

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD

MOBILEYE GLOBAL, INC.)
)
 Petitioner,) Inter Partes Review
) No. IPR2024-01111
 vs.)
) U.S. Patent No.
FACET TECHNOLOGY CORP.,) 9,671,328
)
 Patent Owner.)

REMOTE VIDEOTAPED DEPOSITION OF
CHARLES E. THORPE, PH.D.
MAY 29, 2025

On the 29th day of May, 2025, from
10:35 a.m. EDT to 5:34 p.m. EDT, the videotaped
deposition of the above-named witness, appearing
from Boston, Massachusetts, was taken at the
instance of the Patent Owner, before Karen L.
Shelton, RDR, CRR, CSR in and for the State of
Texas, via Zoom videoconference, pursuant to any
provisions stated on the record or attached hereto.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

R E M O T E A P P E A R A N C E S

ON BEHALF OF THE PETITIONER and THE DEPONENT:

MR. ROBERT K. HIGH
MR. WYATT L. BAZROD
FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER
LLP
271 17th Street, NW
Suite 1400
Atlanta, Georgia 30363-6209
(404) 653-6400
robert.high@finnegan.com
wyatt.bazrod@finnegan.com

ON BEHALF OF THE PATENT OWNER:

MR. MICHAEL D. SAUNDERS
DICKINSON WRIGHT PLLC
607 West 3rd Street
Suite 2500
Austin, Texas 78701
(512) 582-6889
msaunders@dickinsonwright.com

ALSO PRESENT:

Mr. Terry West - Videographer

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

I N D E X

	Page
Appearances	2
CHARLES E. THORPE, PH.D.	
Examination By Mr. Saunders	6
Examination By Mr. High	178
Reporter's Certificate	182

PREVIOUSLY MARKED EXHIBITS

No.	Description	Page
Exhibit 1001		9
	U.S. Patent 9,671,328	
Exhibit 1003		8
	Declaration of Charles E. Thorpe, Ph.D.	
Exhibit 1005		9
	U.S. Patent Publication No. 2002/0063638	
Exhibit 1006		9
	U.S. Patent No. 5,796,094	
Exhibit 1007		121
	U.S. Patent No. 5,202,742	
Exhibit 1008		143
	1997 Annual Book of ASTM Standards	
Exhibit 1009		147
	U.S. Patent No. 5,313,262	
Exhibit 1010		147
	International Publication No. WO 96/17258	

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

P R O C E E D I N G S

THE VIDEOGRAPHER: Good morning. We are going on the record at 10:35 a.m. on May 29th, 2025. Please note that this deposition is being conducted virtually. Quality of recording depends on the quality of camera and internet connection of participants. What is seen from the witness and heard on screen is what will be recorded. Audio and video recording will continue to take place unless all parties agree to go off the record.

This is Media Unit 1 of the video-recorded deposition of Dr. Charles Thorpe, Ph.D., taken by counsel for patent owner in the matter of Mobileye Global, Inc., versus Facet Technology Corp., filed in the U.S. Patent and Trademark Office, Case No. IPR2024-01110. This deposition is being conducted remotely using virtual technology.

My name is Terry West representing Veritext Legal Solutions, and I am the videographer. The court reporter is Karen Shelton from the firm Veritext Legal Solutions. I am not related to any party in this action, nor am I financially interested in the outcome. If there are any objections to proceeding, please state them at the time of your appearance.

1 Counsel and all present, including
2 remotely, will now state their appearances and
3 affiliations for the record beginning with the
4 noticing attorney.

5 MR. SAUNDERS: This is Michael Saunders of
6 Dickinson Wright for patent owner.

7 MR. HIGH: This is Robert High of Finnegan
8 on behalf of petitioner. With me today is Wyatt
9 Bazrod, also with Finnegan. And I'm also here for
10 the witness.

11 THE VIDEOGRAPHER: Will the court reporter
12 please swear in the witness and then counsel may
13 proceed.

14 (The witness was sworn by the reporter.)

15 MR. SAUNDERS: And Counsel, before we
16 start, I think the read-in said IPR2024-01111 or,
17 sorry, 1110. I think we're agreed that the notice
18 was for IPR2024-01111. Is that your understanding,
19 Counsel?

20 MR. HIGH: That's my understanding, yes.

21 MR. SAUNDERS: Okay. Thank you.

22 ///
23 ///
24 ///
25 ///
26 ///
27 ///
28 ///
29 ///
30 ///
31 ///
32 ///
33 ///
34 ///
35 ///
36 ///
37 ///
38 ///
39 ///
40 ///
41 ///
42 ///
43 ///
44 ///
45 ///
46 ///
47 ///
48 ///
49 ///
50 ///
51 ///
52 ///
53 ///
54 ///
55 ///
56 ///
57 ///
58 ///
59 ///
60 ///
61 ///
62 ///
63 ///
64 ///
65 ///
66 ///
67 ///
68 ///
69 ///
70 ///
71 ///
72 ///
73 ///
74 ///
75 ///
76 ///
77 ///
78 ///
79 ///
80 ///
81 ///
82 ///
83 ///
84 ///
85 ///
86 ///
87 ///
88 ///
89 ///
90 ///
91 ///
92 ///
93 ///
94 ///
95 ///
96 ///
97 ///
98 ///
99 ///
100 ///
101 ///
102 ///
103 ///
104 ///
105 ///
106 ///
107 ///
108 ///
109 ///
110 ///
111 ///
112 ///
113 ///
114 ///
115 ///
116 ///
117 ///
118 ///
119 ///
120 ///
121 ///
122 ///
123 ///
124 ///
125 ///
126 ///
127 ///
128 ///
129 ///
130 ///
131 ///
132 ///
133 ///
134 ///
135 ///
136 ///
137 ///
138 ///
139 ///
140 ///
141 ///
142 ///
143 ///
144 ///
145 ///
146 ///
147 ///
148 ///
149 ///
150 ///
151 ///
152 ///
153 ///
154 ///
155 ///
156 ///
157 ///
158 ///
159 ///
160 ///
161 ///
162 ///
163 ///
164 ///
165 ///
166 ///
167 ///
168 ///
169 ///
170 ///
171 ///
172 ///
173 ///
174 ///
175 ///
176 ///
177 ///
178 ///
179 ///
180 ///
181 ///
182 ///
183 ///
184 ///
185 ///
186 ///
187 ///
188 ///
189 ///
190 ///
191 ///
192 ///
193 ///
194 ///
195 ///
196 ///
197 ///
198 ///
199 ///
200 ///
201 ///
202 ///
203 ///
204 ///
205 ///
206 ///
207 ///
208 ///
209 ///
210 ///
211 ///
212 ///
213 ///
214 ///
215 ///
216 ///
217 ///
218 ///
219 ///
220 ///
221 ///
222 ///
223 ///
224 ///
225 ///
226 ///
227 ///
228 ///
229 ///
230 ///
231 ///
232 ///
233 ///
234 ///
235 ///
236 ///
237 ///
238 ///
239 ///
240 ///
241 ///
242 ///
243 ///
244 ///
245 ///
246 ///
247 ///
248 ///
249 ///
250 ///
251 ///
252 ///
253 ///
254 ///
255 ///
256 ///
257 ///
258 ///
259 ///
260 ///
261 ///
262 ///
263 ///
264 ///
265 ///
266 ///
267 ///
268 ///
269 ///
270 ///
271 ///
272 ///
273 ///
274 ///
275 ///
276 ///
277 ///
278 ///
279 ///
280 ///
281 ///
282 ///
283 ///
284 ///
285 ///
286 ///
287 ///
288 ///
289 ///
290 ///
291 ///
292 ///
293 ///
294 ///
295 ///
296 ///
297 ///
298 ///
299 ///
300 ///
301 ///
302 ///
303 ///
304 ///
305 ///
306 ///
307 ///
308 ///
309 ///
310 ///
311 ///
312 ///
313 ///
314 ///
315 ///
316 ///
317 ///
318 ///
319 ///
320 ///
321 ///
322 ///
323 ///
324 ///
325 ///
326 ///
327 ///
328 ///
329 ///
330 ///
331 ///
332 ///
333 ///
334 ///
335 ///
336 ///
337 ///
338 ///
339 ///
340 ///
341 ///
342 ///
343 ///
344 ///
345 ///
346 ///
347 ///
348 ///
349 ///
350 ///
351 ///
352 ///
353 ///
354 ///
355 ///
356 ///
357 ///
358 ///
359 ///
360 ///
361 ///
362 ///
363 ///
364 ///
365 ///
366 ///
367 ///
368 ///
369 ///
370 ///
371 ///
372 ///
373 ///
374 ///
375 ///
376 ///
377 ///
378 ///
379 ///
380 ///
381 ///
382 ///
383 ///
384 ///
385 ///
386 ///
387 ///
388 ///
389 ///
390 ///
391 ///
392 ///
393 ///
394 ///
395 ///
396 ///
397 ///
398 ///
399 ///
400 ///
401 ///
402 ///
403 ///
404 ///
405 ///
406 ///
407 ///
408 ///
409 ///
410 ///
411 ///
412 ///
413 ///
414 ///
415 ///
416 ///
417 ///
418 ///
419 ///
420 ///
421 ///
422 ///
423 ///
424 ///
425 ///
426 ///
427 ///
428 ///
429 ///
430 ///
431 ///
432 ///
433 ///
434 ///
435 ///
436 ///
437 ///
438 ///
439 ///
440 ///
441 ///
442 ///
443 ///
444 ///
445 ///
446 ///
447 ///
448 ///
449 ///
450 ///
451 ///
452 ///
453 ///
454 ///
455 ///
456 ///
457 ///
458 ///
459 ///
460 ///
461 ///
462 ///
463 ///
464 ///
465 ///
466 ///
467 ///
468 ///
469 ///
470 ///
471 ///
472 ///
473 ///
474 ///
475 ///
476 ///
477 ///
478 ///
479 ///
480 ///
481 ///
482 ///
483 ///
484 ///
485 ///
486 ///
487 ///
488 ///
489 ///
490 ///
491 ///
492 ///
493 ///
494 ///
495 ///
496 ///
497 ///
498 ///
499 ///
500 ///
501 ///
502 ///
503 ///
504 ///
505 ///
506 ///
507 ///
508 ///
509 ///
510 ///
511 ///
512 ///
513 ///
514 ///
515 ///
516 ///
517 ///
518 ///
519 ///
520 ///
521 ///
522 ///
523 ///
524 ///
525 ///
526 ///
527 ///
528 ///
529 ///
530 ///
531 ///
532 ///
533 ///
534 ///
535 ///
536 ///
537 ///
538 ///
539 ///
540 ///
541 ///
542 ///
543 ///
544 ///
545 ///
546 ///
547 ///
548 ///
549 ///
550 ///
551 ///
552 ///
553 ///
554 ///
555 ///
556 ///
557 ///
558 ///
559 ///
560 ///
561 ///
562 ///
563 ///
564 ///
565 ///
566 ///
567 ///
568 ///
569 ///
570 ///
571 ///
572 ///
573 ///
574 ///
575 ///
576 ///
577 ///
578 ///
579 ///
580 ///
581 ///
582 ///
583 ///
584 ///
585 ///
586 ///
587 ///
588 ///
589 ///
590 ///
591 ///
592 ///
593 ///
594 ///
595 ///
596 ///
597 ///
598 ///
599 ///
600 ///
601 ///
602 ///
603 ///
604 ///
605 ///
606 ///
607 ///
608 ///
609 ///
610 ///
611 ///
612 ///
613 ///
614 ///
615 ///
616 ///
617 ///
618 ///
619 ///
620 ///
621 ///
622 ///
623 ///
624 ///
625 ///
626 ///
627 ///
628 ///
629 ///
630 ///
631 ///
632 ///
633 ///
634 ///
635 ///
636 ///
637 ///
638 ///
639 ///
640 ///
641 ///
642 ///
643 ///
644 ///
645 ///
646 ///
647 ///
648 ///
649 ///
650 ///
651 ///
652 ///
653 ///
654 ///
655 ///
656 ///
657 ///
658 ///
659 ///
660 ///
661 ///
662 ///
663 ///
664 ///
665 ///
666 ///
667 ///
668 ///
669 ///
670 ///
671 ///
672 ///
673 ///
674 ///
675 ///
676 ///
677 ///
678 ///
679 ///
680 ///
681 ///
682 ///
683 ///
684 ///
685 ///
686 ///
687 ///
688 ///
689 ///
690 ///
691 ///
692 ///
693 ///
694 ///
695 ///
696 ///
697 ///
698 ///
699 ///
700 ///
701 ///
702 ///
703 ///
704 ///
705 ///
706 ///
707 ///
708 ///
709 ///
710 ///
711 ///
712 ///
713 ///
714 ///
715 ///
716 ///
717 ///
718 ///
719 ///
720 ///
721 ///
722 ///
723 ///
724 ///
725 ///
726 ///
727 ///
728 ///
729 ///
730 ///
731 ///
732 ///
733 ///
734 ///
735 ///
736 ///
737 ///
738 ///
739 ///
740 ///
741 ///
742 ///
743 ///
744 ///
745 ///
746 ///
747 ///
748 ///
749 ///
750 ///
751 ///
752 ///
753 ///
754 ///
755 ///
756 ///
757 ///
758 ///
759 ///
760 ///
761 ///
762 ///
763 ///
764 ///
765 ///
766 ///
767 ///
768 ///
769 ///
770 ///
771 ///
772 ///
773 ///
774 ///
775 ///
776 ///
777 ///
778 ///
779 ///
780 ///
781 ///
782 ///
783 ///
784 ///
785 ///
786 ///
787 ///
788 ///
789 ///
790 ///
791 ///
792 ///
793 ///
794 ///
795 ///
796 ///
797 ///
798 ///
799 ///
800 ///
801 ///
802 ///
803 ///
804 ///
805 ///
806 ///
807 ///
808 ///
809 ///
810 ///
811 ///
812 ///
813 ///
814 ///
815 ///
816 ///
817 ///
818 ///
819 ///
820 ///
821 ///
822 ///
823 ///
824 ///
825 ///
826 ///
827 ///
828 ///
829 ///
830 ///
831 ///
832 ///
833 ///
834 ///
835 ///
836 ///
837 ///
838 ///
839 ///
840 ///
841 ///
842 ///
843 ///
844 ///
845 ///
846 ///
847 ///
848 ///
849 ///
850 ///
851 ///
852 ///
853 ///
854 ///
855 ///
856 ///
857 ///
858 ///
859 ///
860 ///
861 ///
862 ///
863 ///
864 ///
865 ///
866 ///
867 ///
868 ///
869 ///
870 ///
871 ///
872 ///
873 ///
874 ///
875 ///
876 ///
877 ///
878 ///
879 ///
880 ///
881 ///
882 ///
883 ///
884 ///
885 ///
886 ///
887 ///
888 ///
889 ///
890 ///
891 ///
892 ///
893 ///
894 ///
895 ///
896 ///
897 ///
898 ///
899 ///
900 ///
901 ///
902 ///
903 ///
904 ///
905 ///
906 ///
907 ///
908 ///
909 ///
910 ///
911 ///
912 ///
913 ///
914 ///
915 ///
916 ///
917 ///
918 ///
919 ///
920 ///
921 ///
922 ///
923 ///
924 ///
925 ///
926 ///
927 ///
928 ///
929 ///
930 ///
931 ///
932 ///
933 ///
934 ///
935 ///
936 ///
937 ///
938 ///
939 ///
940 ///
941 ///
942 ///
943 ///
944 ///
945 ///
946 ///
947 ///
948 ///
949 ///
950 ///
951 ///
952 ///
953 ///
954 ///
955 ///
956 ///
957 ///
958 ///
959 ///
960 ///
961 ///
962 ///
963 ///
964 ///
965 ///
966 ///
967 ///
968 ///
969 ///
970 ///
971 ///
972 ///
973 ///
974 ///
975 ///
976 ///
977 ///
978 ///
979 ///
980 ///
981 ///
982 ///
983 ///
984 ///
985 ///
986 ///
987 ///
988 ///
989 ///
990 ///
991 ///
992 ///
993 ///
994 ///
995 ///
996 ///
997 ///
998 ///
999 ///
1000 ///
1001 ///
1002 ///
1003 ///
1004 ///
1005 ///
1006 ///
1007 ///
1008 ///
1009 ///
1010 ///
1011 ///
1012 ///
1013 ///
1014 ///
1015 ///
1016 ///
1017 ///
1018 ///
1019 ///
1020 ///
1021 ///
1022 ///
1023 ///
1024 ///
1025 ///
1026 ///
1027 ///
1028 ///
1029 ///
1030 ///
1031 ///
1032 ///
1033 ///
1034 ///
1035 ///
1036 ///
1037 ///
1038 ///
1039 ///
1040 ///
1041 ///
1042 ///
1043 ///
1044 ///
1045 ///
1046 ///
1047 ///
1048 ///
1049 ///
1050 ///
1051 ///
1052 ///
1053 ///
1054 ///
1055 ///
1056 ///
1057 ///
1058 ///
1059 ///
1060 ///
1061 ///
1062 ///
1063 ///
1064 ///
1065 ///
1066 ///
1067 ///
1068 ///
1069 ///
1070 ///
1071 ///
1072 ///
1073 ///
1074 ///
1075 ///
1076 ///
1077 ///
1078 ///
1079 ///
1080 ///
1081 ///
1082 ///
1083 ///
1084 ///
1085 ///
1086 ///
1087 ///
1088 ///
1089 ///
1090 ///
1091 ///
1092 ///
1093 ///
1094 ///
1095 ///
1096 ///
1097 ///
1098 ///
1099 ///
1100 ///
1101 ///
1102 ///
1103 ///
1104 ///
1105 ///
1106 ///
1107 ///
1108 ///
1109 ///
1110 ///
1111 ///
1112 ///
1113 ///
1114 ///
1115 ///
1116 ///
1117 ///
1118 ///
1119 ///
1120 ///
1121 ///
1122 ///
1123 ///
1124 ///
1125 ///
1126 ///
1127 ///
1128 ///
1129 ///
1130 ///
1131 ///
1132 ///
1133 ///
1134 ///
1135 ///
1136 ///
1137 ///
1138 ///
1139 ///
1140 ///
1141 ///
1142 ///
1143 ///
1144 ///
1145 ///
1146 ///
1147 ///
1148 ///
1149 ///
1150 ///
1151 ///
1152 ///
1153 ///
1154 ///
1155 ///
1156 ///
1157 ///
1158 ///
1159 ///
1160 ///
1161 ///
1162 ///
1163 ///
1164 ///
1165 ///
1166 ///
1167 ///
1168 ///
1169 ///
1170 ///
1171 ///
1172 ///
1173 ///
1174 ///
1175 ///
1176 ///
1177 ///
1178 ///
1179 ///
1180 ///
1181 ///
1182 ///
1183 ///
1184 ///
1185 ///
1186 ///
1187 ///
1188 ///
1189 ///
1190 ///
11

