

Line of Sight (LoS)



Evaluation and Validation

General

The presence, or absence, of Line of Sight (LoS) is an important aspect of combat and combat training and, therefore, critical in the design of a live fire training range. Long distances, topography of the natural terrain, structures, plus firing positions and targets can all combine to block the view downrange. The designer must perform a graphical and/or numerical line-of-sight analysis during the design process to ensure that all firing positions, targets, limit markers, lane markers, etc. are properly sited and visible from the required location(s). LoS analysis may also be required from control and camera towers to targets, firing positions, maneuver areas, etc. This computer-based analysis must be based on an accurate terrain model. Topographic surveys for the design of a range require sufficient accuracy to produce 1/2-m (1ft) contour intervals. The individual range sections in the RDG contain specific information on the LoS requirements for each particular range. In addition, on mounted maneuver ranges, the designer must coordinate with the range training and functional support personnel at the installation, ACOM, and TCM Ranges to determine the required training engagements and develop the target engagement capability matrix and subsequent LoS requirements.

The RTLP MCX at the Huntsville Center reviews the required LoS as part of the design review process. For the larger maneuver ranges, the MCX uses a computer tool to analyze the LoS at designated milestones during the design; generally, the 35% and 95% design stages. The designer must provide fully modeled data, to include survey data, proposed trails, proposed target berms, proposed downrange power centers, target engagement capability matrix, and proposed firing and target positions in the format defined below for the evaluation. The MCX processes the data through the LOS analysis tool to determine/verify that the proposed range meets training table requirements. For small arms qualification ranges, the MCX may only verify that the designer has performed the required LoS analysis. The designer must provide profiles showing the required LoS. The stakeholders will evaluate and validate that the range provides the required LoS. None of these reviews absolves the designer from the responsibility of providing required line-of-sight when designing the range.

The angle of fire (AoF) is an important piece of information that the LoS calculates. The AoF affects the berms design and its protection of the target equipment. Refer to the individual targetry emplacement sections in the RDG for detailed requirements/limits for angle of fire.

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The other element of target visibility, (i.e. the target lifters ability to present 100% of the target silhouette above the berm), is beyond the scope of the RDG and not addressed in this section.

Line of Sight tools also perform beaten zone analyses. The beaten zone is the areas behind targets where rounds regularly hit. The repeated impact of rounds in the same small area can cause severe damage to range infrastructure and terrain features. Beaten zone analysis is especially critical on heavily used stationary firing position to stationary target combinations; like tank zeroing and small arms qualification ranges. The designer is responsible for minimizing the risk of damage to critical downrange features or structures.

Line of Sight Philosophy

It is critical during the range design process to provide maximum target visibility for the shooter. With very few exceptions, design the ranges to provide 100% visibility of all required targets. This is critical for qualification ranges in order to maintain qualification standards; extremely little variance is allowed. On some tactical and maneuver ranges, the intent is sometimes to provide more realistic battlefield conditions and in some cases, 100% target visibility may not always be required; some allowances may be possible with the approval of the installation, the MCX, and TCM Ranges. Coordinate with the stakeholders and refer to the individual ranges for specific information on the LoS requirements for each particular range.

Note that there are two different sets of criteria used for ranges, one during the design and construction process and another for training purposes. Design and construct ranges for 100% target visibility with very few exceptions; TCM Ranges, RTLP MCX and the installation, must all be aware of and approve any exceptions. During training, the target is 'available' with 90% target visibility.

It is the designer's responsibility to provide the required LoS. The designer must provide sufficient analysis and/or calculations to prove that the proposed design provides all required visibility.

Use the following generally acceptable criteria as a starting point for LoS analysis; coordinate with the stakeholders for each particular range.

Firing Points

The firing point is the point where LoS is required 'From'. The control tower, camera locations, etc. can also be 'firing points' in a LoS analysis. The designer is responsible for ensuring visibility from every 'probable' point within a firing position, both horizontal and vertical. However, the sheer number can make it impractical to analyze all possibilities. As a practical minimum, designers perform LoS analysis from the worst-case horizontal and vertical limits and at discrete points within the firing area. The spacing of the discrete points depends on the type of firing position, the terrain, and the range type.

The following criteria are the minimum typically used.

