTV70OPT	Volume at 70Gy [%]	Halcyon 15.6	97.87 %	19.29	20.00
2	PTV70OPT	Dose at 99.5% [Gy]	Halcyon 15.6	69.28 Gy	1.37	1.50
3	PTV70OPT	Dose at 0.03CC [Gy]	Halcyon 15.6	73.89 Gy	9.22	10.00
4	PTV63	Volume at 63Gy [%]	Halcyon 15.6	98.10 %	16.52	17.00
5	PTV63	Dose at 99.5% [Gy]	Halcyon 15.6	61.93 Gy	1.29	1.50
6	PTV63-PTV70	Volume at 66.15Gy [%]	Halcyon 15.6	56.36 %	3.20	8.00
7	PTV56	Volume at 56Gy [%]	Halcyon 15.6	98.31 %	14.72	15.00
8	PTV56	Dose at 99.5% [Gy]	Halcyon 15.6	55.06 Gy	1.29	1.50
9	PTV56-PTV63	Volume at 58.8Gy [%]	Halcyon 15.6	34.30 %	7.18	8.00
10	SpinalCord05	Dose at 0.03CC [Gy]	Halcyon 15.6	44.93 Gy	6.00	6.50
11	SpinalCord05	Volume at 40Gy [%]	Halcyon 15.6	0.43 %	1.96	2.00
12	SpinalCord05	Volume at 30Gy [%]	Halcyon 15.6	14.92 %	1.75	2.00
13	Brainstem03	Dose at 0.03CC [Gy]	Halcyon 15.6	39.34 Gy	3.27	4.00
14	Brain	Dose at 0.03CC [Gy]	Halcyon 15.6	57.87 Gy	1.61	2.00
15	Brain	Volume at 50Gy [CC]	Halcyon 15.6	0.19 CC	3.00	3.00
16	Pituitary	MeanDose [Gy]	Halcyon 15.6	4.11 Gy	0.96	1.00
17	Chiasm	Dose at 0.03CC [Gy]	Halcyon 15.6	3.15 Gy	2.96	3.00
18	OpticNerveL	Dose at 0.03CC [Gy]	Halcyon 15.6	3.08 Gy	2.95	3.00
19	OpticNerveR	Dose at 0.03CC [Gy]	Halcyon 15.6	3.45 Gy	2.94	3.00
20	LacrimalGlands	MeanDose [Gy]	Halcyon 15.6	1.97 Gy	2.89	3.00
21	CochleaR	Volume at 40Gy [%]	Halcyon 15.6	0.00 %	3.00	3.00
22	CochleaL	Volume at 40Gy [%]	Halcyon 15.6	0.00 %	3.00	3.00
23	LensR	Dose at 0.03CC [Gy]	Halcyon 15.6	2.39 Gy	2.26	2.50
24	LensL	Dose at 0.03CC [Gy]	Halcyon 15.6	2.14 Gy	2.29	2.50
25	EyeR	Dose at 0.03CC [Gy]	Halcyon 15.6	5.00 Gy	1.90	2.00
26	EyeR	MeanDose [Gy]	Halcyon 15.6	2.51 Gy	1.94	2.00
27	EyeL	Dose at 0.03CC [Gy]	Halcyon 15.6	3.05 Gy	1.94	2.00