1 CHARLES E. THORPE, PH.D.,
2 having been first duly sworn, testified as follows:

3 E X A M I N A T I O N

4 BY MR. SAUNDERS:

5 Q. Good morning, Dr. Thorpe.

6 A. Good morning.

7 Q. Can you state your full name for the
8 record.

9 A. Charles E. Thorpe.

10 Q. And you're appearing today remotely via
11 Zoom? Is that correct?

12 A. That is correct.

13 Q. And where are you physically located right
14 now?

15 A. I am physically located in Boston in the
16 offices of Finnegan.

17 Q. And who else is in the room with you
18 today?

19 A. The attorneys, attorney High and attorney
20 Bazrod.

21 Q. And you've been deposed before, correct?

22 A. I have.

23 Q. You understand you're under oath?

24 A. I do.

25 Q. And you understand that the court reporter

1 needs verbal answers to questions rather than
2 nodding your head or gesturing?

3 A. That is correct.

4 Q. And do you understand that if you don't
5 understand any of my questions today, you can ask me
6 to clarify them?

7 A. I understand I can ask you for
8 clarification.

9 Q. And you understand that you can ask for a
10 break when you need one?

11 A. I will be asking for a break as I need
12 them.

13 Q. And is there any reason why you can't
14 provide truthful and complete testimony today?

15 A. There is no reason I cannot provide
16 truthful and complete testimony.

17 Q. And since I'm not there with you, will you
18 agree you won't communicate with anyone secretly
19 while you're on the record at this deposition?

20 A. I will not communicate with anyone
21 secretly while I'm on the record.

22 Q. Do you have any physical papers with you?

23 A. I do. I have copies of my declaration.
24 I have copies of your patents. I have copies of the
25 referenced documents, both for '328 and for, when we

1 get to it, the '255. These are unmarked -- unmarked
2 copies.

3 Q. Okay. Great. And do you also have access
4 to the Exhibit Share platform on your computer?

5 A. I see -- what I see so far is Patent '328,
6 my declaration, the Schofield patent, and U.S.
7 Patent Publication 2002/0063638.

8 Q. So you see Exhibit 1001, 1003, 1005 and
9 1006?

10 A. That's how they are numbered, yes.

11 Q. All right. And you understand you're here
12 today to discuss a declaration you submitted in
13 IPR2024-01111 filed in the Patent Trial and Appeal
14 Board relating to U.S. Patent No. 9,671,328?

15 A. That is correct.

16 Q. And the Exhibit 1003 that we've uploaded,
17 that's your declaration you submitted regarding the
18 '328 patent?

19 A. That's what it says. Let me take a quick
20 look at the exhibits. Exhibit 3 appears to be my
21 declaration.

22 Q. And if I refer to the '328 patent today,
23 you understand I'm referring to that patent number
24 9,671,328?

25 A. That is correct.

1 Q. And that's Exhibit 1001 that I've uploaded
2 in Exhibit Share?

3 A. That is the '328 patent.

4 Q. And Exhibit 1005 is the Gallagher
5 reference you analyzed? Is that correct?

6 A. Yes, that is the Gallagher reference.

7 Q. And Exhibit 1006 is the Schofield
8 reference you analyzed?

9 A. That appears to be the Schofield
10 reference.

11 Q. Okay. And today you understand if I'm
12 asking you questions about one of the documents you
13 have on paper, you feel free -- you can feel free to
14 refer to your copy that you have on paper there with
15 you? Do you understand that?

16 A. Thank you.

17 Q. Okay. So starting with the Gallagher
18 reference, that is one of the references you used in
19 every ground in your declaration in this IPR.

20 Is that correct?

21 A. It is every ground. I believe that is
22 correct.

23 Q. And what is the purpose of the Gallagher
24 reference?

25 MR. HIGH: Objection, form.

1 A. Can you restate that question?

2 Q. Yes. So the Gallagher reference teaches a
3 particular system, correct?

4 A. It does teach a particular system.

5 Q. And what is that system trying to do?

6 A. The title of the patent is "Reflectivity
7 Measuring Apparatus and Method."

8 Q. Is the Gallagher system attempting to
9 determine whether road markings are present on a
10 roadway?

11 A. So what I said in my written testimony,
12 "discloses a reflectivity measuring apparatus used
13 on a moving vehicle. Discloses that light
14 reflective road markings and markers are extensively
15 used to demarcate vehicle lanes and supply vital
16 information to drivers about sections of the road."

17 Gallagher says that he "tests road
18 markings and road markers such as, for example, road
19 signs and posts, reflective painted lines whether
20 continuous or broken, and raised pavement markers."

21 This is on pages 36 and 37 of my
22 declaration.

23 Q. So how does Gallagher detect a road
24 marking?

25 A. Well, includes a light source in the form

Page 10

1 of a standard headlight in one example, although he
2 does disclose the use of other kinds of
3 illumination. Arranged to deflect -- and then
4 multiple sensors arranged to detect reflected light
5 from a relatively small viewing angle.

6 In one example he uses a handful of
7 sensors, but he discloses he could use more sensors
8 or different kinds of sensors as needed. And he
9 discloses that these sensors could be used to
10 indicate the color of the road marking being tested.

11 Q. So in Gallagher, the output from the
12 sensors goes into a computer? Is that correct?

13 A. The output of the sensors is processed by
14 a computer.

15 Q. How does the computer determine that the
16 output of the sensors indicates that a road marker
17 is present?

18 MR. HIGH: Objection, form.

19 A. Can you restate that?

20 Q. Yeah. So in Gallagher, how does that
21 computer work to detect road markers?

22 A. So if we look at the Gallagher patent, in
23 his paragraphs 15, 16, 17, and 18, the computer is
24 programmed to carry out the steps of getting data on
25 the reflectance level of road markings, calibrating

1 the data by multiplying the data with a
2 predetermined calibration factor, and determining
3 whether the road marking meets a predetermined
4 acceptable reflectance level.

5 If we skip down, he lays out the detail of
6 this in paragraphs approximately 56 through
7 approximately 74.

8 Q. Is your answer complete?

9 A. Is there a particular section of that that
10 you want more detail on?

11 Q. Well, let's start with paragraph 56. It
12 mentions that there's an output from ADC 13.

13 Do you see that?

14 A. Yes.

15 Q. So that's analog to -- sorry. Let me ask
16 it this way. I'll withdraw that question.

17 What is ADC 13?

18 A. Analog-to-digital converter to take the
19 data from the photodiode and turn it into a number.

20 Q. And that number goes into the computer?

21 A. That is correct.

22 Q. And so how does Gallagher's computer use
23 that number to decide whether or not a road marker
24 is present?

25 A. First of all, in step 60, paragraph 60,

1 Gallagher is using the numbers from each of the
2 light sensors and comparing the data from each of
3 the light sensors to determine which one has the
4 highest reflectance level and, given the highest
5 reflectance level, uses that in paragraph 61 to give
6 the operator of the vehicle a notion of how to steer
7 so as to keep the field of view of interest centered
8 in the sensing field of the apparatus.