Vertical

- Six Inches (6") above foxhole or prone firing area on small arms qualification ranges
- Lowest barrel or weapon/commander sight heights for all vehicles trained

Note: For ranges where vertical angle of fire is critical or may be an issue, LoS analysis may be required from multiple vertical elevations.

Horizontal

- Center front on single foxholes and prone firing positions
- Four corners and center point on Sniper firing positions
- Start, End, and 50' intervals along the centerline of firing box trail
- Center of the pad in both Hull Down and Turret Down positions

Camera

LoS for cameras is typically from a point 1' above the height of the camera mounting plate.

Control Tower

For visibility from the control tower, assume a seated position behind the counter, (i.e. 3' AFF and 3' back from the window). Include any obstructions from the tower itself in the analysis, (e.g. the wall below the window, walkways around the front of the tower, any railings, etc.) as well as any buildings/terrain around the tower that might block visibility.

Target Point

The Target point is where LoS is required 'To'. The intent, as stated above, is to provide 100% visibility of the target silhouette. In most cases, a significant portion of the target berm is visible from the firing point, especially on many small arms ranges. On ranges where significant amounts of cut and fill is required to achieve LoS or on ranges that have long distance requirements, visibility is only economically achievable to the very top of the berm. Because computerized LoS tools would show LoS failure from the berm itself, the MCX developed the following Target LoS points used in the LoS tool for design/construction and availability based on the standard emplacement configuration. (On the standard SIT/MIT, the berm is 3 inches above the concrete wall.)

Small Arms Qualification Ranges

Small arms qualification ranges do not differentiate between design and availability.

Design Criteria

- LoS point on a SIT or MIT is 0.2 Inches (0.2") above the berm or one tenth of a foot (0.1') above the top of the concrete front wall.
- LoS point on a SAT or MAT is 0.6 inches (0.6") above the berm or three tenths of a foot (0.3') above the top of the concrete.

Maneuver Ranges

Design Criteria,

The design criteria are the same as that used for small arms qualification ranges.

- LoS point on a SIT or MIT is 0.2 Inches (0.2") above the berm or one tenth of a foot (0.1') above the top of the concrete front wall.
- LoS point on a SAT or MAT is 0.6 inches (0.6") above the berm or three tenths of a foot (0.3') above the top of the concrete.

Availability Analysis Criteria

A target is 'available' when at least 90% of the target is visible. Use the following criteria based on the standard silhouettes.

- LoS point on a SIT or MIT is 5 Inches (5") above the berm/timber or one-half of a foot (0.5') above the top of the concrete front wall.
- LoS point on a SAT or MAT is 9 inches (9") above the berm or one foot (1.0') above the top of the wall.

Horizontal

Use the following criteria to ensure that the entire width of the target is visible, and visible along the entire track for moving targets.

- SIT both sides of the target wall
- SAT both sides and the center point of the target point
- MIT both ends and a minimum of 5-meter intervals along the target wall
- MAT Start and end point of track and a minimum of 50-meter intervals along the target wall.

Ground Clearance

Terrain and vegetation between the firing point and the target are significant issues affecting LoS. Design the range so that the vegetation, when kept at the typical heights at the particular location, does not interfere with LoS. Include a consideration of the fact that shrinking maintenance budgets often means increased mowing intervals and higher vegetation. Consider standard construction tolerances and the thickness of added topsoil in the design. At a minimum, design the range so that LoS clears intermediate ground by the typical, maintained vegetation heights (use six inches as a minimum). That means a required overcut for LoS of at least 6 inches.

Target Engagement Capability Matrix.

For Mounted Maneuver Ranges, the Project Development Team (PDT), [the designer, the stakeholders (functional range training support personnel at the installation, ACOM, TCM Ranges), and the RTLP MCX] develop the project's Target Engagement Capability Matrix (capability matrix) based on training standards and the installation's training requirements at the beginning of the design process. The capability matrix contains the critical engagements that the range must provide in order for the project to meet Army training standards and the MCX uses it to analyze and validate LoS requirements. The matrix starts with a list of required engagements for the range. During the design process, the PDT adds the specific firing point/target combinations that meet those training engagements. The designer must include the capability

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matrix in each design submittal for validation. Designers should consider hiring their own functional range training support personnel to aid in the design process. The final design product also includes an availability report. The availability report is a spreadsheet for each firing point showing which targets are visible from that point with the corresponding distance, azimuth, and angle of fire.