28	EyeL	MeanDose [Gy]	Halcyon 15.6	2.11 Gy	1.95	2.00
29	Lips	MeanDose [Gy]	Halcyon 15.6	24.55 Gy	2.73	7.00
30	ParotidIps-PTV	MeanDose [Gy]	Halcyon 15.6	23.72 Gy	9.00	12.00
31	ParotidCon-PTV	MeanDose [Gy]	Halcyon 15.6	13.97 Gy	12.93	15.00
32	PharConst-PTV	MeanDose [Gy]	Halcyon 15.6	20.91 Gy	4.64	5.00
33	Mandible-PTV	Volume at 70Gy [%]	Halcyon 15.6	0.20 %	4.95	5.00
34	Mandible-PTV	Volume at 60Gy [%]	Halcyon 15.6	14.99 %	1.67	2.00
35	Mandible-PTV	Volume at 50Gy [%]	Halcyon 15.6	52.83 %	0.47	2.00
36	Esophagus	MeanDose [Gy]	Halcyon 15.6	7.80 Gy	3.93	4.00
37	Esophagus	Dose at 0.03CC [Gy]	Halcyon 15.6	35.88 Gy	3.00	3.00
38	OCavity-PTV	MeanDose [Gy]	Halcyon 15.6	45.87 Gy	0.00	6.00
39	OCavity-PTV	Dose at 0.03CC [Gy]	Halcyon 15.6	64.57 Gy	1.16	2.00
40	Larynx-PTV	MeanDose [Gy]	Halcyon 15.6	13.29 Gy	6.84	7.00
41	Thyroid-PTV	MeanDose [Gy]	Halcyon 15.6	43.89 Gy	1.06	2.00
42	BrachialPlexusL	Dose at 0.1CC [Gy]	Halcyon 15.6	58.09 Gy	3.60	4.00
43	BrachialPlexusR	Dose at 0.1CC [Gy]	Halcyon 15.6	58.43 Gy	3.58	4.00
44	SubmandL-PTV	MeanDose [Gy]	Halcyon 15.6	- Gy	0.00	9.25
45	SubmandR-PTV	MeanDose [Gy]	Halcyon 15.6	- Gy	0.00	9.25
46	TMJoint	Dose at 0.03CC [Gy]	Halcyon 15.6	28.36 Gy	1.80	2.00
47	RingPTV70	Dose at 0.03CC [Gy]	Halcyon 15.6	70.97 Gy	4.65	5.00
48	RingPTV63	Dose at 0.03CC [Gy]	Halcyon 15.6	63.82 Gy	4.67	5.00
49	RingPTV56	Dose at 0.03CC [Gy]	Halcyon 15.6	57.71 Gy	2.92	5.00
50	PosteriorNeck	Volume at 35Gy [%]	Halcyon 15.6	0.03 %	5.00	5.00
51	Trachea	MeanDose [Gy]	Halcyon 15.6	13.67 Gy	2.09	2.50
52	Lungs	Volume at 20Gy [CC]	Halcyon 15.6	10.39 CC	1.99	2.00
53	Shoulders	MeanDose [Gy]	Halcyon 15.6	4.46 Gy	0.92	1.00

