

Working Report on Visible and IR Electromagnetic Emissions from HMMWV External Black-Out (BO) Lighting

Submitted to PM Tactical Vehicles

by

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Report Documentation Page

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Purpose:

The purpose of this preliminary set of measurements is to obtain a qualitative idea of the magnitude of visible and infrared emissions of the Black-Out (BO) lamps on a M1025 vehicle HMMWV. The question to be answered is the degree of infrared security that exists with the present BO drive and marker lamps. Also, what effect, if any, does an IR filter kit has on the infrared security of the vehicle.

Procedure:

During the last week of September 2004, members of the TARDEC visual perception lab team collected infrared and visual imagery of the BO drive and marker lamps on a HMMWV for PM Tactical Vehicle. The imagery was taken inside the 'dark chamber' of the PM TV. The HMMWV light switch modes, clock time, and observations were recorded concurrently with the imagery.

Imaging cameras used:

Three imaging cameras were used for this test. They are listed and described below.

1. Indigo Omega Longwave (7.5 – 13.5 micron) IR camera, 160 H by 120 V resolution.



Fig. 1: Indigo miniature IR camera

2. SONY Handycam (0.38 to 1.5 micron)



Fig. 2: SONY HandyCam

3. AN/VVS-2V(2A) Army Image Intensifier Periscope

An Image Intensifier (I2) night vision system detects light energy and wavelengths that are outside the detection range of the unaided human eye, converts these electromagnetic waves into electrical energy, processes and amplifies the signal, and then displays the output on a phosphor screen that is viewable by the human eye. The photocathode of the I2 device is sensitive to wavelengths of light that begin around 0.6 microns (in the yellow part of the visible spectrum) and end around 1.0 micron (in the near infrared, so-called short-wave, part of the spectrum).



Fig. 3: Image Intensifier

Definitions:

Visible hand camera is the Sony HandyCam camcorder.

Visible (Night shot on) is the Sony HandyCam camcorder with the night shot feature on.

IR is the Omega Indigo longwave infrared camera.

Scope is the image intensifier periscope shown above in Figure 3.

Scope (night shot on) is when the image was recorded through the image intensifier with the night shot feature on.

Data:

The following pages contain imagery collected on the visibility of the BO lamps from the front and rear of the HMMWV with the three different imagers.

Table 1: Data taken in the morning on 16 Sept 2004

Image #	Switch mode	segment	start	end	Sensor	side	camera pstrn	Camera D	Height	D Composite	P Composite	BO Drive light
1	BO DRIVE	1	0:00	1:55	IR	Front	Driver side	10'	47"	Original	Original	Original
	BO DRIVE	2	1:55	2:12	IR (Interruption - human)	Front	Driver side	10'	47"	Original	Original	Original
	BO DRIVE	3	2:12	2:35	IR	Front	Driver side	10'	47"	Original	Original	Original
	BO DRIVE	4	2:35	3:42	IR (Interruption - human)	Front	Driver side	10'	47"	Original	Original	Original
	BO DRIVE	5	3:42	3:57	IR	Front	Driver side	10'	47"	Original	Original	Original
	BO DRIVE	6	3:37	5:11	IR (Interruption - human)	Front	Driver side	10'	47"	Original	Original	Original
2	BO DRIVE	7	5:11	5:22	IR	Front	Driver side	10'	47"	Original	Original	Original
3	BO DRIVE	8	5:22	7:06	Scope with visible night shot	Front	Center	10'	47"	Original	Original	Original
4	BO DRIVE	9	7:06	7:36	Visible (Night shot)	Front	Driver side	10'	47"	Original	Original	Original
	BO DRIVE	10	7:36	7:39	Visible (Interruption - light)	Front	Driver side	10'	47"	Original	Original	Original
5	BO DRIVE	11	7:39	7:55	Visible	Front	Driver side	10'	47"	Original	Original	Original
6	BO DRIVE	12	7:55	8:29	Visible	Front	Closeup BO Drive	2'	5'	Original	Original	Original
7	BO DRIVE	13	8:29	9:26	IR	Front	Closeup BO Drive	2'	5'	Original	Original	Original
8	BO DRIVE	14	9:26	9:57	Scope	Front	Closeup BO Drive	2'	41"	Original	Original	Original
9	BO DRIVE	15	9:57	10:31	Scope	Front	Closeup BO Drive	3'	5'	Original	Original	Original
10	BO DRIVE	16	9:31	11:16	IR	Front	Closeup BO Drive	3'	5'	Original	Original	Original
	BO DRIVE	17	11:16	12:01	IR	Front	moving away	3' - 10'	47"	Original	Original	Original
11	BO Marker	18	12:01	12:26	IR	Rear	Driver side	10'	47"	Original	Original	NA
	BO Marker	19	12:26	12:44	IR	Rear	Moving closer	10' - 3'	5'	Original	Original	NA
12	BO Marker	20	12:44	12:51	IR	Rear	Driver side	3'	5'	Original	Original	NA
13	BO Marker	21	12:51	13:05	Visible (Night shot)	Rear	Center	10'	47"	Original	Original	NA
14	BO Marker	22	13:05	14:00	Scope (visible night shot)	Rear	Center	10'	47"	Original	Original	NA
	BO Marker	23	14:00	14:17	Scope (moving)	Rear	Center	10'	47"	Original	Original	NA
	BO Marker	24	14:17	14:23	Scope (visible night shot)	Rear	Center	10'	47"	Original	Original	NA
15	BO Marker	25	14:23	15:51	IR	Rear	Center	10'	47"	Original	Original	NA
	BO Marker	26	15:51	16:14	IR (Interruption)	Rear	Center	10'	47"	Original	Original	NA
	BO Marker	27	16:14	16:38	IR (closer look than seg 26)	Rear	Center	10'	47"	Original	Original	NA