81	ABRAMS TABLE VI DEFE	NSIVE ENGAGEME	NT POSSI	BILITIES						
VI IG	SIGHT AND CONDITIONS	CREWMEMBERS	TARGET TYPE	TARGET	Target Specifics of Engagements	BP 10	HBP 11	HBP XO3	HBP 12	BP 13
0	GPCH Fail	TC	KE	Moving	1 Moving Tank, <800m or >2000m or 800m-2000m	MB1 or M04 or M02,M02	M- or MOS,MOS or MORMOS,HOA	M02 or M- or M/05 M04 M05 M05	M- or M- or M0330043005805	MO4 or M- or MD5 MD8
	Machine Gun Pure	Gunner	Coax	Area <u>or</u> Point	1 Set of Troops, RPG Tm, Moving Int, Sniper (Façade) or Technical Truck, <300m or 300m400m	C01 / IM+ / F+ / V01 or C03,C01,C05 C02 / M1 (M02 / F1- 31,F1 02 / V02,V04	C08 / IM01 / F1-01 / V03 or (018 C07 / IM03 / F1-C2/73-01 / V055-VC7/V08	C++ / M++ / F++ / V++ er C09.011.012.014 / M++ / F+ / V11F.012.013F.014	C07 / IM03 / F= / V09 or C09,010,011:012 / M= / 7501 / V12,V14	C10 / IM- / F5-01 / V- or (015 / IM- / F7-01 F6-32 / VISE-33
61			Coax	Area <u>or</u> Point	1 Set of Troops, RPG Tm, Moving Inf, Sniper (Fecede) or Technical Truck, <300m or 300m400m	C01 / IM- / F- / V01 or C03,004,005 005 / IM01,5002 / F1 01 F1-02 / V02 V04	C03 / IM05 / F1-01 / V03 or C35 C07 / IM05 / F1 C2/3 01 / V009 VC7 V03	G+ 7 IM = 7 F= 7 V= or 009 C10 C11 C12 C14 7 IM 7 F 7 V11E V12 V12E V12	ED7 / IM03 / P= / VEB or C09.C10.C11.C12 / M/ / 15.01 / V12.V14	C10 / IM- / F5-01 / V- or C15, / IM- / F5-01 F7-02 / V46FV2
62	Machine Gun Pure	Gunner	Coas	Area <u>or</u> Point	1 Set of Troops, RPG Tm, Moving Int, Sniper (Façade) or Technical Truck, <300m or 300m600m	C01 / IM- / F- / V01 or C05,004 (055,001 / IM2 (3607 / FI- 31,F1-02 / V03,001	C08 / IM01 / F1-01 / V03 or C08 C07 / IM03 / F1-02 F3-01 / V05F,VC7 /003	C++ F IM++ F F++ F V++ or construction critic (14 × IM++7 H++ × V11F(v12,V13F,V++	C07 / IM03 / F= / V08 or C09,010 C11 C12 / B2= / PSO1 / V12,V14	C10 / IM- / F5-01 / V- or C15, / I4- / F7-01F7-02 / V18F V2
			Coax		1 Set of Troops, RPG Tm, Moving Int, Sniper (Paçada) or Technical Truck, <300m or 300m 800m	C01 / IM- / F+ / V01 er C03,C01,C05,C06 / IM3 (M02 / F1- 21,F1.02 / V03,V04	C03 / IM01 / F1-01 / V03 or C03 C07 / IM03 / F1-C2/F3-01 / V05F_VC7/V09	C++ F IM++ F F++ F V++ er C09 C+C,C111C12,C14, F IM++ F F+- F V11F,V12,V13F,V14	C07 / IMOS / F- / V09 cc C09.C10.C11.C12 / M- / F6-01 / V12.V14	010 / IM- / F5-01 / V- or C15 7 IM / F7-01 F7-02 / VI6E V3
3	Main Gun Pure	Gunner	KE	Moving	1 Moving Tank, <800m or >2000m or 800m-2000m	M01 or M04 or 5102,5102	M- or MOS,MOS or MU2MUB,804	NO2 or M- or MOXAR4ARS MOS	M= or M+ or 303,404,405,806	M04 or M= or MP5 M02
64	Main Gun Pure	Gunner	CE	Stationary	1 Stationary Truck, Bunker or PC, >900m-1600m or APC or Bunker, <800m or 800m-1600m	00.55, 902, 902, 9135, 9135, 9145, 914 or 908, or 9035, 902, 912, 9135, 9145, 914, 912, 912, 914	915,919,915,917,917,918,913, or 937,908, or 913,914,915,919-,918,918,930	916 947F 943,920 921,922 923,929 9 26 927,928 or 943,944 or 916 941F 948,920 921,922 92,928 9 26 927,928	915,017F,015,020,021,022,028,021,0 25,026,027,028,021,022,028,021,0 215,017F,018,018,021,029,029,024,044,0 25,026,027,028	921,922,924,925,926,928,928,930 916,919, or 921,932,936,935, 936,938,938,9