9 Q. Is that discussion in paragraph 60 about
10 providing the indicator means for the operator of
11 the vehicle, is that used as part of Gallagher's
12 determination of whether or not a road marker is
13 present?

14 A. That is used to --

15 MR. HIGH: Objection, form.

16 A. Could you restate that?

17 Q. Well, do you understand the question?

18 A. If you look at Figure 2 of Gallagher on
19 page 2, his field of view of a sensor is covering
20 occasionally reflective raised pavement markers but
21 is also covering painted stripes.

22 So the method in Process 60 may well be
23 picking up painted stripes as well as reflectors.
24 And --

25 Q. Let me ask the question another way.

1 You see in paragraph 64 of Gallagher it
2 says, "This information is used to tag or identify
3 the road markers tested along a stretch of road."

4 Do you see that?

5 A. I see that.

6 Q. And do you see paragraph 65 mentions
7 step F and involves determining the background
8 reflectance level on the road? Do you see that?

9 A. I see that.

10 Q. And then you see in paragraph 66 there's
11 step G, says, "involves selecting, from the data
12 obtained in step A, which reflectance levels
13 indicate a road marker"? Do you see that?

14 A. I see that.

15 Q. So is Gallagher in step G in paragraph 66
16 using any of the indicator signal that's generated
17 in paragraph 60?

18 MR. HIGH: Objection, form.

19 A. Can you restate that?

20 Q. Yes. I'm just going to give you some
21 context. I think a few questions ago I was asking
22 you how does Gallagher actually use the number
23 output from the ADC to decide whether or not a road
24 marker was present. And I think in one of your
25 answers you identified paragraph 60 to me which is

1 the step D about providing that indicator means, and
2 I tried to understand whether it was your point of
3 view that step D had some relation to step G which
4 selects which reflectance levels indicate a road
5 marker.

6 So do you think that there's some
7 connection with the data generated in step D and the
8 data that's processed in step G in paragraph 66?

9 A. Certainly Gallagher is watching the signal
10 received in each of his photodetectors, watching to
11 see which ones of those has the highest output,
12 using that in paragraphs 60, 61, 62 for a lateral
13 offset.

14 He is not specific as to the tie between
15 that and the peak detection, but it would be logical
16 to say that the output sensor with the highest
17 output would be the one which needs to be examined
18 to see if it's a retroreflector.

19 He does, however, also contemplate
20 detecting multiple reflectors side by side, so that
21 would require different processing that would
22 require not just looking at the single brightest but
23 looking at all of his reflectors.

24 (Reporter Clarification)

25 A. If he's looking for multiple reflectors

1 side by side, then he has to look at multiple of his
2 photodetectors at the same time. So it would not be
3 just the brightest one. It may be multiple ones.

4 Q. Step D that's in paragraphs 60, 61, and
5 62, that happens while an operator is driving the
6 vehicle of Gallagher. Is that right?

7 A. That is correct.

8 Q. Does step 66 happen while the vehicle is
9 being driven as well? Let me withdraw.

10 Does the step G in paragraph 66 of
11 Gallagher occur while the operator is driving the
12 vehicle?

13 A. Because Gallagher is sensing a single
14 line, the way that he senses the entire road is by
15 push-brooming that line along the road. So you
16 can't determine a peak unless the vehicle is in
17 motion. Otherwise, you're examining the same spot.

18 Q. Let's go back to paragraph 18. You
19 pointed to me that earlier. That paragraph recites,
20 "Determining whether the road marking meets a
21 predetermined acceptable reflectance level."

22 Do you see that?

23 A. I see that.

24 Q. How does Gallagher disclose setting that
25 predetermined acceptable reflectance level?

1 A. So from my expert declaration, Gallagher
2 discloses its computer obtaining the data on the
3 reflected light detected by the light sensor 6,
4 determining the background reflectance level on the
5 road and establishing non-marker reflectance levels,
6 and selecting from data obtained which reflectance
7 levels indicate reflective surface of a road marker.

8 Q. But how does it -- how does it decide --
9 is there a threshold that Gallagher uses to
10 determine that if it gets a number from the ADC
11 above a certain number that that means that there's
12 a road marker present?

13 MR. HIGH: Objection, form.

14 A. Can you restate that?

15 Q. Yeah. So I'm trying to understand your
16 understanding of how Gallagher works. Does
17 Gallagher compare the output of the ADC to a
18 particular number and then decide that something is
19 a road marker based on whether the value returned
20 from the ADC is above that predetermined number?

21 A. So process step G involves selecting which
22 reflectance levels indicate a road marker. In the
23 case of road markers, the peak responses sensed are
24 determined as the highly reflective surfaces of a
25 road marker.

1 So as you push-broom the sensors of a
2 light source across the road, when the reflectors
3 start to enter the field of view of the sensor,
4 there will be a small response. As they are
5 centered in the field of view of the sensor, there
6 will be a higher response. As you leave the field
7 of view, they will drop off. By sensing that peak
8 location, you can then very accurately determine the
9 location of those peaks.

10 And Gallagher does talk about
11 distinguishing their reflectance levels from the
12 non-marker reflectance levels.

13 Q. So how does Gallagher establish non-marker
14 reflectance levels?

15 A. Gallagher is continuously watching the
16 background to establish the background reflectance
17 level.

18 Q. Well, Gallagher can't determine a
19 background reflectance level while it's got a road
20 marker in front of it, right?

21 A. Gallagher has multiple sensors. If one or
22 two of the sensors are picking up road markers, the
23 others will be picking up background levels.

24 Q. How does Gallagher use the non-marker
25 reflectance levels?

1 A. So if we back up and look at paragraphs 58
2 and 59, the data collected in page -- in paragraph
3 56 is filtered in paragraph 57. I assume that
4 filtering does two things. It filters for noise
5 induced by bouncing of the vehicle over a rough
6 road, and it filters for electrical noise. So now
7 we have an average and filtered value which will be
8 more accurate than any one reading. Any electrical
9 measurement will have some noise associated with it.
10 Taking multiple measurements and averaging them will
11 give you a better value. So that's in 57 is the
12 filtering.

13 58, calibrating the data by multiplying
14 the data with a predetermined calibration factor.
15 And page 59 talks about how the predetermined
16 calibration factors are calculated. One example of
17 how they are calculated, and there's other ways of
18 doing this, is to have a controlled conveyor belt
19 that moves these reflectors past the sensor. You
20 can therefore calculate the response of a particular
21 sensor. You can calculate the response of each
22 sensor at different offsets.

23 Q. Okay. Maybe I don't understand your
24 response, but my question was, how does Gallagher
25 use the non-marker reflectance levels? And so you

1 identified a few different paragraphs to me, so is
2 there something in those paragraphs that relates to
3 non-marker reflectance levels?

4 A. I was answering a previous question, which
5 was, how does he detect the reflectance, reflectors.

6 Q. Okay.

7 A. And detecting the reflectors requires the
8 calibration in 59.

9 Q. So how does Gallagher use non-marker
10 reflectance values? Or sorry. Let me withdraw.

11 How does Gallagher use non-marker
12 reflectance levels?

13 A. Well, paragraph 60 talks about collecting
14 the reflectance levels. Given that background
15 reflectance levels on the non-road marking sections
16 are low and road markers are relatively high, it can
17 detect which light sensor is reading the highest
18 reflectance reading.

19 Q. Is there any other way that Gallagher uses
20 the non-marker reflectance levels?

21 A. I can search the document to find --

22 In 65 and in 66. 65 is determining the
23 background reflectance level. 66 is finding things
24 which are above the background reflectance level.

25 Q. So if something is above the non-marker

1 reflectance level, it's determined to be a road
2 marker?

3 MR. HIGH: Objection, form.

4 A. Can you restate that?

5 Q. Did you understand the question?

6 A. In paragraph 60, he's talking about road
7 markers being higher than the background reflectance
8 level.

9 Q. Let me ask the question this way.

10 So step F is in paragraph 65, and that
11 mentions establishing non-marker reflectance levels.

12 Do you see that?

13 A. I see that.

14 Q. And then step G is the next paragraph,
15 paragraph 66, and that mentions that, "In the case
16 of road markers, the peak responses sensed are
17 determined as the highly reflective surfaces of a
18 road marker." Do you see that?

19 A. I see that.

20 Q. Is the non-marker reflectance level from
21 step F used in step G?

22 A. He is not specific on that.

23 Q. You don't know one way or another?

24 A. I don't believe the patent is specific.

25 Q. So as Gallagher's vehicle is going down

1 the road and imagine it's going down a path that
2 doesn't have any road markers or reflective paint or
3 anything. The outputs from the photodiodes are
4 still going to go up and down to some degree based
5 on different illumination of the road, correct?

6 MR. HIGH: Objection, form.

7 A. Can you restate the question?

8 Q. Yeah. So, I mean, the sensor -- light
9 sensors in Gallagher, they will have different
10 outputs based on different light levels they detect,
11 correct?

12 A. That is correct.

13 Q. And if you have a stretch of pavement that
14 doesn't have any road markers or other reflective
15 surfaces, that light level can still vary. For
16 example, if you're underneath a street lamp, you're
17 going to have a higher level than if you're in a
18 patch of road with no street lamp. Correct?

19 A. Correct.

20 Q. Okay. But Gallagher isn't going to say
21 that there's a road marker there just because the
22 photodiodes go up a little bit when it goes
23 underneath a street lamp, right?

24 A. It goes up a little bit, then that does
25 not indicate the reflectance levels that indicate a

1 road marker.

2 Q. Okay. So there's some number from the ADC
3 output that says -- that Gallagher says, okay,
4 that's a number that I know is high enough that it
5 is a road marker. Is that correct?

6 A. Which comes from the calibration factor in
7 paragraph 59.

8 Q. Okay. So the answer is yes, based on a
9 calibration factor? Is that correct?

10 A. Now, be careful. You're saying there is a
11 road marker. There are high-quality road markers
12 and there are damaged road markers. You could
13 certainly imagine a road marker covered by dirt.
14 So he is not guaranteeing he's going to detect all
15 of the road markers.

16 If you look at Figure 5 on page 5, B.
17 Let's go look at what the description of that is.
18 Where do we find the description of Figure 5?

19 Turn now to Figure 5, paragraph 78.
20 X component is the location of each road marker and
21 the distance traveled. Y component is the
22 reflectance levels of the front face of each marker.
23 Negative Y is the reflectance level of the rear face
24 of each marker. And in this case he has a threshold
25 minimum acceptable reflectance level, B, as shown on

Page 23

1 the figure.

2 So in that case of Figure 5, he has a
3 minimum acceptable reflectance level. And you can
4 see in Figure 5 some of his detections are above the
5 threshold and there are places which are apparently
6 gaps.

7 Q. So looking at Figure 5, what parts of that
8 figure do you think are the ones that are gaps?

9 A. Well, for instance, if you look at the
10 rear face, you can see a number of markers above the
11 threshold B and a gap where there are nothing.
12 Either there are no markers there or they are
13 defective markers.

14 Q. So does Gallagher distinguish between
15 defective markers and the absence of a road marker?

16 A. Gallagher is looking for the minimum
17 acceptable reflectance level. If they do not meet
18 the minimum acceptable reflectance level, then in
19 paragraph 21, "the process further includes a step
20 of activating a road marker tagging means to tag a
21 road marker if it is determined as having a
22 reflectivity level which does not meet the
23 predetermined acceptable reflectance level."

24 Q. So how does Gallagher know that there is a
25 road marker present which does not meet the

1 predetermined acceptable reflectance level?

2 A. As I said, a road marker covered with dirt
3 would be invisible. So you can --

4 Q. How does --

5 A. -- take a hypothetical situation --
6 Go ahead.

7 Q. How does Gallagher distinguish between a
8 road marker covered in dirt as opposed to variations
9 in the illumination level of the road such as caused
10 by a streetlight?

11 MR. HIGH: Objection, form.

12 A. Can you restate the question?

13 Q. Yeah. I'm trying to -- I'm trying to
14 understand how Gallagher works and in particular
15 whether it's able to distinguish between a road
16 marker that is degraded, for example, because it's
17 covered in dirt versus the absence of a road marker.

18 And you mentioned the predetermined
19 acceptable reflectance levels. And I was trying to
20 understand, how does that relate to the situation
21 of, well, we know that the road has difference in
22 light anyways, for example, because of a -- of a --
23 for example, the presence of streetlights.

24 Do you understand the background of what
25 I'm asking?

1 A. Not completely. If you get a strong
2 enough return, above threshold B, you have a
3 functioning marker.

4 Q. Okay. What if we're in the situation
5 where we're below that threshold B? How do we know
6 whether -- in Gallagher whether it's a road marker
7 that's covered in dirt or simply just the space
8 between road markers?

9 A. Let's see what Gallagher says.

10 Paragraph 23, "Preferably the process
11 further includes the step of determining the
12 location of any missing road markers by recognizing
13 patterns in existing road marker locations and with
14 being provided with information on the spacing of
15 known valid road markers."