Table 2: Data taken in the afternoon on 16 Sept 2004

Image #	Switch mode	segment	start	end	Sensor	side	camera pstn	Camera D	Height	D Composite	P Composite	BO Drive light
16		1	0:00	0:06	Visible with light	Rear	Passenger	10'	47'	NA	NA	NA
17		2	0:29	0:30	Visible with light	Side	Setup	10'	5'	NA	NA	NA
18		3	0:40	0:46	Visible with light	Rear	Closeup	2'	5'	NA	NA	NA
		4	0:49	0:57	Visible with light	Front	working	10'	5'	NA	NA	NA
19		5	0:57	1:05	Visible with light	Rear	Setup	8'	5'	NA	NA	NA
		6	1:07	1:15	Visible with light	Rear	Setup		5'	NA	NA	NA
20	BO Marker	7	1:15	2:43	IR	Rear	Center	10'	47'	Truck Lite	RC 1st	NA
21	BO Marker	8	2:43	3:41	Scope (Visible night shot on)	Rear	Center	10'	47'	Truck Lite	RC 1st	NA
22	BO Marker	9	3:41	4:58	Scope (Visible)	Rear	Center	10'	47'	Truck Lite	RC 1st	NA
	BO Marker	10	4:58	5:37	Scope (Interruption - light, human)	Rear	Center	10'	47'	Truck Lite	RC 1st	NA
	BO Marker	11	5:37	6:04	Scope (Visible - brake on/off)	Rear	Center	10'	47'	Truck Lite	RC 1st	NA
23	BO Marker	12	6:04	6:53	Scope (Visible - brake on)	Rear	Center	10'	47'	Truck Lite	RC 1st	NA
	BO Marker	13	6:53	7:13	Scope (brake on/off)	Rear	Center	10'	47'	Truck Lite	RC 1st	NA
	BO Marker	14	7:13	7:22	IR	Rear	Center	10'	47'	Truck Lite	RC 1st	NA
24	BO Marker	15	7:22	8:47	IR (brake on/off)	Rear	Center	10'	47'	Truck Lite	RC 1st	NA
25	BO Drive	16	8:47	9:21	Visible	Front	Driver side	10'	47'	RC 1st	Truck Lite	Truck Lite
26	BO Drive	17	9:21	9:43	Visible(Night shot on)	Front	Driver side	10'	47'	RC 1st	Truck Lite	Truck Lite
27	BO Drive	18	9:43	10:39	IR	Front	Driver side	10'	47'	RC 1st	Truck Lite	Truck Lite
	BO Drive	19	10:39	11:17	IR (Interruption - human)	Front	Driver side	10'	47'	RC 1st	Truck Lite	Truck Lite
28	BO Drive	20	11:17	11:35	Visible (Night shot on)	Forward	Driver seat	10'	47'	RC 1st	Truck Lite	Truck Lite
29	BO Drive	21	11:35	12:14	Visible	Forward	Driver seat	10'	47'	RC 1st	Truck Lite	Truck Lite
	BO Drive	22	12:14	12:17	moving					RC 1st	Truck Lite	Truck Lite
30	BO Marker	23	12:17	13:15	IR	Front	Driver side	10'	47'	Original	Original	Aurora
31	BO Marker	24	13:15	13:29	Visible	Front	Center	10'	47'	Original	Original	Aurora
32	BO Marker	25	13:29	13:48	Visible (Night shot on)	Front	Center	10'	47'	Original	Original	Aurora
	BO Marker	26	13:49	14:28	IR	Front	Center	10'	47'	Original	Original	Aurora
	BO Marker	27	14:28	14:45	Visible (off)	Front	Center	10'	47'	Original	Original	Aurora
	BO Marker	28	14:45	15:07	Visible (on)	Front	Center	10'	47'	Original	Original	Aurora
33	BO Marker	29	15:07	15:45	Scope	Front	Center	10'	47'	Original	Original	Aurora
	BO Marker	30	15:45	16:08	IR	Front	Driver side	10'	47'	Original	Original	Aurora
	BO Marker	31	16:08	16:21	IR (Moving)	Front	Center	10'	47'	Original	Original	Aurora
34	BO Marker	32	16:21	17:03	IR	Front	Center	10'	47'	Original	Original	Aurora