			CE	Stationary	1 Stationary Truck, Bunker or PC, >900m-1600m or APC or Bunker, <800m or 800m-1600m	VCIP VOT VITE VITE VITE VITE VITE VITE VITE VIT	915,916,915,917,918,918,920 977,908, or 915,916,917,918,918,920	V16 V17F V18, V20 V21, V12 V23, V26 V 25 V22, V26 of V13, V14 of V15, V14, V10, V20, V21, V22 V23, V2 20, V27, V26	915,017F,015,023,027,122,028,924,9 22,530,927,928,or,908,943,944,or 915,014,012,022,027,922,023,944,9 25,920,927,928	V21 V22 V24 V25 V21 V25 V26 V29 V29 V21 V25 V24 V25 V25 V25 V26 V29
			KE - delay	Moving	1 Moving Tank, <800m or >2000m or 800m-2000m	MD1 or M04 or MC2/MC3	M- or M05,M06 or N02M03,H04	N02 or M+ or M03,M04,M05M03	M- or M- or H03,434,435,806	M04 or M+ or M05 M08
65	Change of Weapon System	Gunner	Coax	Area <u>or</u> Point	1 Set of Troops, RPG Tm, Moving Inf, Sniper (Fecede) or Technical Truck, <300m or 300m600m	C01 / IM- / F- / V01 or C03,C04,C05.006 / M01,M02 / F1- 01,F1-02 / V03,V04	C03 / IM01 / F1-01 / V03 or C03 C07 / IM03 / F1 C2 F3-01 / V05F V(7,V03	C++ / IM+ / F+ / V+ or 009 C10 01 1012 014 / IM+ / F+ / V11F (v12 v13F,v14	C07 / IMOS / F= / V08 pr 009.010,011.012 / M= / 75.01 / V18,V14	C10 / IM- / F5-01 / V- or C15 / I4- / F7-01 F7-02 / V18F/v2
			KE	Stationary	1 Stationary Tank, <800m or >2000m or 900m-2000m	VED or V16F.V19,V20 or V05- 300, V10, V13- V11- V12, V12 V16, V17F.V19	V87,V08 or V23,V24,V25,V27 or V13,V14,V15,V17,V18,V19,V20,V21,V 22	V13/V14 or V- or V15/V14 V11/V10/V14/V12/V12/V15/V 25/V17/V20/V10/V10	V08,913,914 or 9- or 915,914,019,910,029,912,933,914,9 26,923,927,928,929,930	V15,V19 or V- or V21,V22,V24 V15 V25 V25,V25,V
56	Change of Weapon System	Gunner	Coax	Area <u>or</u> Point	1 Bet of Troops, RPG Tm, Briger (Façade) or Technical Truck, <300m or 300m4800m	C01 / IM- / F- / V01 or C03,C01,C05,C06 / IM32,M02 / F1- 31,F1-02 / V02,V04	C03 / IM01 / F1-01 / V03 or C05 C07 / IM03 / F1-C2/F3-01 / V00F/VC2/V03	C+-7 IM-7 F-7 V- et C09 C10	C07 / IMOS / F- / V08 or 009.010.011.012 / M/= / F601 / V12.V14	C10 / IM- / F5-01 / V- or C15 / IM- / F5-01 F7-02 / VI6F V5
			CE	Stationary	1 Stationary Truck, Bunker or PC,>900m-1800m or APC or Bunker, <800m or 800m-1800m	V03- V02, V13, V10- V11- V12, V12, V14 or V03 or V03- V02, V13, V11- V12, V12, V14	913,914,915,917,917,918,913,020 912,914,915,917,913,913,920	V15 V17E V13/V30 V31/V32 V33/V32 V3 28 V37 V28 or V13/V14 or V15 V17E V18/V30 V31/V32 V33/V35 V 26 V27/V30	V15, V14, V15, V15, V17, V17, V12, V14, V17, V15, V14, V17, V15, V17, V12, V12, V12, V12, V14, V15, V17, V15, V15, V17, V15, V13, V17, V12, V12, V14, V15, V17, V12, V14, V14, V15, V17, V12, V14, V14, V14, V15, V17, V12, V14, V14, V14, V14, V14, V14, V14, V14	V21,977,934,975,937,937,878,937,937 V16,919, or V21,923,924,938,928,938,938,9
67	Degraded	Gunner	CE	Stationary	1 Stationary Truck, Bunker or PC, >800m-1400m or APC or Bunker, <800m or 800m-1400m	936F_937 V08;910F_or_ 903_or 939F;937,938,910F	V333/16 or V07.V08 or 913.914	915 911 916 916 926 921 922 923 923 92 25,937 pr 913,914 pr 915 917 916,920 921,922 923,925 9 26,937	915 V105 319,920 301 llar NOI, V13, V14 llar V15, V17, V19 920, V21	V21,V22,V24,V25,V26,V26, or V15 or V21,V22,V34,V25,V23,V20