16 So if you know the pattern, a road marker
17 is supposed to appear every so many meters, and
18 you've gone that number of meters and not seen a
19 road marker above the threshold, you can tag it.

20 Q. So either a road marker is present because
21 it's above the threshold B or a road marker is not
22 present or degraded, and then there's a second
23 determination of whether we've passed a distance
24 where there should have been a road marker?

25 Is that correct?

1 MR. HIGH: Objection, form.

2 A. Can you restate that?

3 Q. Yes. Are there two determinations
4 occurring in Gallagher; one, whether or not we've
5 sensed a peak that's above the threshold B, and
6 second, a determination of whether we've passed a
7 certain amount of distance where there should have
8 been a peak above the threshold B?

9 Is that accurate?

10 A. So the peak above the threshold B is what
11 is shown in the figure, and that is then tagged as a
12 valid and functioning road reflector.

13 Paragraph 23 talks about if you did not
14 see one where you expected to see one, then there is
15 either a degraded or a missing road marker and it
16 should be tagged.

17 Q. Let's talk a little bit about the sensors
18 used in Gallagher. Gallagher mentions photodiodes.

19 Is that correct?

20 A. Show me which paragraph.

21 Q. For example, paragraph 39.

22 A. In paragraph 39 he's talking about
23 photodiodes.

24 Q. Okay. And what is a photodiode?

25 A. It is a piece of electronics which

1 produces a voltage proportional to the amount of
2 light landing on it. And there are lots of
3 different kinds of photodiodes, so I don't know the
4 specifics of this one.

5 Q. So a photodiode measures an intensity of
6 light received?

7 A. That'll be correct.

8 Q. And in Gallagher it's able to turn that
9 intensity measurement into a number using the ADC?

10 A. That's what the ADC does.

11 Q. And Gallagher mentions in paragraph 38 an
12 array of five or ten sensors, generally. Do you see
13 that?

14 A. And this is one specific embodiment.

15 Q. You see in paragraph 38 the reference to
16 five or ten sensors, correct?

17 A. I see the reference to five or ten in one
18 embodiment of his system.

19 Q. Is there another embodiment of Gallagher
20 that you're relying on other than the array of
21 photodiode sensors discussed in paragraphs 38 and
22 39?

23 A. Well, certainly in paragraph 40 he's
24 talking about a higher number of light sensors.

25 Q. 40 mentions ten sensors, right?

1 A. It mentions a higher number of sensors,
2 desirably about ten sensors. But I'm also looking
3 for -- says in this embodiment sensor arrays
4 containing a plurality of sensors are advantageously
5 used.

6 It is obvious to a person of ordinary
7 skill in the art that there are other ways of
8 sensing light intensity than an array of
9 photodiodes.

10 Q. Gallagher itself doesn't describe how to
11 detect road markers other than using an array of
12 photodiodes. Is that correct?

13 MR. HIGH: Objection, form.

14 A. Can you restate that?

15 Q. Yeah. Is there -- there isn't a
16 disclosure in Gallagher of how to detect road
17 markers other than using an array of photodiodes.

18 Is that correct?

19 A. Paragraph 9, "Advantageously a plurality
20 of light sensors are provided to cover a wide field
21 of view, each said light sensor detecting any
22 reflected light from a different area of road and
23 providing a data signal to the processing means
24 representing the reflectivity of each said area of
25 road."

1 So that is a pretty broad definition of
2 light sensors that could go from an array of
3 photodiodes up to a video camera.

4 Q. Gallagher doesn't mention cameras,
5 correct?

6 A. Without reading the entire patent
7 carefully, I can't answer that.

8 Q. Sitting here right now, you don't recall
9 Gallagher mentioning cameras. Is that correct?

10 A. I would have to read the patent, which I
11 would be pleased to do.

12 Q. I'm just asking, your current
13 recollection, without reading the patent, you can't
14 recall a place where Gallagher mentions cameras,
15 correct?

16 A. I would have to read the patent.

17 Q. You don't recall a disclosure in Gallagher
18 of how to detect road markers using a camera,
19 correct?

20 A. Again, paragraph 9 is the general way of
21 sensing light which involves -- which includes a
22 wide variety of ways of doing it. Paragraph 7, "a
23 light sensor and processing means."

24 So his summary of the invention is quite
25 broad as to what the light sensors could be. His

1 specific embodiment is narrower.

2 Q. The output from a camera isn't just a
3 voltage that can be turned into a number with an
4 ADC, correct?

5 A. Well, the output of an analog camera is
6 indeed voltages that need to be digitized to create
7 intensity levels.

8 Q. Well, the output of a camera has a
9 resolution that's vertical and horizontal array of
10 pixels. Is that correct?

11 A. That's correct.

12 Q. And a photodiode doesn't have that,
13 correct?

14 A. Photodiode is a single spot. An array of
15 photodiodes can be analogous to a single row of a
16 camera.

17 Q. In Gallagher, how is the array of
18 photodiodes arranged?

19 A. Figure 2 and Figure 1 give a picture of
20 how everything is arranged.

21 Q. So I'll ask the question this way.

22 In the array of Gallagher's photodiodes,
23 are those photodiodes in a single row horizontally?

24 A. That is my understanding is that they are
25 in a fan arranged horizontally to scan a single line

1 of the roadway. Gallagher is in essence producing
2 an image row by row by what we would call
3 push-brooming, one row, the next row, the next row,
4 as you drive down the road. That creates a series
5 of rows which creates a form of an image.

6 Q. I want to go back to paragraph 57 of
7 Gallagher I think we talked about before. Let me
8 know when you're there.

9 A. 57, process step B.

10 Q. Yeah. So that mentions filtering the data
11 by calculating the average reflectance level from a
12 set of sample data. Do you see that?

13 A. Yes.

14 Q. Is that sample data the data that's
15 collected in step A?

16 A. That is the sample data which is collected
17 in step A.

18 Q. So to do the filtering in step B, it
19 already needs to have data that it has collected?

20 Is that correct?

21 A. So to do the back-of-the-envelope
22 calculation, he's talking about sampling at a high
23 rate. And I'm looking to see where he lists the
24 rate. Traveling at speeds up to a hundred
25 kilometers per hour. Oh, paragraph 47, sampling at

1 10 kilohertz. So he's sampling 10,000 times per
2 second on his A-to-D converters.

3 If you're moving at a hundred kilometers
4 an hour, divide that by 60 minutes, divide that by
5 60 seconds, you're moving approximately -- and I'm
6 not going to do the exact math -- 30 meters per
7 second. So if you're moving about 30 meters per
8 second and you're sampling 10,000 times, 30 divided
9 by 10 gives you 3 meters. 3 meters divided by a
10 thousand gives you 3 millimeters.

11 So he is taking samplings every
12 3 millimeters along the road as he moves. That's
13 far denser than he needs in order to detect an
14 object of interest. So what he does is he takes
15 several of these samples very close to each other
16 and, in the paragraph you pointed me to, paragraph
17 57, averages them. That takes care of funny little
18 defects like a bump in the road causing your sensors
19 to look not quite where they're supposed to or funny
20 noise in the electronics or something like that.

21 So he has -- because he's using the
22 photodiodes, he can sample them much faster than he
23 would sample a camera. He takes advantage of that
24 to filter and smooth the data to give him more
25 reliable data.

1 Q. And it's that smoothed result of the
2 average reflectance level that's compared against
3 the value B in Figure 5?

4 A. I believe so.

5 Q. Now, let's turn to paragraph 59. That
6 discusses calibration factor. Do you see that?

7 A. Yes.

8 Q. That's done some in advance, before the
9 vehicle is driven on the roadway? Is that correct?

10 A. It says "one type of static test." So
11 that is one way of doing it. It also talks about
12 multiple static tests test different tracking
13 distances.

14 Q. Those are all happening before the vehicle
15 is run along the roadway, right?

16 A. In -- in this embodiment, that's how they
17 are done.

18 Q. What is your understanding of the meaning
19 of a static test?

20 A. Say that again?

21 Q. What is your understanding of the meaning
22 of "static test"?

23 A. Static means the vehicle not moving. But
24 he says there's also additionally checks on the
25 road. So you can calibrate this in a lab. You can

1 calibrate this on the road.

2 Q. Where does he refer to checks -- let me
3 withdraw.

4 Does Gallagher explain what it means by
5 "checks on the road"?

6 A. I don't believe he offers more detail on
7 that. So in summary, he's collecting the data. He
8 is smoothing the data. He's examining the data to
9 detect relatively high signals for steering. He is
10 further examining the data to detect peaks. He's
11 examining the peaks to detect if they are above a
12 threshold which has been determined by the static
13 calibration.

14 Q. Can Gallagher distinguish between a road
15 marker with good reflectance as opposed to a strong
16 flashlight that's pointed at one of the photodiodes?

17 MR. HIGH: Objection, form.

18 A. Can you rephrase the question?

19 Q. Yeah. Is there functionality in Gallagher
20 for distinguishing between reflective road markers
21 and other strong sources of light?

22 A. He talks about that in paragraph 39. In
23 the case of sensing colored markers, light sensors
24 with different spectral responses can be used. So
25 if he's looking for yellow reflectors and he has

Page 35

1 either a sensor or a filter looking for yellow, then
2 a bright blue light source would not be picked up by
3 his system.

4 Q. So can Gallagher distinguish between a
5 reflective road marker and a strong light source of
6 the same wavelength?

7 A. If you've got flashlights shining up at
8 you from the road surface, you're in trouble.

9 Q. But in that situation, could Gallagher
10 distinguish between the two?

11 A. If you have a light source which is the
12 same as a retroreflector, it will look like a
13 retroreflector. If it is not the same as a
14 retroreflector, either by spectrum or by shape, then
15 the spectral filtering discussed in 39 could
16 distinguish it. The peak detection would have a
17 different shaped peak.

18 But the ultimate end of your question is
19 if a truckload of retroreflectors lost its cargo,
20 could you tell which of these are bolted down to the
21 pavement and which are just scattered over the
22 pavement. At that point they appear identical to a
23 human as well as to Gallagher's system.

24 Q. Well, let's talk about shape a little bit.
25 How does Gallagher's system use shape in detecting

1 road markers?

2 A. It is not specified. But the peak
3 detection, which is used to determine precise
4 location, certainly the shape of that peak is
5 different if you're looking at an extended light
6 source versus looking at a retroreflector.

7 Q. So Gallagher doesn't distinguish -- let
8 me just --

9 Gallagher doesn't teach you how to
10 distinguish peaks from road markers as opposed to
11 peaks from other bright light sources.

12 Is that correct?

13 A. I'm not sure that Gallagher contemplated
14 that issue.

15 Q. All right. How far ahead does Gallagher
16 detect road markers?

17 A. Gallagher has deliberately set up his
18 system to look about 2.3 meters from the platform.
19 I'm in paragraph 35.

20 Q. So that broom you talked about earlier,
21 that's moving along the roadway about 2.3 meters
22 ahead of the vehicle? Is that right?

23 A. I believe that is correct.

24 MR. SAUNDERS: We've been going for about
25 an hour. Why don't we go ahead and go off record

1 for a break.

2 THE VIDEOGRAPHER: Okay. We're going off
3 the record. The time now is 11:35 a.m.

4 (Recess from 11:35 to 11:46)

5 THE VIDEOGRAPHER: Okay. We are back on
6 the record. The time now is 11:46 a.m.

7 BY MR. SAUNDERS:

8 Q. All right. Welcome back, Dr. -- sorry,
9 Dr. Thorpe. All right. We were talking about the
10 Gallagher reference before the break. What is the
11 field of view in the Gallagher reference?

12 A. So he mentions that again in the same
13 paragraph, paragraph 35. He's looking at an area of
14 about 3 meters by about a half meter.

15 Q. So that 3 meters is as determined by both
16 the number of sensors it has horizontally and also
17 the angle of which those photodiode receptors are
18 receptive to signals? Is that correct?

19 A. This is his particular embodiment. It
20 would be no problem to scale everything up. It
21 would require a stronger light source. It would
22 require more sensors. It would require different
23 mounting. So it's all proportional.

24 Q. But in this example -- let's ask about the
25 0.5 meter. In this example that's disclosed in

1 Gallagher, that 0.5 meters is determined by the
2 angle, vertical angle of receptivity of the
3 photodiode sensors? Is that correct?

4 A. I'm not sure that's correct. He's talking
5 about the light source. "The light source 4 is of
6 relatively constant and even intensity when a wide
7 beam is projected about 2.3 meters from a platform
8 or unit 5 located at the front of the vehicle to
9 cover a 3 meter by half meter area."

10 So I believe he's talking about the field
11 of view of the light source in paragraph 35.

12 Q. Does Gallagher say what the field of view
13 of its sensors are?

14 A. Believe he says they are mounted at a
15 height and angle to properly detect reflected light
16 but does not specify for these particular sensors
17 what their field of view is.

18 Q. So it's not specifically said, but it's
19 looking at the same place that the light is shining,
20 generally. Is that fair?