Download full Scorecard(json), DICOM case example and this RapidPlan model:
https://medicalaffairs.varian.com/hn-sib-bpi-rapidplan-vmat2

Annex C: Dosimetric scorecard and **PlansScoreCard** ESAPI tool

C2 PlanScoreCard ESAPI tool: where to find

[Varian-MedicalAffairsAppliedSolutions](https://github.com/Varian-MedicalAffairsAppliedSolutions) (https://github.com/Varian-MedicalAffairsAppliedSolutions/MAAS-PlanScoreCard)



Currently, the source code is shared on the Varian Medical Affairs Applied Solutions GitHub where it can be downloaded and complied with Visual Studio 2022 (including with the free community edition), now in the releases section users can find precompiled binaries ready to run in all compatible versions of Eclipse (v15.6+). PlanScoreCard is made available under the Varian Limited Use Software License Agreement.

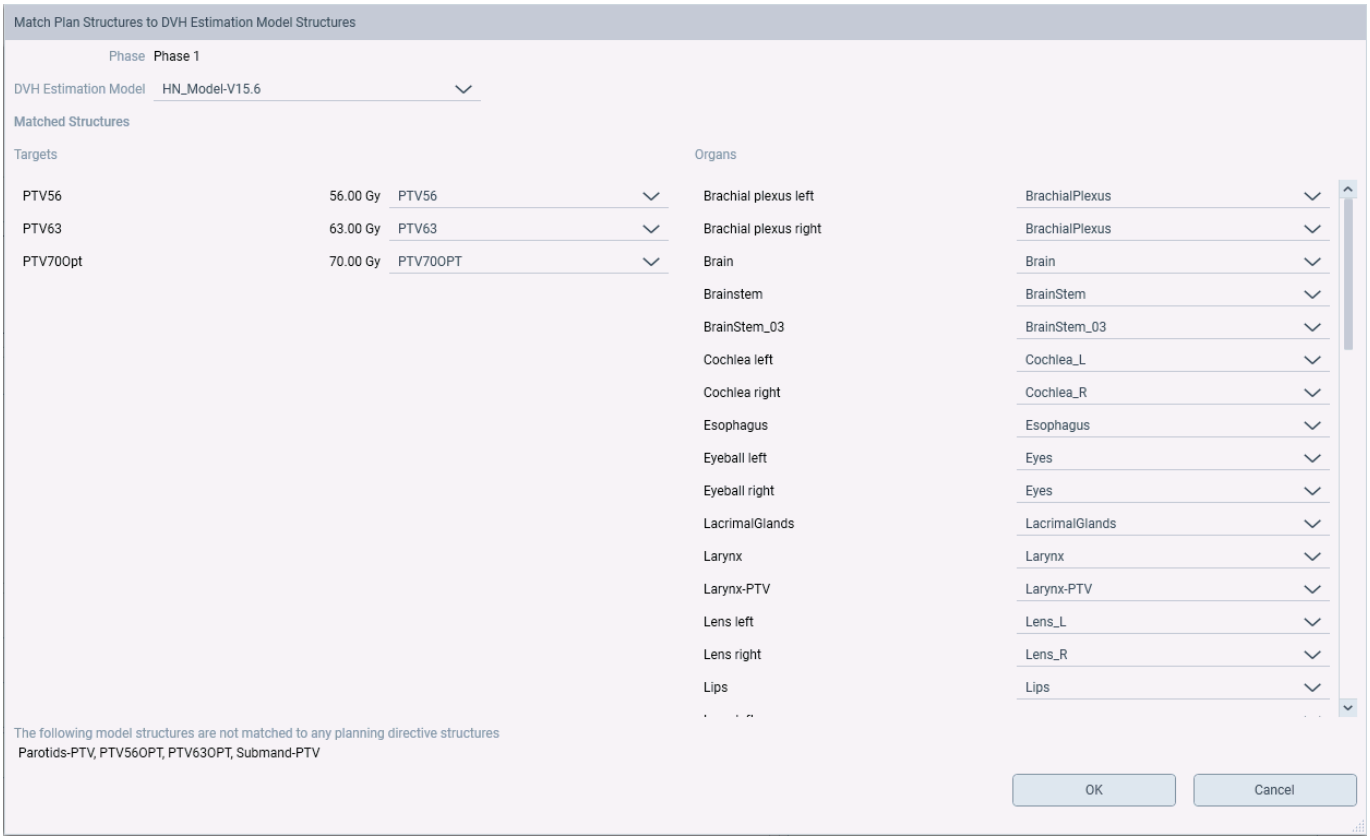
C3 PlanScoreCard ESAPI tool: automatically generate derived structures

The PlanScoreCard tool has a feature where derived structures (made with Boolean and expansion tools) can be created automatically. These structures can be created temporarily (to be used for scoring the plan but never saved back to the database) or (if the ESAPI tool has been approved for writing) the PlanScoreCard tool's configuration file can be edited so these generated structures are saved.