ĺ		Gunner	CE	Stationary	1 Stationary Truck, Bunker or PC, >800m-1400m or APC or Bunker, <800m or 800m-1400m	206F,V17/V08,V10F or V03 or V03F,V17/V(8,V10F	V13,9% or V07,908 or 213.914	V 6 V17F V15,020 V21,022 V23,025 V 26,027 or V18,V14 or V16 V17F V18,V10 V21,022 V23,025 V 20,027	V 6 V17F V13,V20 V21 ev V08,V13,V14 ev V15,V17F,V19 V20,V21	V21,V12,V24,V15,V26,V16 or V16 or V21,V22,V34,V25,V26,V28
8	Degraded	Gunner	KE		1 Moving Tank, <800m or 800m-1600m	MD1 or MD2	M or M023702	M02 or 1905/404	M- or M03,804 M15	MD4 or MC63/06
	Simultaneous	Loader	M240	Stationary - Flank	1 Set of Troops, RPG Tm, Moving Int, Sniper (Fagade) or Technical Truck, <900m (LDR)	C01 7 (MH 7 F1:01,75:02 7 MH)	C // M01 M05 / F1 01,71 02,F3 01 / V38	010,011,014,7 MH / 7H / 9415.	007,010 / M05 / F3-01,75-01 / 908	C16,C17 7 M 17 76 01 F7 01 F7 V18
69		TC	Cal.60	Stationary - Vehicle	1 Set of Troops, RPG Tm, Moving Int, Sniper (Façade) or Technical Truck, or PC <1800m [TC]	DEX CD4 C05, C05, D07 // IND E1MOB / F= / VD1/VD3, VD4 (VD8F/VD7, VD8	C05.007,C10 2 M+ 7 F+ 2 V05.V0EF,V37	C05.012.019 / M = / P = / V10F.V117.V12,V %	CHU212,014,714+7.F+7 V07,V13,V14	C10 G27 G227 IM=7 F=7 V14,V25,V18-V17+
		Gunner	Corpo- delay	Area <u>or</u> Point	1 Set of Troops, RPG Tm, Moving Int, Sniper (Fasade) or Technical Truck, <300m or 300m-800m	C01 / IM- / F- / V01 ar C30,004,005,002 / Rd2,5802 / H1 01,F1 02 / V02,V04	003 / IM01 / F1-01 / V03 or C03 C07 / IM03 / F1 023-2 01 / V050_V07,V00	C++ / IM+ / F+ / V+ or OWCPECTECTECTECH / M / F+ / VIIEVIEVIEV/2	C07 / IM03 / F= / V08 or C09.010.011.017 / M / / H 01 / V12.V14	D10 / IM- / F0-01 / V- or 0.15 7 IA: 7 I7 01 F7 02 / VISF V2
				Legend	Target Listings		neet the conditions (type & dist spaces between each target listi		rgets are listed in the order show	n in "Target Specifics of
					V#	Indicates a SAT emplacement				
					N# C#	Indicates a MAT emplacement Indicates a 7-SIT cluster emplacement	ament			
					C#	Indicates a 7-SIT cluster emplacement Indicates a 40m MIT emplacement				
					F#-01 or F#-02	Indicates a Façade F#-01=1-stor	v / F#-02=2-story			
					15+50	For Offensive engagements, Inc	licates the location (Stationing P	oint) on the trail where the enga	ngement starts.	
					Black Font	Indicates that we have LOS to the	ne target from the specified firing			arriet in viewable from the
					Plum Font	Turret-Down position, but the L	OS software only counts full LO:	s.	s provide that a portion of the t	anger to we wante in our the
Red Ford Indicates that we do not have LOS for that target from the specified timing point.										
	Vet.004 / Vet.004 / Vet.014 / Vet.014 / Engagement conditions met and at least one MPL is available.									
					16450 F1402 / P04 / IR01 V20,V22 / V28,V29,V25 / V28,V24	Engagement condutors met but no MPL is available. All engagement conditions met but at least one target condition is not viewable from turret-down, so it is not a complete engagement.				
					NTA	All least one target condition for the task is not target conductor in the viewboard monitor recording to a stand a complete engigement.				
						er contaitoit ter				