21 A. They are certainly looking within the
22 illuminated area of the scene.

23 Q. Okay. Now, Gallagher mentions different
24 angles for the sensors in paragraph 36.

25 Do you see that?

1 A. Paragraph 36. Yes.

2 Q. And it mentions that -- adjusting the
3 incident angle to account for factors including
4 undulating roads. Do you see that?

5 A. Yes, I see that.

6 Q. So that means roads that go up and down?

7 A. Yes.

8 Q. Okay.

9 A. Wavy roads.

10 Q. So if Gallagher's vehicle is cresting over
11 a steep hill, it's potential that the field of view
12 of a sensor could go beyond the roadway.

13 Is that correct?

14 A. There are standards for allowable vertical
15 curvature, this way or this way, of roads that are
16 set by AASHTO, American Association of State
17 Transportation and Highway Officials, and they are
18 deliberately set to make sure that your headlights
19 are illuminating the road that you're driving on.

20 I would have to get out a piece of paper
21 and a pencil and draw pictures to find out if you
22 could ever have that steep of a vertical curvature.

23 Q. Well, if --

24 A. It was --

25 Q. -- Gallagher's view -- goal was --

1 MR. HIGH: I think he was just about to
2 finish.

3 A. He says preferably between 13 and
4 17 degrees. So if you're looking down at
5 13 degrees, how steep of a vertical curve would you
6 have to have in order to not hit the ground with
7 your lights? We could do that calculation if you
8 want.

9 Q. If you had a 17-degree grade transitioning
10 onto a flat grade, that light source would start
11 coming off the road over the crest of the hill,
12 right?

13 A. But you're not allowed to have an
14 instantaneous transition for precisely that reason,
15 because then standard vehicle headlights would not
16 pick things up and you would have a blind zone and
17 be susceptible to collisions with objects on the
18 roadway.

19 Q. Now, paragraph 36 of Gallagher discusses
20 that the incident angle between the angle of the
21 beam to road level is held constant over any one
22 test. Do you see that?

23 A. Yes, I see that.

24 Q. And so Gallagher can't test for road signs
25 at the same time it's trying to look for pavement

1 markers, right?

2 MR. HIGH: Objection, form.

3 A. So Gallagher discusses that the method
4 he's talking about can be used for a variety of
5 different purposes and -- where does he say it --
6 preferred embodiments of the invention will now be
7 illustrated.

8 So are you talking about the preferred
9 embodiment, or are you talking about the general
10 principle?

11 Q. Well, let's start with the preferred
12 embodiment. In the preferred embodiment, it can't
13 sense both -- in one test both pavement markers and
14 road signs. Is that correct?

15 A. In the preferred embodiment here, he's
16 looking down, so he's looking at things on the
17 roadway.

18 Q. And then is there anywhere in Gallagher a
19 disclosure of how to, in one test, be able to detect
20 both pavement markers and road signs?

21 A. Well, for instance, in paragraph 9,
22 plurality of light sensors to cover a wide field of
23 view.

24 Q. A plurality of sensors just means more
25 than one sensor, right?

1 A. His abstract, he's talking about
2 reflective surfaces.

3 Q. The abstract doesn't tell you how to look
4 for both road signs and pavement markers in the same
5 test, right?

6 A. In places like paragraph 1, more
7 particularly but not exclusively, this invention
8 relates to a method and apparatus for assessing the
9 integrity of road markings, road markers and
10 markings.

11 Q. That's not telling you how to actually
12 look for road signs and pavement markers in the same
13 test, right?

14 A. So in his preferred embodiment he is
15 looking down, and so he is not looking for signs.

16 Q. And he's not disclosing how another
17 embodiment would work that is able to look for signs
18 and pavement markings at the same time, right?

19 A. That is not something which he has
20 explicitly described. The question is would it be
21 obvious to a person of ordinary skill in the art to
22 say if you've got this push-brooming along the
23 ground, let's have something looking out also. And
24 I would think that that would be pretty obvious.

25 Q. All right. We've been talking about

1 Gallagher a lot right now, so I'd like to turn to
2 the Schofield reference, Exhibit 1006. Let me know
3 when you have that up.

4 A. I have that up.

5 Q. So what is the purpose of the system in
6 the Schofield reference?

7 MR. HIGH: Objection, form.

8 A. So Schofield is a wonderful reference
9 because he's doing a variety of image processing
10 techniques in an automotive setting.

11 Q. Is your answer complete?

12 A. Tell me more. What more do you want?

13 Q. Well, is there a particular goal of
14 Schofield that it's trying to achieve?

15 MR. HIGH: Objection, form.

16 A. Schofield also talks about a wide variety
17 of applications of his system, including looking at
18 traffic lights, looking at signs, looking at a
19 variety of different things.

20 The particular embodiment on which he
21 spends most of his time has to do with looking at
22 taillights and headlights, but it is much more
23 broadly applicable than that.

24 Q. It's fair to say that the primary purpose
25 of the Schofield reference is to detect taillights

1 and headlights so you can turn down the vehicle's
2 headlight in response to detecting another vehicle
3 on the road. Is that fair?

4 MR. HIGH: Objection, form.

5 A. I'm trying to find the paragraph where he
6 talks about all the other kinds of things this could
7 do.

8 For example, in the top of column 12,
9 "The invention may be utilized to identify
10 particular traffic signs by their spectral signature
11 as well as their geometric organization. For
12 example, red octagons may be identified as stop
13 signs, yellow triangles as caution signs, and the
14 like."

15 By the way, the yellow triangles as
16 caution signs tells you something about the period
17 at which this patent was issued. Caution signs are
18 no longer yellow triangles. But at the time, that
19 was a wonderful example.

20 Q. We'll definitely get back to there at the
21 top of column 12, but I'm asking about the overall
22 primary purpose of Schofield.

23 You'd agree with me that the primary
24 purpose of the Schofield reference is to detect
25 headlights and taillights so that the vehicle can

1 adjust the headlamps when it detects that there's
2 another vehicle in the road that those headlamps
3 could be shining on. Is that correct?

4 MR. HIGH: Objection. Asked and answered.

5 A. You slide further down in paragraph 12,
6 line 40, "The present invention can be used to
7 detect lane markers in order to either assist in
8 steering the vehicle or provide a warning to the
9 driver that a lane change is occurring."

10 So there are a variety of purposes that
11 Schofield is contemplating. He does spend most of
12 his text in the particular examples of headlights
13 and taillights, but he very clearly lays out all of
14 the other possibilities that his system could
15 provide.

16 Q. How does Schofield detect light sources?

17 A. Well, with a camera.

18 Q. Well, how does -- so the output of
19 Schofield's camera goes into a computer, correct?

20 A. That is correct.

21 Q. How does Schofield's computer determine
22 the presence of a light source in the data it gets
23 from the camera?

24 A. Okay. "Schofield's system includes an
25 imaging sensor module 14 which senses light from a

1 scene forward of vehicle 10 and an imaging control
2 circuit 13 which receives data from sensor 14.
3 Imaging sensor module" -- I'm reading from my
4 document page 41. "Imaging sensor module 14
5 includes an optical device such as a lens, an array
6 of photon-accumulating light sensors, filter array
7 for separating light from the scene forward of
8 vehicle 10 into a plurality of spectral bands. The
9 array may be a charge couple device array of the
10 type commonly used in video camcorders and the like
11 and may include an array of light-sensing pixels
12 each made up of a photosensor element 42." So for
13 example, he's using a color video camera.

14 "Imaging control circuit responds to the
15 plurality of sensors in order to determine if
16 spatially adjacent regions of the field of view
17 forward of the vehicle include light of a particular
18 spectral signature above a particular intensity
19 level."

20 He has fairly sophisticated processing
21 going on here, looking at the color, looking at the
22 brightness, and looking at the size and looking at
23 multiple patterns.

24 Q. "Spectral signature" refers to the color
25 of light? Is that correct?

1 A. That's an informal description, yes.

2 Q. And then you mentioned size. How does
3 Gallagher -- sorry, withdraw.

4 How does Schofield use size?

5 A. Well, the pattern recognition. Let's turn
6 to 10, 51. "By spatial filtering is meant
7 consideration of not only whether a particular pixel
8 is detecting a light source but also what adjacent,
9 or closely related, pixels or pixel groups are
10 detecting. For example, it can be concluded that
11 very closely adjacent red and white light sources
12 are not of interest as oncoming headlights or
13 taillights. An example where such a pattern could
14 be observed is a streetlight observed with a system
15 having imperfect color correction, which can produce
16 a white light surrounded by a red halo."

17 So he's using this pattern recognition.
18 At the top of column 11, "Pattern recognition
19 identifies objects of interest based upon their
20 shape, reflectivity, luminance, and spectral
21 characteristics. For example, the fact that
22 headlights and taillights usually occur in pairs
23 could be used to assist in qualifying or
24 disqualifying objects as headlights and taillights."

25 So if you see a pair of white lights in

1 the appropriate geometric configuration, that adds
2 to the evidence that you're looking at oncoming
3 headlights.

4 Q. I want to direct you to Schofield column 1
5 starting at about line 37. Let me know when you're
6 there.

7 A. On 1, 37.

8 Q. See a sentence says, "The headlights of
9 oncoming vehicles are, at least from a distance,
10 point sources of light"? Do you see that?

11 A. I see that.

12 Q. And what is your understanding of the term
13 "point sources of light"?

14 A. If the vehicle is far enough away, and we
15 could do the math to figure out how far away, then a
16 headlight will fall predominantly in only one pixel
17 of your camera.

18 He goes on in that paragraph to talk about
19 the difficulty of detecting really bright sources
20 like headlights and dimmer sources like taillights.
21 And that's part of what he discloses in the rest of
22 the invention is some very clever processing to
23 enable them to do both.

24 Q. Like to go back to that top of column 12
25 in Schofield that you were talking about earlier.

1 Let me know when you're there.

2 A. Top of column 12. Got it.

3 Q. So Schofield mentions in here traffic
4 signs in that paragraph. Do you see that?

5 A. I see that.

6 Q. How does Schofield disclose identifying
7 traffic signs?

8 A. He's talking about the spectral signature
9 of traffic line (sic) and the shape of traffic
10 signs. So combining those two gives you your
11 indication that this is a traffic sign.

12 And his processing talks about how you can
13 set up the sensor if you know what color you're
14 looking for; if you're looking for red stop signs,
15 how do you set it up to look for red. The
16 techniques that he uses to look for red in
17 taillights could be used to look for red in stop
18 signs.

19 So while his specific example is
20 headlights and taillights, the techniques that he
21 develops there are really extended to traffic signs
22 and, as he points out, to retroreflectors.

23 Q. Now, ordinarily a traffic sign at night is
24 going to be illuminated by the vehicle's own
25 headlights. Is that right?

1 A. There are certainly signs with overhead
2 lighting on them, but you are also looking at signs
3 lit up by the headlights.

4 Q. So for a sign that doesn't have its own
5 lighting to be visible by a camera, it has to be
6 within a certain distance of the headlight.

7 Is that right?

8 A. That would be correct.

9 Q. Are traffic signs ever going to act as
10 point sources of light if they don't have their own
11 illumination?

12 MR. HIGH: Objection, form.

13 A. That's a good question. You would have to
14 understand the field of view of the camera, the size
15 of an individual pixel, the sensitivity. It's a
16 more complicated calculation than I would like to do
17 in real time.

18 Could you see a stop sign in the high
19 beams at such a long range that it would appear as a
20 single pixel? I don't know the answer to that. The
21 calculation's not difficult, it's just tedious.

22 Q. Now, turning to column 12, line 40. I
23 believe you pointed there earlier in relation to the
24 discussion of lane markers. Do you see that?

25 A. Line which?

1 Q. Column 12, line 40.

2 A. "Present invention can be used to detect
3 lane markers."

4 Q. How does Schofield's disclosures tell one
5 of skill in the art how to detect lane markers?

6 A. In two ways. He is looking in his image
7 for predominantly point sources of a particular
8 spectral characteristic, and it would be very easy
9 to identify the spectral characteristic of lane
10 markers and it will be different spectral
11 characteristics depending on the kind of lane
12 marker.

13 But he also talks in detail about patterns
14 of these detected point sources; for instance, a
15 pair of white lights indicating a higher probability
16 of headlights. So that kind of pattern recognition,
17 looking for continuous dots of the same desired
18 color, it's the combination of the spectral
19 processing he's doing and the pattern recognition
20 processing that he's doing.

21 Q. So looking for the color of lane markers
22 spaced apart as you'd expect lane markers to be
23 spaced apart? Is that what you --

24 A. And the spacing apart of the lane markers
25 again is driven by AASHTO standards for how much the

1 road can curve, how quickly it can change curvature,
2 et cetera. So those are fairly easy patterns to
3 look for.

4 Q. What is the field of view of the camera in
5 Schofield?

6 A. I'm not sure that he specifies that.

7 Q. Is Figure -- go ahead.

8 A. Do you see a specification?

9 Q. Is Figure 11a in Schofield a depiction of
10 the field of view in Schofield?

11 A. Figure 11a is a picture. Is that
12 actually -- from that picture could you determine
13 the field of view? No. There's no dimensions on
14 it.