Table 3: Data taken in the morning of 17 Sept 2004

Image #	Switch mode	segment	start	end	Sensor	side	camera pstn	Camera D	Height	D Composite	P Composite	BO Drive light
35	BO Marker	1	0:00	0:23	Visible (Night shot on)	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
36	BO Marker	2	0:23	0:33	Visible	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
	BO Marker	3	0:33	0:45	Visible (off -interrupt)	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
	BO Marker	4	0:45	1:16	Visible	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
37	BO Marker	5	1:17	2:00	IR	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
	BO Marker	6	2:00	2:51	IR (interruption - human)	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
	BO Marker	7	2:51	3:08	IR	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
38	BO Marker	8	3:08	3:43	IR	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
	BO Marker	9	3:43	4:06	IR (interruption - human)	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
	BO Marker	10	4:06	5:00	IR	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
39	BO Marker	11	5:00	6:09	Scope (Visible)	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
40	Service (w/o hdlight GND)	12	6:10	6:38	Visible	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
41	Service (w/o hdlight GND)	13	6:39	7:00	Visible (Night shot on)	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
	Service (w/o hdlight GND)	14	7:00	7:03	Visible	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
42	Service (w/o hdlight GND)	15	7:03	8:45	IR	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
43	Service (w/o hdlight GND)	16	8:45	9:35	Scope	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
44	Service (w/o hdlight GND)	17	9:36	10:00	Visible (off) -D trun sig	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
45	Service (w/o hdlight GND)	18	10:00	10:13	Visible (night shot on) -D trun sig	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
46	Service (w/o hdlight GND)	19	10:17	10:42	Scope -driver turn sig	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
47	Service (w/o hdlight GND)	20	10:43	11:30	Visible (off) -P trun sig	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
48	Service (w/o hdlight GND)	21	11:31	11:55	Visible (night shot on) -P trun sig	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
49	Service (w/o hdlight GND)	22	11:59	12:36	Scope -P turn sig	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
50	Service (w/o hdlight GND)	23	12:37	12:51	Visible (off) -P trun sig - P Filter on	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
51	Service (w/o hdlight GND)	24	12:51	13:02	Visible (on) -P trun sig - P Filter on	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
	Service (w/o hdlight GND)	25	13:06	13:37	IR - P turn sig - P Filter on -interrupt	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
52	Service (w/o hdlight GND)	26	13:37	13:50	IR - P turn sig - P Filter on	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
53	Service (w/o hdlight GND)	27	14:01	14:03	IR - P turn sig - P filter off	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
54	Service (w/o hdlight GND)	28	14:32	14:40	IR - D turn sig -P,D Filter on	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
55	Service (w/o hdlight GND)	29	14:40	14:54	IR - D turn sig _P filter on	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
	Service (w/o hdlight GND)	30	14:54	15:10	IR - D turn sig -P,D Filter on -interrupt	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
56	Service (w/o hdlight GND)	31	15:10	15:13	Scope - D turn sig -P filter on	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
57	Service (w/o hdlight GND)	32	15:24	15:26	Scope - D turn sig -P,D Filter on	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
58	Service (w/o hdlight GND)	33	15:38	15:48	Scope - P turn sig -P, D Filter on	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
	Service (w/o hdlight GND)	34	15:55	16:10	Scope - P turn sig, Driver filter on	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
59	Service	35	16:18	16:40	Visible	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
60	Service	36	16:40	17:13	Visible (on)	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
61	Service	37	17:14	18:23	IR	Front	Center	10'	47"	RC First Co.	Truck Lite	NA

Table 4: Data taken with the IR pass filters on all lights

Image #	Switch mode	segment	start	end	Sensor	side	camera pstn	Camera D	Height	D Composite	P Composite	BO Drive light
62	Service	38	18:23	18:26	Visible (Night shot on)	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
63	Service	39	18:26	18:39	Visible	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
	Service	40	18:39	18:51	Visible (Night shot on)	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
	Service	41	18:51	19:26	Visible	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
64	Service	1	0:00	0:38	IR	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
	Service	2	0:38	1:05	Visible	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
65	Service	3	1:05	2:02	Scope	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
66	Service	4	2:02	2:13	Visible -Left signal on	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
67	Service	5	2:13	2:56	Visible -Right signal on	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
	Service	6	2:56	4:12	IR - signal	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
	Service	7	4:12	5:39	IR - interruption	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
	BO Marker	8	5:39	5:54	Visible	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
	Service	9	5:54	6:18	IR	Front	Center	10'	47"	RC First Co.	Truck Lite	NA
		1	0:00	0:39	Scope (Visible)	Front	Center	10'	47"	RC First Co.	Truck Lite	NA