SAMPLE TARGET ENGAGEMENT CAPABILITY MATRIX

The designer should coordinate with the Government about whether or not to include field verification of LoS in the construction contract. The field verification occurs as early as possible in the construction process. The contractor informs the Government if any of the engagements included in the availability report are not visible. The Government investigates the cause, (survey bust, construction or design error, etc.), and determines if or how to correct the issue.

LOS Data Submittal Requirements

The designer is required to provide the following information to the RTLP MCX for LoS analysis and validation on Mounted Maneuver Ranges:

Layer/Level Standards Document

The designer will provide the layer/level standards document used for range design. This document should include the following:

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- a. Layer names/number and description of type of data contained
- b. Drawing naming convention
- c. Drawing units (English or metric)
- d. Target and firing point naming convention
- e. Firing/Target type designation
- f. Inventory of files contained within the submittal and a description of the data contained

Existing Digital Model

The designer will provide an existing surface digital terrain model using <u>one</u> of the following formats:

- a. Preferred dtm formatted Bentley InRoads version 8.4 surface
- b. Land XML Format
- c. Electronic **comma or space** delimited ASCII formatted files containing digital surface information. Each type of data should be in a separate file. The file formats are as follows:
 - a. Random Points should have the following format: ID*, Northing, Easting, Elevation, Feature*
 - b. Breakline Information:
 - i. ID*, Northing, Easting Elevation, Feature*, Pencode
 - ii. Pencode This field defines for each linear feature a zero (0) or one (1). A one identifies the first point of a linear component followed other points within the line having zero. The next new line will start with a one.
 - c. For electronic **comma or space** delimited ASCII formatted files containing triangle point information (TIN), the file format is as follows:
 - i. Random Points should have the following format.
 - ii. ID*, Northing, Easting, Elevation, Feature*

(NOTE: * = Optional parameters)

Trail / Moving Target Emplacement Locations

- a. Electronic file containing 3D graphic alignments shown at zero elevation at the centerline of trails and moving target emplacements
- b. Profile of existing and proposed alignments and associated profile report in text format.

Stationary Target Emplacement

Electronic comma or space delimited

ASCII formatted file with the following information: Name-Type, Northing, Easting, and Elevation

Start / End Trail Firing Positions

In an electronic CAD file, the designer must locate and label starting and ending firing positions along the trails.

Proposed Range Digital Terrain

The designer must provide a proposed digital terrain model including all trails, firing positions, target locations, and any other site grading required on the project. Use <u>one</u> of the following formats:

- a. Preferred dtm formatted Bentley InRoads version 8.4 surface
- b. Land XML Format
- c. 3D Electronic drawing containing 3D data defining proposed range: breakline features are preferred, but contours can be submitted