15 Q. But is that depicting the field of view of
16 the camera in Schofield?

17 A. Well, let's go and see where he describes
18 Figure 11a. This is in column 9 beginning about
19 line 24. "Present invention is ... determining
20 point sources. For example, as best seen by
21 reference to Figure 11a, particular relationships
22 have been discovered to exist between light sources
23 of interest and a spatial location forward of the
24 vehicle. Oncoming headlights and leading taillights
25 of interest can be characterized, at least in part,

1 based upon their displacement from the central axis
2 of the vehicle."

3 So I believe 11a is an example of what
4 could be a field of view.

5 Q. What is Figure 11b depicting?

6 A. Now he's way down into the grungy details
7 of how he's going to do the processing. So that's
8 on column 10 starting at about line 11.

9 "Such spatial differentiation could also
10 be accomplished by a non-symmetrical mapping of
11 light to the sensor array, as illustrated in Figure
12 11b, or by masking portions 98a, 98b, 98c, at the
13 periphery of the scene so these portions are not
14 sensed at all. Spatial differentiation could also
15 be accomplished by providing a non-uniform pixel
16 size."

17 So if you are more worried about detail in
18 one part of the scene than in another part of the
19 scene, he is saying you could actually build a
20 sensor that has more pixels in one place than in
21 another or you could subsample your image or you
22 could ignore parts of the image that you know are
23 above the horizon.

24 Q. So Figures 11b and 11c are supposed to
25 correspond to different ways of analyzing the view

1 depicted in Figure 11a? Is that fair?

2 A. Different ways that one could analyze the
3 scene, yes.

4 Q. And what does Schofield mean by "spatial
5 differentiation"?

6 A. Give me a reference. Where are you?

7 Q. I think you just read from that.

8 A. Yeah, and then I flipped away to get to
9 the picture. Spatial differentiation. So this is
10 column 10, 15.

11 Q. Yeah, it starts at column 9, line 58, and
12 continues on to column 10, line 17.

13 A. Well, if you bounce back up in column 9,
14 line 35, "On-axis light sources of interest can be
15 at both close and far away separation distances.
16 However, off-axis light sources may only be of
17 interest if at a close separation distance from the
18 vehicle." So, "Headlights and taillights of
19 interest occupy an increasing spatial area as they
20 move off axis. Therefore, the resolution to detect
21 lights of interest may decrease off axis."

22 If you're not worried about things which
23 are next to you but you're more worried about things
24 straight in front of you, then you can have a lower
25 resolution in your periphery than you have in your

1 central field of view.

2 Q. Axis means the center of where that camera
3 in Schofield is pointed?

4 A. That would be correct. Things near the
5 axis -- because your camera is pointed roughly the
6 direction you're going, things near the axis are, of
7 course, of much more concern to you than things off
8 axis.

9 Q. Does Schofield's system require
10 calibration?

11 MR. HIGH: Objection, form.

12 A. You know, this is a good case for me to go
13 pop up. Schofield talks in great detail about the
14 different gain settings required for detecting white
15 headlights versus detecting dimmer red taillights,
16 so setting the exposure time, estimating the CIE
17 illumination charts known to skilled artisans.

18 So give me your question again. Does
19 Schofield require calibration?

20 Q. Yes.

21 A. Every computer vision system requires
22 calibration of multiple types. There's geometric
23 calibration, where is your camera, where is it
24 pointing, what is the lens doing, how wide is your
25 field of view. There is the color calibration, what

1 does this brightness of this pixel mean.

2 This is so well known in the art that it
3 is assumed and not often written.

4 Q. And more specifically, does Schofield's
5 pattern recognition functionality require
6 calibration?

7 A. Schofield needs to know how bright is
8 white and how bright is red, so that requires
9 knowing the responses of the camera.

10 Q. And that calibration is going to depend on
11 the particular camera that you used, right?

12 A. Will depend on the particular camera. It
13 may depend on the windshield that you're looking
14 through in his embodiment.

15 Q. Does Schofield's pattern recognition
16 functionality have to calibrate to be able to detect
17 different shapes?

18 MR. HIGH: Objection, form.

19 A. Shape detection in the image does not
20 require calibration. Shape detection in the real
21 world, for instance, you need to know the aspect
22 ratio of the camera. If a certain number of pixels
23 map horizontally to a different size than a certain
24 number of pixels map vertically, then a square
25 object will show up as a squished square.

1 So you certainly need to know the
2 geometric calibration of the camera and lens in
3 order to have true shapes of the objects that you're
4 looking at.

5 Q. Does Schofield say what the resolution of
6 its camera is?

7 A. Yes, he does. Column 4, line 29. He's
8 got 512 rows by 512 columns.

9 Q. The -- and he refers to that intersection
10 of a row and column as a pixel?

11 A. That would be correct.

12 Q. So with a worse resolution and a lower
13 number of pixels, it would be harder to determine
14 the shape of an object. Is that correct?

15 A. Harder to determine the shape of an object
16 at distance.

17 Q. And with a worse resolution of the sensor
18 and a lower number of pixels, it would be harder to
19 determine whether something was two separate light
20 sources or one light source. Is that correct?

21 A. That's the definition of resolution is can
22 you determine two light sources versus one light
23 source.

24 Q. Let's go to your declaration now, and I
25 have a few questions about the declaration.

1 First I want to ask for a little bit of
2 clarification in paragraph 65 and particularly the
3 part that goes on to paragraph -- or page 47.

4 Let me know when you're there.

5 A. Paragraph 65. I've got it.

6 Q. And so my question is, there's a citation
7 at the very end of paragraph 65 that says Schofield
8 comma and then bracket 0033 bracket.

9 A. Let's go take a look. I believe that is a
10 typo.

11 Q. Okay.

12 A. If we look at Gallagher 33. That -- my
13 apologies. That should be Gallagher. Please
14 correct that.

15 Q. Okay.

16 A. And that's the paragraph where Gallagher
17 is talking about -- this is the paragraph I was
18 looking for before, "reflectivity of a wide variety
19 of reflective road markings and road markers such
20 as, for example, road signs and posts, reflective
21 painted lines whether continuous or broken, and more
22 particularly raised pavement markers. For
23 simplicity, the description of the preferred
24 embodiment will be limited to raised pavement
25 markers. However, it will be appreciated by those

1 skilled in the art that the apparatus can be adapted
2 to measure other types of reflective markings on or
3 adjacent the road."

4 So here's where he's talking about the
5 wider use of it. His particular embodiment is
6 raised pavement markers, but the general technique
7 is much more useful than that.

8 Q. Okay. Appreciate the clarification.

9 Now let's go up a little bit in your
10 report to paragraph 60. Let me know when you're
11 there.

12 A. Paragraph 60. Good.

13 Q. In your first sentence, you mention field
14 of endeavor; namely, automated object recognition.

15 Do you see that?

16 A. I see that.

17 Q. Is automated object recognition a
18 recognized field?

19 A. Yes.

20 Q. Are there books entitled "Automated Object
21 Recognition"?

22 MR. HIGH: Objection, form.

23 A. There are lots of papers titled "Object
24 Recognition." There are lots of papers titled
25 "Autonomous Systems." This is a term of art.

1 Q. Are there classes at universities called
2 "Automated Object Recognition"?

3 MR. HIGH: Objection, form, scope.

4 A. The classes tend to be called things like
5 "Computer Vision," which is a little different from
6 a signal processing course. Signal processing may
7 be at a lower level. Computer vision ends up with,
8 at the top of the hierarchy, automated object
9 recognition.

10 Q. How would you define computer vision?

11 A. Processing data from -- computer
12 processing data from imaging sensors and a variety
13 of image sensors from Gallagher's push broom line to
14 Schofield's 2D camera to scanning laser rangefinders
15 to synthetic aperture radar, anything that produces
16 an image.

17 The early work in this field that I got my
18 teeth cut on was funded by DARPA and was titled
19 "Image Understanding." And it embraced that whole
20 realm of things, ending up with automated image
21 detection, image recog- -- automated object
22 recognition.

23 Q. Does Gallagher's photodiode array generate
24 an image?

25 A. As he push-brooms that along the road,

1 he's generating an image row by row by row by row by
2 row, and that's an image.

3 Q. And that image in the embodiments with ten
4 photodiodes is ten pixels wide?

5 MR. HIGH: Objection, form.

6 A. So if we look at Gallagher, what he
7 mentions is, in his paragraph 80, generating
8 graphical displays of test results to be viewed in
9 real time by an operator as a check that tests are
10 being conducted properly.

11 So those are the images that he is -- he
12 is producing.

13 Q. I thought we were discussing the analysis
14 of images. Is -- computer vision isn't just
15 anything that involves the generation of images,
16 right?

17 A. The fact that Gallagher is collecting
18 these a row at a time and creating a 2D image, this
19 is all within the realm of automated object
20 recognition.

21 Q. I'm asking a little bit --

22 A. Automated object recognition can include
23 1D sensors such as Gallagher's as well as 2D sensors
24 such as Schofield's as well as 3D laser sensors.

25 Q. I'm asking a little bit different question

1 specifically about computer vision. And computer
2 vision involves the analysis of images, not the
3 generation of images, correct?

4 A. There is an increasing trend in computer
5 vision to say can you process one image and turn it
6 into another image. So sometimes it is producing
7 images rather than producing labels. So, no, it can
8 include producing images also.

9 Q. That example you gave me, though, it did
10 also involve taking in an image as an input. Is
11 that correct?

12 A. That is correct.

13 Q. So in computer vision in general, you're
14 taking in images or video as input, correct?

15 A. As opposed to computer graphics where you
16 take in a description and produce an image.
17 Computer vision usually begins with an image.

18 Q. And so I'm trying to understand. Let me
19 ask the question this way. Would one of skill in
20 the art understand the Gallagher reference as being
21 in the field of computer vision?

22 A. Oh, def- -- yes, definitely. You're
23 getting pixel data from some number of pixels,
24 smaller than you would have in a camera. You are
25 push-brooming those pixels across the scene to

1 produce multiple rows, and that's image processing.

2 You are processing it to determine objects
3 of interest, processing to determine quality of the
4 reflected data. You're processing it over the
5 sequence to determine patterns, whether the
6 reflectors are appearing as expected or whether
7 there's gaps in it. So that is all definitely image
8 processing.

9 Q. And when you mentioned pixels in your
10 answer, the pixels in Gallagher are -- in width are
11 the number of photodiodes in Gallagher's array.

12 Is that correct?

13 A. That is correct. Let me give another
14 editorial comment here. When I first started doing
15 automated object recognition, the computers we had
16 did not have enough memory to store an entire image.
17 So even if we had a 512 by 512 pixel image, we could
18 only process them a row at a time because that's all
19 the memory we had in our computers.

20 So the notion of processing data row by
21 row is a very old and accepted notion.

22 Q. Does Gallagher have the capability of
23 recognizing different types of objects?

24 A. Gallagher 33, "The apparatus can test the
25 reflectivity of a wide variety of reflective road

1 markings and road markers such as, for example, road
2 signs and posts, reflective painted lines whether
3 continuous or broken, and more particularly, raised
4 pavement markers."

5 So, for instance, if you are trying to do
6 quality control on a dashed line, that requires
7 exactly what we were talking about, processing
8 individual slices to find the line or processing
9 series of these slices as an image to find where the
10 dash starts, where the dash ends, where the next
11 dash starts, where the next dash ends. So that's
12 all automated object recognition.

13 Q. The output from Gallagher is a yes/no as
14 to whether a road marking is present and above the B
15 threshold in Figure 5 or is not. Is that correct?

16 A. Remember --

17 MR. HIGH: Objection, form.

18 A. Remember there are multiple outputs.

19 MR. HIGH: Objection, form.

20 A. There's a left/right output to assist the
21 human driver in steering. There's the graphical
22 output, this created image, which can be stored and
23 viewed later. And the -- there is an indication if
24 you are over threshold. There is an indication if
25 you expected to find a marker and did not to trigger

1 the tagging mechanism.

2 Q. Gallagher can't tell you whether something
3 is a reflective pavement marker or a painted line,
4 correct?

5 MR. HIGH: Objection, form.

6 A. I'm not sure that's correct.

7 Q. Where does Gallagher disclose that?

8 A. Gallagher -- the reflective painted lines
9 will not rise to the threshold of a properly
10 functioning reflector, will not hit that threshold
11 B.

12 Q. Gallagher can't detect multiple different
13 types of objects and then differentiate among them.

14 Is that correct?

15 A. I don't believe that's correct either
16 because Gallagher talks about setting up his system
17 with multiple light sensors with different spectral
18 responses in 39.

19 So if you've got light sensors with
20 different spectral responses, you're certainly
21 differentiating between reflectors of different
22 colors, and that's in this embodiment. In a more
23 general embodiment, you could be doing a wider
24 variety of differentiation.

25 Q. So in that embodiment, Gallagher can tell

1 you if there's a peak value for a particular color.