Table 5: (a) BO drive lamp data, (b) Front BO marker data, (c) Rear BO stop light data, (d) Front composite with the turn signal on data, (e) Service light on data, (f) Service light with filters mounted data

	BO Drive Lamp		
	Truck-Lite	Aurora	Existing bulb
Visible	Detect (25)	Not Detect (5)	Detect (31)
Visible(night shot)	Detect (26)	Not Detect (4)	Detect (32)
IR	Detect (27)	Detect (2)	Detect (30)
Scope	Data not available	Detect (3)	Detect (33)

(a)

	Front BO Marker		Rear BO Marker		
	Truck-Lite	RC First	Truck-Lite	RC First	Existing bulb
Visible	Detect (36)	Detect (brighter) (36)	Data not available	Data not available	Detect (?)
Visible(night shot)	Detect (35)	Detect (brighter) (35)	Data not available	Data not available	Detect (13)
IR	Detect (38)	Detect (38)	Detect (24)	Detect (brighter) (24)	Detect (15)
Scope	Detect (39)	Detect (brighter) (39)	Detect (21)	Detect (brighter) (21)	Detect (14)

(b)

	Rear BO Stop light	
	Truck-Lite	RC First
Visible	Data not available	Data not available
Visible(night shot)	Data not available	Data not available
IR	Not Detect (24)	Not Detect (24)
Scope	Detect (23)	Detect (23)

(c)

	Head lamp disconnected/ Front Composite/Turn signal on			
			Filter mounted	
	Truck-Lite	RC First	Truck-Lite	RC First
Visible	YES (47)	YES (44)	NO (50)	Data not available
Visible(night shot)	YES (48)	YES (45)	NO (51)	Data not available
IR	NO	NO	NO (52)	NO (55)
Scope	YES (49)	YES (46,56)	NO (58)	NO (57)

} Camera height at 41 inches

(d)

	Service light/Headlamp disconnected		Service light		
	Truck-Lite Front composite	RC First Front composite	Headlamp	Truck-Lite Front composite	RC First Front composite
Visible	Detect (40)	Detect (40)	Detect (59)	Detect (59)	Detect (59)
Visible(night shot)	Detect (41)	Detect (41)	Detect (60)	Detect (60)	Detect (60)
IR	Detect (42)	Detect (42)	Detect (61)	Detect (61)	Detect (61)
Scope	Detect (43)	Detect (43)	Unit turned off	Unit Turned off	Unit Turned off

(e)

	Service light/ Filter on				
	Headlamp	Truck-Lite Front composite	RC First Front composite	Truck-Lite Turn signal	RC First Turn signal
Visible	Detect (63)	Not Detect (63)	Not Detect (63)	NO (67)	NO (66)
Visible(night shot)	Detect (62)	Detect (62)	Detect (62)	Data Not available	Data Not available
IR	Detect (64)	Detect (64)	Detect (64)	Data Not available	Data Not available
Scope	Detect (65)	Not Detect (65)	Not Detect (65)	Data Not available	Data Not available

(f)

* Scope automatically shutdown when headlamps were on; heat only

Switch setting: BO Drive Lamp

View: Front

Lights: Driver: LED replacement bulb (RC First)
Passenger: LED front composite Lamp (Truck-Lite)
BO Drive light: LED BO Drive light (Truck-Lite)



25: Visible



26: Visible (night shot on)



27: IR

BO Drive light: LED BO Drive light (Truck-Lite)

FROM driver seat – forward view



28: Scope



29: Visible

Note: IR image is not obtained since IR does not penetrate windshield glass

Switch setting: BO Drive Lamp

View: Front

Lights: Existing A1, with LED BO Drive PN 07320



5: Visible



4: Visible (night shot on)



2: IR

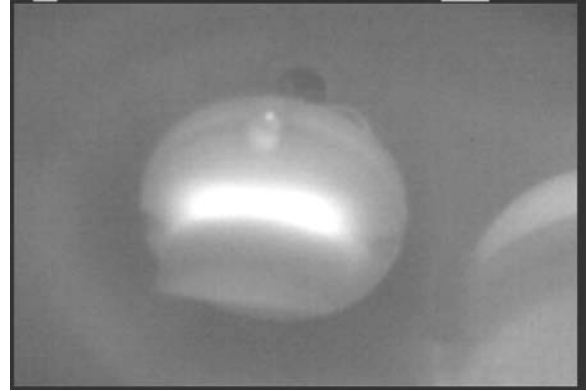


3: Scope (night shot on)