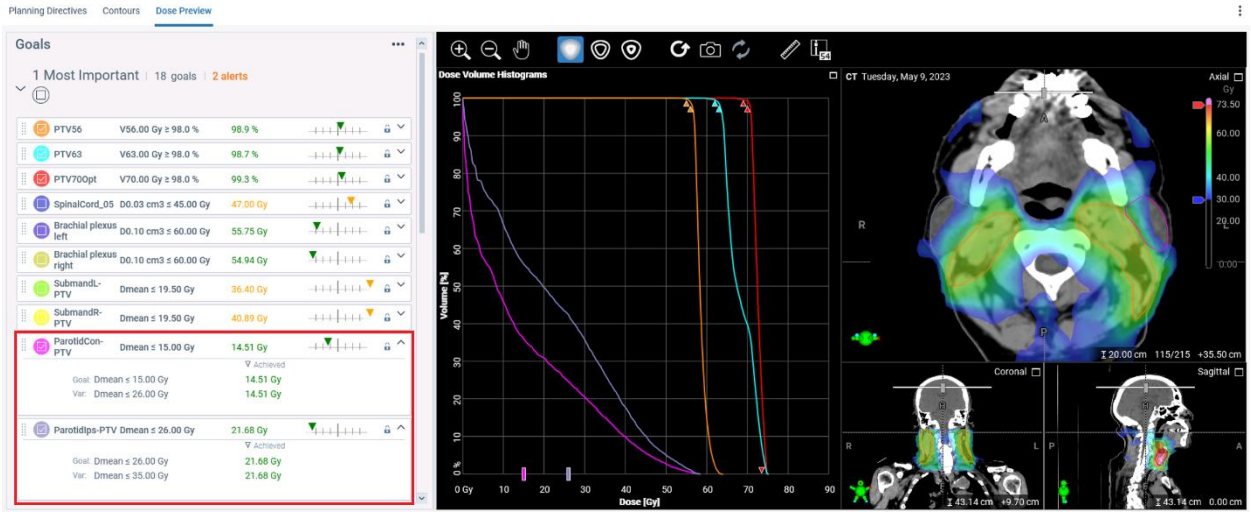
Annex D: Use in Ethos

Example applying this model with Ethos

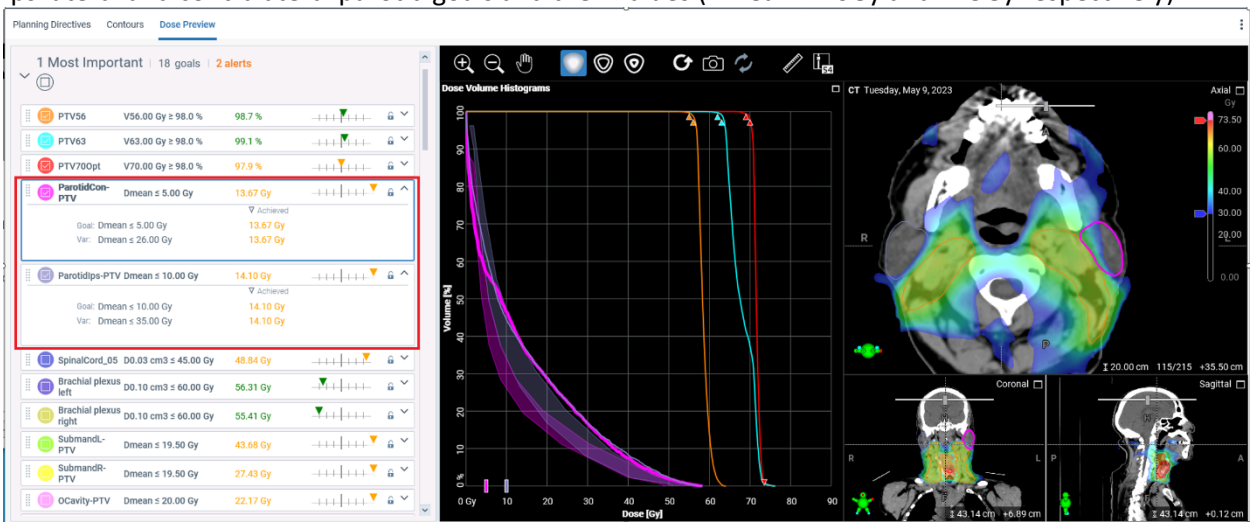
This RapidPlan model can also be imported and utilized in the Ethos treatment planning system to generate DVH estimations. If attaching this RapidPlan model to an Ethos head and neck clinical directive template, it will be used during optimization for both the initial and the online adaptive planning workflows.
The DVH estimation bands can be seen in the dose preview workspace, providing additional insight for tuning and adjusting the clinical goals for OAR's on a given case. The DVH estimation also provides additional optimization weighting within the intelligent optimization engine (IOE). The IOE takes the estimation bands and derives the lowest border of the bands as separate goals for each OAR amongst the other clinical goals provided in the clinical directive template. While the optimization is still mainly driven by the clinical goals, the goals in the background generated by this head and neck model could lead to improved plan quality. Also, using the DVH estimation bands can illustrate what plan quality may be achievable for a specific case, thus helping guide treatment planners to further refine their clinical directive templates.
If this model is used in Ethos, it is suggested that users follow the same instructions as when this model is used to optimize treatment plans in Eclipse.