2 Is that correct?

3 A. So he can tell you if there is an
4 above-threshold peak for, say, a white reflector, an
5 above-threshold peak for, say, a red reflector.

6 So if you're tracking road edge markers
7 and you want to know where the exit starts, in the
8 U.S. the color of those reflectors will change when
9 you hit the exit. And by having multiple filters on
10 different of his sensors, he can detect where the
11 color changes and therefore detect that this is an
12 exit.

13 Q. Let's go back to your declaration and
14 starting in paragraph 61 on page 43.

15 A. Paragraph 61. Okay.

16 Q. So this is the beginning of the portion of
17 your declaration where you do a
18 limitation-by-limitation comparison of the prior art
19 to the language of claim 9 of the '328 patent?

20 Is that correct?

21 A. That is correct.

22 Q. And so the first place in claim 9 that you
23 apply the Schofield reference is in limitation 9F
24 starting at paragraph 75 on page 54.

25 Is that correct?

1 A. Until then, we were relying on Gallagher.

2 Q. So going back to 9A starting on page (sic)

3 63. Let me know when you're there.

4 A. 9A.

5 Q. You actually -- you group 9A, 9B, and 9C

6 into one subsection in your declaration.

7 Is that right?

8 A. What page are you on here?

9 Q. Page 45.

10 A. 9A, 9B, 9C, correct.

11 Q. And so you're relying on Gallagher for

12 limitation 9C which is, "a light sensor that

13 measures a plurality of light intensity values

14 within a field of view which includes at least a

15 portion of the area illuminated by the light

16 source"? Is that correct?

17 A. That is correct.

18 Q. And you start discussing 9C in detail in

19 paragraph 67 of your declaration? Is that correct?

20 A. Well, they're all lumped together, so some

21 of it is in 65. 66 is particularly 9B. 67 is 9C.

22 Yes.

23 Q. And you're relying on the light sensors 6

24 in Gallagher for limitation 9C?

25 A. "Is a light sensor module 6A with an array

Page 68

1 of light sensors 6, one or more of which detects
2 reflected light from a reflective surface of a
3 marker."

4 Q. And let's go now to paragraph 9 --
5 sorry -- paragraph 7D, 6. Let me know when you're
6 there.

7 A. 7D, 6. So we are in 9F.

8 Q. Yeah.

9 A. Okay.

10 Q. You say, "A POSITA would have found it
11 obvious to implement Schofield's determination of a
12 light source's location within a field of view to
13 distinguish between different types of road
14 markers." Do you see that?

15 A. I see that.

16 Q. Now, with Gallagher's array of sensors,
17 that can only tell you which of the sensors is
18 detecting a peak at any one time, correct?

19 MR. HIGH: Objection, form.

20 A. It could be multiple sensors detecting
21 multiple peaks. And because he's storing it in any
22 one instance, he's giving the values for that row,
23 but then he's accumulating those rows as he moves.

24 Q. So how can Gallagher's array of light
25 sensors be used to determine an assessment of a

1 discrete location of a road marker within the field
2 of view?

3 A. Well, remember, we are combining Gallagher
4 and Schofield here. Gallagher by himself determines
5 the location of a road marker by saying here is the
6 photodiode which is picking up the road marker, and
7 so that corresponds to one spot along one row of
8 this image that he's building.

9 Schofield, with the 2D color camera, it is
10 more obvious in that case how you determine where in
11 the field of view a particular object of interest is
12 located.

13 Putting the two of them together is not
14 difficult. You could do it in several different
15 ways. One way is you could just use Schofield's
16 camera for Gallagher's sensor, and instead of
17 photodiodes you could use one row of Schofield's
18 camera and do the processing the same way that we've
19 been talking about.

20 But another way of combining them is
21 hanging Schofield's sensor on top of Gallagher's
22 existing apparatus. And if you know the location of
23 the Schofield camera relative to the location of the
24 Gallagher setup, now you have a straightforward
25 camera calibration to say that this object seen by

1 Gallagher should appear at this location in
2 Schofield's image. And now you can process
3 Gallagher's processing and Schofield's processing at
4 the same time and have confirmation from multiple
5 sources of what's happening.

6 The third way that combining these makes a
7 lot of sense is to say let's just use Schofield's
8 processing, not even Schofield's sensor, and things
9 like Schofield talking about looking for spatial
10 relationships between taillights, use that same
11 processing to look for spatial relationship between
12 reflectors. So if you know that you're supposed to
13 be finding pairs of reflectors, you could do that.
14 If you know you're supposed to be finding reflectors
15 spaced along the road, you can look for that.

16 So in those three instances, it's
17 straightforward to combine Gallagher and Schofield.

18 Q. What is the way of combining Gallagher and
19 Schofield that you disclosed in your declaration
20 with respect to claim 9?

21 MR. HIGH: Objection, form.

22 A. I just explained to you the three ways
23 that I would combine, either by swapping the sensor,
24 by using both sensors, or by using the processing
25 from Schofield and the data collected by Gallagher.

1 Q. Can you point me to a paragraph in your
2 declaration that identifies those three ways?

3 A. So, for instance, in paragraph 79 at the
4 bottom, "This combination would have merely required
5 the use of Schofield's known technique to improve
6 Gallagher's similar device in the same way."

7 Q. Anywhere other than paragraph 79?

8 A. I'm at the bottom of 79.

9 Q. Any other place that you mention those
10 three different ways in connection with claim 9?

11 A. Well, for instance, at the bottom of
12 paragraph 78 it's talking about applying Schofield's
13 pattern recognition and Gallagher's data.

14 Q. And which of the three ways is that
15 referring to?

16 A. That is referring to using Gallagher's
17 data and Schofield's processing techniques.

18 Q. So using Gallagher's photodiode array and
19 Schofield's processing techniques?

20 MR. HIGH: Objection, form.

21 A. It is applying this pattern recognition --
22 and "this pattern recognition" refers to Schofield's
23 techniques -- to identify the data that Gallagher is
24 collecting.

25 Q. And the data that Gallagher is collecting

1 is the data coming from Gallagher's sensor array,
2 correct?

3 A. That is one of the examples.

4 Q. And then turning to paragraph 79 in your
5 declaration, there you note that Schofield discloses
6 that its technique can be implemented using a
7 photosensing array of photodiodes. Is that correct?

8 A. That is correct.

9 Q. Schofield doesn't say how many sensors
10 you'd need to achieve its result if you're using a
11 array of photodiodes, correct?

12 A. Let's go see. We're referring to
13 Schofield 2, 36 to 41. Let's see what he says.

14 "Solid-state light-imaging array is
15 provided that is made up of a plurality of sensors
16 that divide the scene forward of the vehicle into
17 spatially separated regions, and light sources are
18 identified, at least in part, according to their
19 spatial distribution across the regions."

20 So then head down to 8, 38.

21 "Photosensing array 38 may be a charge
22 couple device of the type commonly used in video
23 cameras and the like. Alternatively, photosensing
24 array could be a CMOS array. Additionally, a hybrid
25 of the CCD and CMOS technology may be employed.

1 Other potentially useful photosensing technologies
2 include CID, MOS, photodiodes, and the like."

3 So he is casting a very broad net and
4 saying you have to have some sensors looking at the
5 scene.

6 Q. But for the example of photodiodes,
7 Schofield doesn't tell you how many photodiodes
8 you'd need to be able to achieve its result,
9 correct?

10 A. He doesn't give a number of sensors for
11 any of those except for his example embodiment. So
12 he leaves that open. And to a person of ordinary
13 skill in the art, it's not hard to compute the range
14 at which you want to see things, the field of view
15 across which you want to see things, and therefore
16 the resolution that you need.

17 Q. And in your declaration in claim 9, you
18 don't give a particular number of photodiodes for
19 your proposed combination of Gallagher and
20 Schofield, correct?

21 A. I do not give a particular number as
22 Schofield and Gallagher both talk about a variety of
23 numbers.

24 Q. Now, in paragraph 80 of your declaration,
25 do you see it says, "To the extent patent owner

1 contends or the board finds that a discrete location
2 of the road marker within the field of view refers
3 to a location in 3-D space"? Do you see that?

4 A. What is the definition of "location within
5 the sensor array's field of view"? Is that within
6 the image, or is that within the scene?

7 Q. I think you're leaping ahead. All I was
8 doing was asking you a question about do you see --
9 I'm trying to orient you to the paragraph I'm
10 talking about right now, so you're kind of
11 getting --

12 A. All right. I am oriented to that
13 paragraph.

14 Q. Okay. So in your declaration, do you
15 render an opinion as to what you believe is the
16 correct meaning of "a discrete location of the road
17 marker within the field of view"?

18 MR. HIGH: Objection, form.

19 A. In my view, this is an ambiguous
20 statement. It could refer to either a row column
21 within an image array or an XY location in the
22 scene. Converting from one to the other is not
23 difficult. Roads tend to be fairly flat, so casting
24 a ray through a calibrated camera from the focal
25 point of the camera through that pixel to intersect

1 with the flat surface of the road gives the location
2 in 3D.

3 So whether this means the location in
4 sensor space or whether this means the location in
5 global space, the conversion between the two of
6 them, subject to a couple of assumptions about the
7 world being relatively flat, it's not a difficult
8 conversion.

9 Q. Is that conversion disclosed in Gallagher?

10 MR. HIGH: Objection, form.

11 A. Does Gallagher say how he figures out
12 where this is in XYZ? So he knows the angle at
13 which his sensors are pointing, so he knows how far
14 in front of the vehicle a detected object is. He
15 knows where his vehicle is in space either by
16 odometry or I believe he says by GPS, which today
17 would be the preferred embodiment, although
18 combining the two of them would be even better.

19 So the only thing left is does he know
20 left and right where he is pointing. So he knows
21 the incident angle. Sensor arrays are
22 advantageously aligned in an encased module,
23 adjustable to increase the accuracy of the
24 measurements.

25 My sense is when he does his calibration

1 in paragraph 59, that's very easy to calibrate for
2 lateral position as well as for the brightness of
3 the reflective light.

4 Q. But does Gallagher actually disclose how
5 to determine the location in 3D space?

6 A. Well, that's what he's doing in paragraph
7 79. Well, no, paragraph 79 is reflectance level, so
8 it's not -- not Y axis.

9 Calculating the X axis Gallagher
10 discloses. Calculating the Y axis is simple
11 geometry from the calibration of the sensors. This
12 would be obvious to a person of ordinary skill in
13 the art.

14 Q. But it's not disclosed in Gallagher --

15 A. Well, you know the angle of the sensor.
16 You know where it hits the ground.

17 Q. But that calculation is not disclosed in
18 Gallagher itself, right?

19 MR. HIGH: Objection, form.

20 A. I would view that kind of calculation as
21 the kind of thing which is taught in image
22 process -- image understanding 101 or computer
23 graphics 101, intersection of a line in space with a
24 flat plane. I wouldn't bother to disclose that.

25 Q. Turning back to your paragraph 80, I want

1 you to look at the last sentence in that paragraph.

2 A. Paragraph 80. And at some point here, we
3 should break for lunch.

4 Q. Yeah, I'll just finish up this and then we
5 can break.

6 A. Okay. "Location corresponds to a discrete
7 location that is within the 3D space covered by the
8 sensor array's field of view."

9 Q. So when you're saying at the beginning of
10 that sentence the phrase "this location," what are
11 you referring to in your prior sentences in
12 paragraph 80?

13 A. Referring to 9F, "analyze the at least one
14 light intensity value to determine an assessment of
15 a discrete location of the road marker within the
16 field of view." So what is that discrete location
17 within the field of view?

18 Q. So when you say "this location" in that
19 last sentence of paragraph 80, you're not referring
20 to something you're talking about in the prior
21 sentence?

22 MR. HIGH: Objection, form.

23 A. "To the extent patent owner contends or
24 the board finds that a discrete location of the road
25 marker within the field of view refers to a location

1 in 3D space, this would also have been obvious
2 because Gallagher discloses determining the location
3 of each road marker. This location corresponds to a
4 discrete location within the 3D space covered by the
5 sensor array's field of view."

6 So I think it refers to in this case a
7 location in 3D space, which is an alternate
8 interpretation of the words in 9F. And Gallagher
9 does that.

10 MR. SAUNDERS: Let's go off the record for
11 a break.

12 THE VIDEOGRAPHER: Okay. We're going off
13 the record. The time now is 1:05 p.m.

14 (Recess from 1:05 to 1:53)

15 THE VIDEOGRAPHER: Okay. We are back on
16 the record. The time now is 1:53 p.m.

17 BY MR. SAUNDERS:

18 Q. All right. Welcome back, Dr. Thorpe.

19 I'd like to direct your attention to your
20 declaration, in particular paragraph -- sorry, one
21 second. Actually just one question before I get to
22 that. Let me withdraw.

23 What range does Schofield detect objects
24 at?

25 A. In a quick scan of the document, I do not

1 see a specific number.

2 Q. Looking at Figure 11a of Schofield and
3 particularly the bottom of that view, do you have
4 any estimate for how far out from the vehicle the
5 bottom of that view in Figure 11a is?