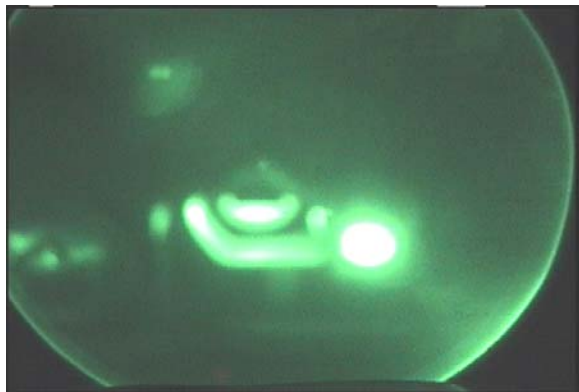
Close up of LED BO Drive light, with Truck-Lite PN 07320



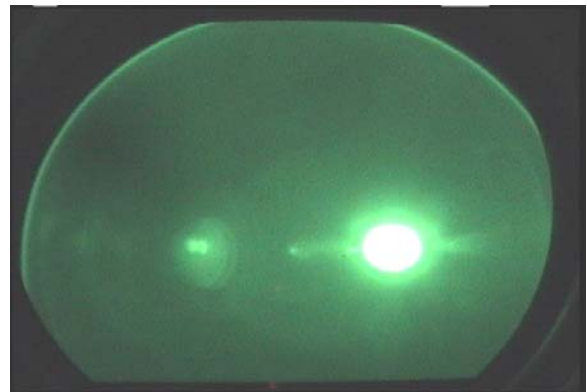
6: Visible



7: IR



8: Scope (41")



9: Scope



10: IR

Switch setting: BO Drive Lamp

View: Front

Lights: Existing A1, with BO Drive, PN 11668932



31: Visible



32: Visible (night shot on)



30: IR



33: Scope (night shot on)

Switch setting: BO Marker

View: Front

**Lights: Driver: LED replacement bulb (RC First)
Passenger: LED front composite Lamp (Truck-Lite)**



36: Visible



35: Visible (night shot on)



38: IR



39: Scope

Switch setting: BO Marker

View: Rear

**Lights: Driver: Rear LED composite Lamp (Truck Lite)
Passenger: LED replacement bulbs (RC First)**



24: IR



22: Scope



21: Scope (night shot on)

Switch setting: BO Marker
View: Rear
Lights: Existing A1



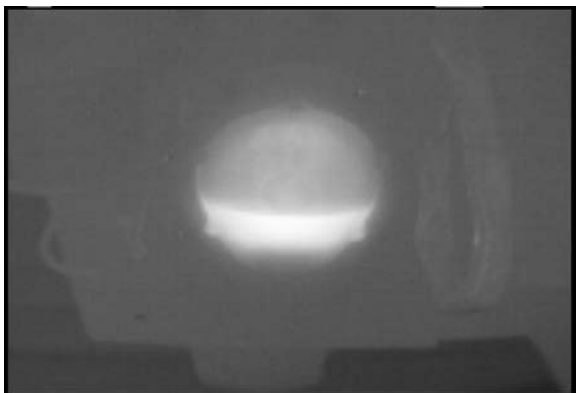
13: Visible (night shot on)



15: IR



14: Scope



12: IR close up

Switch setting: BO Stop light

View: Rear

**Lights: Driver: Rear LED composite Lamp (Truck Lite)
Passenger: LED replacement bulbs (RC First)**



24: IR – brake on



23: Scope – brake on

Switch setting: Service (without headlight GND)

View: Front

**Lights: Driver: LED replacement bulb (RC First)
Passenger: LED front composite Lamp (Truck-Lite)**

Turn signal test – passenger side



**47a: Visible
Passenger side turn signal on**



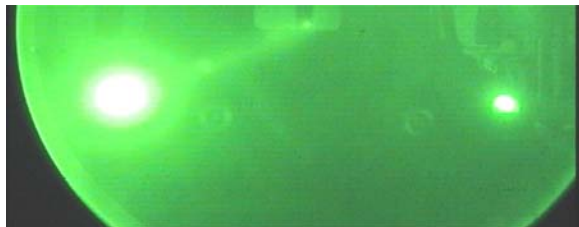
**47b: Visible
Passenger side turn signal off**



**48a: Visible (night shot on)
Passenger side turn signal on**



**48b: Visible (night shot on)
Passenger side turn signal off**



**49a: Scope
Passenger side turn signal on**



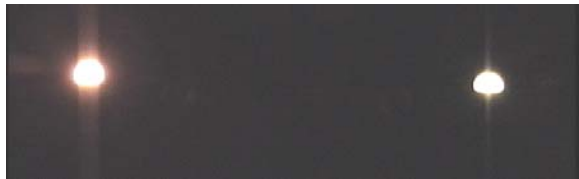
**49b: Scope
Passenger side turn signal off**

Switch setting: Service (without headlight GND)