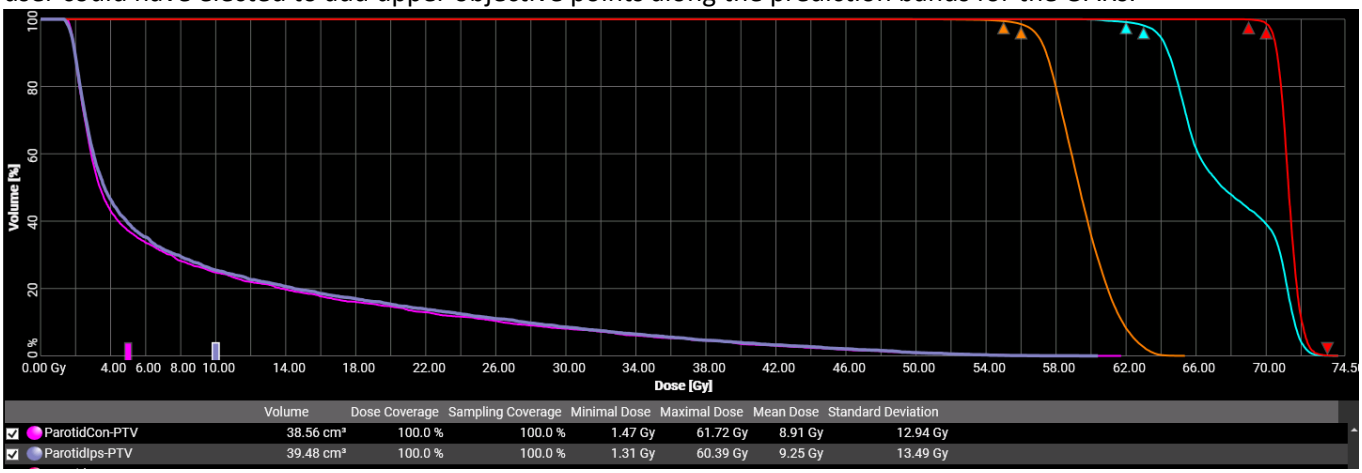
1. Figure showing the menu of matching plan structures to the DVH estimation model



2.Case example where the model is not matched to the clinical directive template. Note the ranking of both ipsilateral and contralateral parotid goals and their values (Dmean < 26Gy and <15Gy respectively).



3.Same case example where the model is now matched to the clinical directive template. Note that the clinical goal ranking was increased and the goal values were lowered for both ipsilateral and contralateral parotids (Dmean <10Gy and <5Gy respectively) by the user after seeing the prediction bands. While not within the DVHe bands (due to limited 9 field beam geometry in dose preview), the shape of the DVH curve is now similar and our clinical goals are more accurate for what can be achieved for this case. Instead of adjusting the mean dose, the user could have elected to add upper objective points along the prediction bands for the OARs.



4.Optimized and calculated dose using 19 static IMRT fields. Mean OAR doses 9.25Gy and 8.91Gy respectively.

Annex E: Acknowledgements

Initial Plans created from “Candidate #1” RapidPlan model by Vanessa Magliari, CMD

3D dose prediction previous work by Elena Czeizler, PhD and María Isabel Cordero Marcos, MS

Manually optimized plans created by Ryan Clark, MS CMD

Manual OAR contouring by Lesley Rosa, CMD and Ryan Clark, MS CMD

All data generated and complied by Ryan Clark, MS CMD, Lesley Rosa, CMD and Anthony Magliari, MS CMD

Dosimetric Scorecard HN-SIB-BPI and derived structures designed by Anthony Magliari, MS CMD and Ryan Clark, MS CMD

Model generated validation plans created by Ryan Clark, MS CMD and Anthony Magliari, MS CMD

Clinical Description document created by Anthony Magliari, MS CMD and Ryan Clark, MS CMD

Please reference future publication:

Head and Neck bilateral parotid involvement: a sub-site specific dosimetric scorecard tuned RapidPlan model validated for use with two treatment planning systems and three delivery systems

Anthony Magliari, Ryan Clark, Lesley Rosa, Sushil Beriwal

Annex F: Distribution and compatibility

This RapidPlan model is to be distributed exclusively via the links found on Varian Medical Affairs:

https://medicalaffairs.varian.com/hn-sib-bpi-rapidplan-vmat2

Please do not re-distribute this model as number of downloads will be tracked (strictly to judge the success of this project).

This RapidPlan model was built with Eclipse v18.0 and rebuild and validated from Eclipse v15.6 RapidPlan for maximal compatibility.