View: Front

**Lights: Driver: LED replacement bulb (RC First)
Passenger: LED front composite Lamp (Truck-Lite)**

Turn signal test Driver side



**44a: Visible
Driver side turn signal on**



**44b: Visible
Driver side turn signal off**



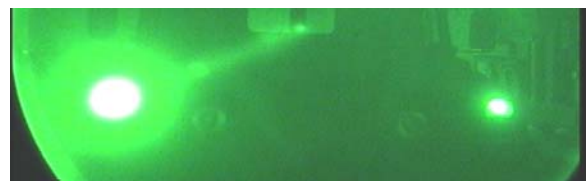
**45a: Visible (night shot on)
Driver side turn signal on**



**45b: Visible (night shot on)
Driver side turn signal off**



46a: Scope



46a: Scope



**56a: Scope (night shot on)
*Passenger side IR pass filter on**



**56b: Scope (night shot on)
*Passenger side IR pass filter
on**

Switch setting: Service (without headlight GND)

View: Front

**Lights: Driver: LED replacement bulb (RC First)
Passenger: LED front composite Lamp (Truck-Lite)**

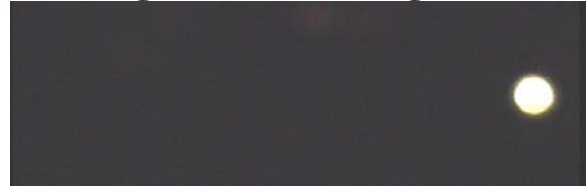
Turn signal test – passenger side with IR pass filter mounted

Passenger side turn signal on

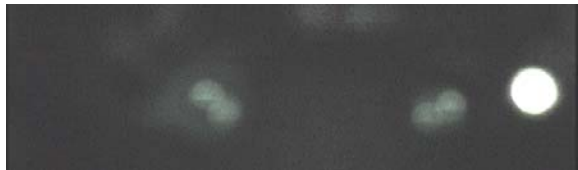


50a: Visible

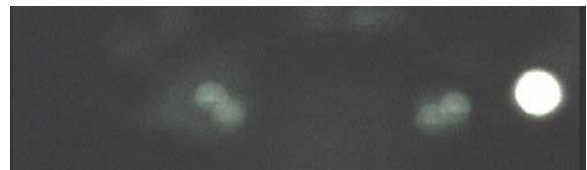
Passenger side turn signal off



50b: Visible



51a: Visible (night shot on)



51b: Visible (night shot on)

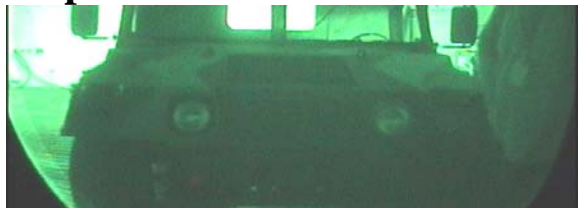


52: IR



53: IR

IR pass filter: filter on both composite lights



58: Scope (night shot on)

Switch setting: Service (without headlight GND)

View: Front

**Lights: Driver: LED replacement bulb (RC First)
Passenger: LED front composite Lamp (Truck-Lite)**

Turn signal test – Driver side with IR pass filter mounted on both composite lights

Driver side turn signal on



55: IR

Driver side turn signal off

Not available



57: Scope (night shot on)

Not available

Switch setting: Service (without headlight GND)

View: Front

**Lights: Driver: LED replacement bulb (RC First)
Passenger: LED front composite Lamp (Truck-Lite)**



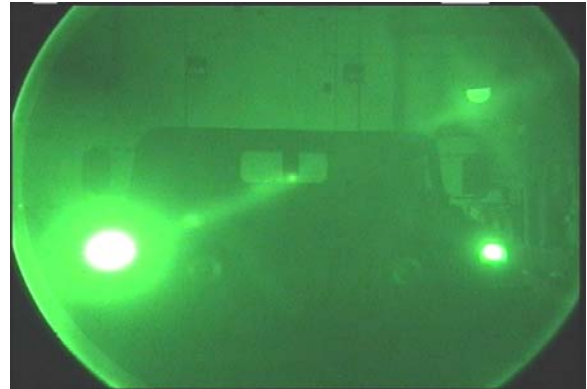
40: Visual



41: Visual (night shot on)



42: IR

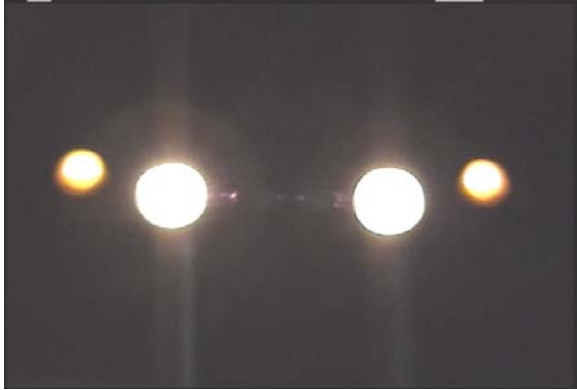


43: Scope

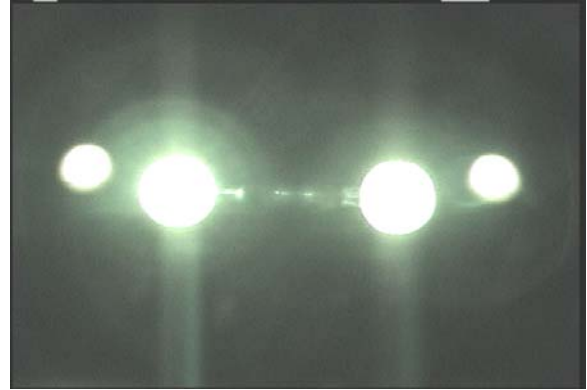
Switch setting: Service light

View: Front

**Lights: Driver: LED replacement bulb (RC First)
Passenger: LED front composite Lamp (Truck-Lite)**



59: Visible



60: Visible (night shot on)



61: IR

****Scope – not attainable**

Switch setting: Service light

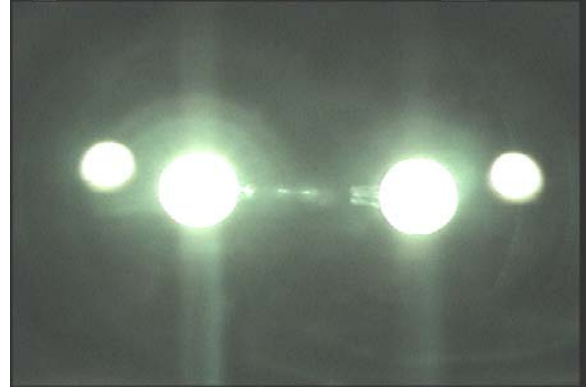
View: Front

**Lights: Driver: LED replacement bulb (RC First)
Passenger: LED front composite Lamp (Truck-Lite)**

IR pass filter: filters on all lights



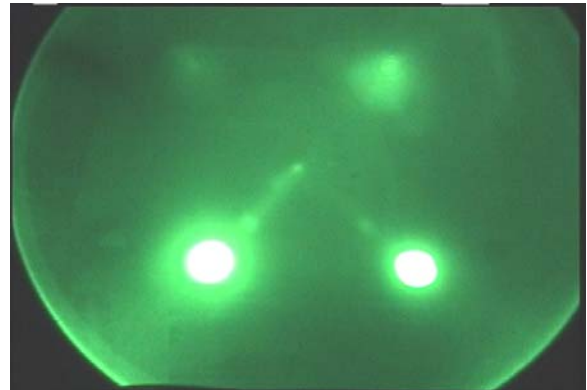
63: Visible



62: Visible (night shot on)



64: IR



65: Scope

Switch setting: Service light

View: Front

**Lights: Driver: LED replacement bulb (RC First)
Passenger: LED front composite Lamp (Truck-Lite)**

IR pass filter: filters on all lights



**66: Visible
Driver side turn signal on**



**67: Visible
Passenger side turn signal on**

Suggestions:

The data collected and reported was qualitative in nature. The Visual Perception Lab can make more quantitative using the visible spectrophotometer for accurate energy measurements per wavelength in the visible spectrum. Similar measurements could be made with the purchase of a radiometric IR imager.

If tactical and scout operations are to be performed, it is desirable to not be detected, hence lights be they infrared or visible should be avoided because the enemy will have imaging sensors to detect those emissions. An alternative to active lighting for low speed driving and surveillance while in stealth-scout mode is to use a passive system to increase situational awareness. Such a system is described in Appendix A.

Appendix A

The Panoramic Image Fusion System to Aid Tactical Operations

Research engineers from the Ford Motor Company and survivability researchers from the Army's TARDEC have jointly developed a prototype system that has applications for military, homeland security and law enforcement. The system will aid soldiers and homeland security officers. It is designed to work in day or night and provide increased situational awareness to the driver and other crew members of a surveillance or scout vehicle. Moreover, one of the major innovative features of the system is that it is modular. This flexibility allows for the system to be deployed as a kit, making it cost efficient. In this way, the system components required for a given application can be based on the needs of that particular application. For example, the modular kit can be mounted on a HMMWV, Stryker, LAV, SUV, or truck.

Important Features of the System

- **Situational Awareness**

The capability to see around the outside of the entire vehicle from display screens inside, while driving or parked. Miniature cameras are mounted around the vehicle to give up to a 360-degree field of view. System modules can be mounted on the front, rear and/or sides of the vehicle to provide the desired area of coverage. The images are seamlessly stitched together to provide a panoramic view. The operator can pan and zoom at will within the panoramic view to examine details and locate specific targets within the context of the larger view. See Figure 1 below.



Figure 1: Panoramic view concept

- **Video Image Stabilization for User Comfort**

The system includes image stabilization to remove the motion of the camera while the data is being viewed and recorded. Without this feature, the image would jitter and be difficult to view, as well as possibly causing headache and dizziness to the viewer. This feature is especially important when the vehicle is traveling at a high rate of speed or on rough terrain.

- **Day and Night System Functionality**

The system pairs **InfraRed (IR)** cameras with visible cameras. The IR cameras are sensitive to body heat and are therefore very useful in detecting objects such as people at night. They are also useful in the daytime. For example, if an insurgent is hiding a recently fired weapon in his pocket, the concealed weapon will be clearly visible in the IR image due to the fact that it is hotter than the surrounding area. IR images are often of poor quality (too few pixels) so the image from the IR camera is fused with the visible camera image to give more information from just the visible or IR image alone. In the figure below, the woman on the far left has a heated object concealed in her pants. The IR cameras can see the object even when the cameras are in bright ambient light but the people are in a dimly lit room. See Figures 2 and 3 below.



Figure 2: Visible image of a group of people



Figure 3: Fused visible and IR image detecting concealed weapon

Recording Capability

The system includes video recorders that record the entire camera views, (the IR and visible cameras, as well as sound). All of the recordings are stamped with the time and GPS location coordinates, so that we can know exactly when and where the recording was made. The GPS information can be very useful in an unknown battlefield situation or MOUT environment where there are no distinguishing landmarks to indicate the exact location of the video. A complete video record of the situation around the vehicle in which the system is installed is invaluable.

- **Threat Identification**

The system will distinguish between stationary and moving objects and determine their direction of motion (even when the vehicle in which the system is mounted is moving). For example, there may be a group of combatants in a MOUT situation that are stationary, while others are moving. Most likely the moving insurgents are of greater interest than the stationary ones. The system would highlight the moving ones to make them easier to spot while the overall panoramic view would give the broad scene context necessary to locate them in the real world

- **Automatic "Wakeup" and Warning on Threat Detection**

In many cases the surveillance or scout task can be very monotonous. A soldier watching a screen displaying the situation outside the vehicle can be very tired or lose focus on the task. This could happen at a border where insurgents are trying to cross, or in a situation where insurgents are holding hostages. With automatic threat detection, the system will detect changes in the scene that might constitute a target or threat, and display (audible, visible or both) an alarm and automatically pan to the area of interest.

- **"Zoom-In" to a Threat Location to Provide More Detail**

This system can also be configured with a separate camera pair (consisting of a visible and IR camera) that can be automatically rotated to the area of interest (picked from the surveillance display). This would provide the user with the ability to get a much higher resolution view of a small area picked from the panorama than is available from the standard computer digital zoom. The camera pair would be mounted on a powered tilt and pan mechanism. The wide area of coverage of the 360 degree panorama allows for wide area surveillance. This 'zoom-in' would allow detailed examination of suspected targets and would be especially useful for surveillance in wooded or built-up areas where enemy combatants might be hiding and would be hard to identify with the standard resolution.

- **Color Code Areas of Interest**

The system will automatically highlight areas of interest in the scene by drawing colored coded borders around such areas. The highlighted color could be used to signify the classification. For example, one color could be used for cold vehicles and a different color for hot vehicles. Warm objects would be a third color and would include enemy soldiers on foot, perhaps hiding in underbrush. Shape recognition software could be added to classify and color-code particular threats, such as weapons.

- **Automatically Track Moving Threats and Illuminate Them**

This technique is called "Smart Spot" and has been patented by Ford (see US patent **6,281,806**.) It uses an IR camera to detect the threat, i.e. a combatant. It then shines a spotlight on the threat and tracks the threat, the keeping it illuminated. This feature could be turned off or controlled by the operator in cases where it may compromise the safety of the vehicle and its occupants.

General Comment

It may appear that the features of this system as described above come from a "science fiction" novel. However, many of these capabilities are currently implemented on our prototype system installed on a Lincoln Navigator. This system is available for demonstration. The features that are not currently implemented have been demonstrated by one of our prime subcontractors, Sarnoff Research Labs. (They are a world leader in advanced vision related technologies.) Many

of these features are in use in military applications. The main task in getting all the features into production is system integration and development of an improved user interface for the system. The components need to be ruggedized, packaged in the U.S. Army vehicles, and a software interface needs to be designed and written so that the system can be easily used in stressful situations. (We are assuming that these situations are when the system will prove to be of greatest use.) These are tasks that Ford and TARDEC are well suited to perform. For further information, contact Dr. Tom Meitzler, Survivability Visual Perception Laboratory, x4-5405.