6 A. No, you could create --

7 MR. HIGH: Objection, form.

8 A. You could create that same picture with a
9 zoom lens looking at a distance or with a wide-angle
10 lens looking up close. There's nothing in Figure
11 11a which indicates quantitative.

12 Q. Okay. All right. Let's go to your
13 declaration, and particularly I want to talk about
14 your analysis of limitation 9D of claim 9 starting
15 at paragraph 70 on page 51.

16 A. 9D, "computer processing system operably
17 connected to the active light sensor and configured
18 to detect objects of interest within the field of
19 view."

20 Q. So earlier we walked through some of the
21 steps in Gallagher that is actually labeled by the
22 Gallagher reference like step A, step B, et cetera.

23 Do you remember that?

24 A. Yes.

25 Q. What step in Gallagher does Gallagher's

1 system detect objects of interest?

2 A. Okay. If we go look at Gallagher -- first
3 of all, in paragraph 33 he discusses detecting a
4 wide variety of objects. Certainly in step 60 when
5 he's doing -- paragraph 60 when he's doing lateral
6 positioning, he's detecting either a stripe or a
7 reflector and giving lateral connection. Step 66,
8 he is detecting road markers.

9 Q. And then turning to your opinions onto
10 limitation 9E of claim 9 which start at paragraph 73
11 on page 53, which of the steps in Gallagher does
12 Gallagher's system determine whether an object of
13 interest includes at least one light intensity value
14 associated with a reflective surface of a road
15 marker in the field of view?

16 MR. HIGH: Objection, form.

17 A. "Selecting, from data obtained ... which
18 reflective (sic) levels indicate a reflective
19 surface of a road marker, determining whether the
20 object of interest includes at least one light
21 intensity value associated with the reflective
22 surface of a road marker in the field of view.
23 Gallagher at 33, 55 to 56, 65 to 66."

24 So each of those locations. And 33 is
25 where he's talking about the wide variety of road

1 markings, in 55 and 56 is collecting the data, and
2 in 65 and 66 determining background reflectance
3 levels and establishing non-marker reflectance
4 levels and then selecting which ones are a road
5 marker.

6 Q. So when I asked you about limitation 9D,
7 you also identified paragraph 66. Are you relying
8 on paragraph 66 for both limitations 9D and 9E?

9 MR. HIGH: Objection, form.

10 A. "Detecting objects of interest and
11 determining whether the object of interest includes
12 at least one light intensity value associated with a
13 reflective surface."

14 So what is your question?

15 Q. Yeah. Are you relying on step G in
16 paragraph 66 for both paragraph -- for -- sorry,
17 withdraw.

18 Are you relying on step G in paragraph 66
19 of Gallagher for both limitations 9D and 9E?

20 MR. HIGH: Objection, form.

21 A. That is -- is step 66 both detecting an
22 object of interest and determining whether it is a
23 reflective surface of a road marker.

24 Well, remember, I refer to multiple
25 paragraphs. For 9D it's all of 55 through 66. So

1 for 9D there's multiple things going on, including
2 lateral determination.

3 Q. I'm sorry. What range did you just give
4 for 9D?

5 A. If you look at paragraph 71, I cite 33,
6 45, 47, and then 55 through 66. 55 through 66 is
7 that entire process which does include detecting
8 markers, but it also includes detecting -- detecting
9 non-marking. It also determines detecting which has
10 the highest reflectance reading. So it's also
11 looking at other objects.

12 Q. What do you mean by "it's looking at other
13 objects"?

14 A. For example, painted stripes.

15 Q. Is there a particular of those steps A, B,
16 et cetera, in Gallagher that's differentiating
17 between painted stripes and other road markers?

18 A. Paragraph 60, "Process step D involves
19 determining the vehicle position on the road and
20 providing an audio or visual indicator means for the
21 operator of the vehicle. This enables the operator
22 to maintain the vehicle in a proper position on the
23 road to allow the apparatus to obtain reflectivity
24 measurements. As each of the five light sensors
25 covers a section of the area and data from each

1 light sensor is received showing the reflectance
2 levels across area A of the road, then given the
3 background reflectance levels on non-road marking
4 sections of the road are low and road markers are
5 relatively high, the computer program can detect
6 which light sensor is reading the highest
7 reflectance reading and provide the operator with
8 that information."

9 So referring back to the figure where this
10 is shown, Figure 2, there are in this case dashed
11 painted lines as well as raised pavement reflectors.

12 Q. Well, let's walk through Gallagher and the
13 parts of Gallagher you cite. So if you turn to
14 paragraph 54 of Gallagher, that's when Gallagher
15 starts disclosing the process of the preferred
16 embodiment of the present invention which employs an
17 algorithm characterized by a series of steps for
18 determining the integrity of particular road
19 markings on a road being tested and storing and/or
20 displaying the results.

21 Do you see that?

22 A. I'm sorry. You're starting at 55?

23 Q. 54.

24 A. 54. Okay.

25 Q. So after 54 we're starting to get steps of

1 the algorithm that Gallagher uses, right?

2 A. That is in his preferred embodiment.

3 Q. And so you cite in limitation 9D to
4 paragraph 55, correct?

5 A. 9D, I view 33, 45, 47, and I start with
6 55.

7 Q. 55 just says that we're starting the
8 process via a control box to operate the computer,
9 right?

10 A. The control box is turning on the system.

11 Q. No detection of objects of interest has
12 occurred yet at 55, right?

13 A. That is correct.

14 Q. And in paragraph 56, that says that step
15 A, it's getting the data output of the ADC which
16 comes from the light sensors, correct?

17 A. Of multiple ADCs from the multiple light
18 sensors.

19 Q. So in paragraph 56, no detection of an
20 object of interest has occurred yet, correct?

21 A. At this point we just have numbers.

22 Q. And paragraph 57, step B, that's where it
23 performs the filtering we discussed before, right?

24 A. That's -- that is averaging.

25 Q. So in paragraph 57, step B, we haven't

1 detected an object of interest yet, right?

2 A. That is correct.

3 Q. Paragraph 58, step C says it involves
4 calibrating the data. We haven't detected an object
5 of interest then, right?

6 A. That is correct.

7 Q. Step D is in paragraph 60. That's the one
8 that talks about providing an indicator means for
9 the operator. Is that right?

10 A. And the way that it provides the indicator
11 to the operator is by detecting which light sensor
12 is reading the highest reflectance reading. It's
13 comparing that with the background reflectance
14 levels. So I take that to say it has detected
15 either a stripe or a reflector.

16 So now you've got something. And the
17 subsequent steps could be, is that something that
18 you got -- first of all, for that step, that
19 something that you've got is enough to steer -- to
20 tell the user how to steer. And the subsequent
21 steps say, "and is that something a fully
22 functioning reflector."

23 Q. So the end of paragraph 60, Gallagher says
24 that the computer program can detect which light
25 sensor 6 is reading the highest reflectance reading

1 and to provide the operator with that information.

2 Is that right?

3 A. Read that in the context of showing
4 reflectance levels across the area given that the
5 background reflectance levels are low and road
6 markers are relatively high. So what is being
7 provided is a detected something.

8 Q. Is there something in Gallagher that's
9 telling you that the highest reflectance reading
10 that's determined in step D is used in any of the
11 subsequent steps in Gallagher?

12 MR. HIGH: Objection, form.

13 A. Since you've determined where the
14 brightest stripe is, would be the brightest stripe
15 between the first one to process to see if it's
16 bright enough to be a peak. You may subsequently
17 need to look at the others also because there may be
18 two side by side, but you would start with the
19 brightest sensor.

20 So if you detected something in 60, and
21 then you will do further analysis of that in 65 and
22 66.

23 Q. Let's go through the other one. So 63 is
24 when we begin step E. Is that right?

25 A. 63 is location.

1 Q. And what it says in 63 is we're getting
2 data from the gearbox sensor? Is that right?

3 A. That's odometry. That's how far you've
4 traveled.

5 Q. And 65 is when we begin step F, correct?

6 A. 65 is the background levels.

7 Q. And so that's determining the background
8 reflectance levels on the road and establishing
9 non-marker reflectance levels?

10 A. And that's also referred to in step 60.

11 Q. So does step 60 require that step F has
12 already been performed?

13 MR. HIGH: Objection, form.

14 A. I don't know the details of the algorithm
15 that they use.

16 Q. All right. Let's go to -- well, let me
17 withdraw.

18 Is there something in Gallagher that tells
19 you in step F that it's using the information
20 generated in step D?

21 MR. HIGH: Objection, form, or
22 objection --

23 A. Using the information in step B?

24 Q. No, let me -- let me reask.

25 So is there anything in Gallagher that

1 tells you in step F that it's using the information
2 it generated back in step D?

3 A. In step D. Step -- paragraph 60 uses the
4 phrase "background reflectance levels on non-road
5 marking surfaces." Paragraph 65 is determining
6 background reflectance level on the road and
7 establishing non-marker reflectance levels. It is
8 parallel language in those two places.

9 Q. So are they happening at the same time?

10 A. There's no strong indication of the
11 sequence between those two steps.

12 Q. Does step F in Gallagher mention using the
13 highest reflectance reading?

14 A. Step F?

15 Q. Yeah.

16 A. Step F is looking not at the highest
17 reflectance level but at the ones which are not the
18 highest reflectance level in order to determine the
19 background.

20 Q. Is step F using the indicator means for
21 the operator of the vehicle?

22 MR. HIGH: Objection, form.

23 A. I could speculate as to how I would
24 implement it, but it is not that clearly spelled out
25 in Gallagher which then flows into which.

1 Q. So let's go to step G in paragraph 66.
2 You see that it says process step G involves
3 selecting from data obtained in step A which
4 reflectance levels indicate a road marker?

5 A. Yes.

6 Q. So it doesn't mention as part of step G
7 any of the data generated in step D, as in dog,
8 correct?

9 A. Nor does it mention process step B and
10 process step C, but those are certainly implied.
11 The reason you do process step B and process step C
12 is so that you have data for process step G. So it
13 is entirely possible that -- it's fairly certain
14 that step B and step C are used. It's entirely
15 possible that step D is also used.

16 Q. Is there anything in Gallagher indicating
17 you one way or another whether in step G it is using
18 any of the data generated back in step D, as in dog?

19 MR. HIGH: Objection, form.

20 A. It does not directly indicate that as it
21 does not directly indicate using data from steps B
22 or C. But it certainly implies that it is using the
23 data from steps B and C.

24 Q. Have you rendered an opinion as to whether
25 Gallagher implies that step G is using data

1 generated during step D, as in dog?

2 MR. HIGH: Objection, form.

3 A. This would be in the context of which of
4 your claims?

5 Q. Well, right now I'm just asking about
6 Gallagher and what Gallagher discloses and your
7 understanding of Gallagher.

8 A. But you've asked about whether I've
9 rendered an opinion, and I am looking over my expert
10 declaration.

11 Q. Okay. Well, we most recently discussed
12 limitations 9D and 9E, and I'm trying to understand
13 how the different parts of Gallagher are being
14 mapped to those limitations in your opinions.

15 And so my focus now is on -- and I think
16 during my questions, you mentioned paragraph 66,
17 both when I was asking about 9D and in 9E. And now
18 I'm trying to understand, do you have an opinion one
19 way or another whether Gallagher implies that step G
20 is using data generated by step D, as in dog?

21 MR. HIGH: Objection, form.

22 A. "Selecting, from data obtained, which
23 reflectance level indicate a reflective surface of a
24 road marker, determining whether the object of
25 interest includes at least one light intensity value

1 associated with the reflective surface of a road
2 marker."

3 So it is clear in step 60, paragraph 60,
4 that there is a detection of the highest
5 reflectivity portion of the road above background
6 reflection. It's clear in 66 there is a detection
7 of is this a road marker. There are multiple ways
8 that one could implement those two steps, and
9 Gallagher is not specific as to how those steps are
10 implemented.

11 Q. Let's go to your analysis of claim 1,
12 starting at paragraph 99. Believe it's starting on
13 page 64. Let me know when you're there.

14 A. Paragraph 99. Good.

15 Q. So this is the part of your declaration
16 where you begin the limitation-by-limitation
17 comparison of claim 1 to the prior art? Is that
18 correct?

19 A. This is comparing claim 1 to the prior
20 art, yes.

21 Q. And so I want to go through the different
22 claim limitations to identify where you're relying
23 only on Gallagher versus where you're only relying
24 on the Schofield reference.

25 So starting with what's been labeled

1 limitation 1P in paragraphs 99 and 100, you're only
2 relying on Gallagher for that, right?

3 A. "An automated system that detects and
4 determines reflective surfaces of interest in a
5 scene of nonreflective surfaces." Gallagher
6 certainly discloses all of that.

7 Q. And so you don't mention Schofield in
8 regards to this section 1P, right?

9 A. Not in paragraph 99 or paragraph 100.

10 Q. So next limitation is 1A, and you rely on
11 Gallagher and Schofield, correct?

12 A. That is correct.

13 Q. And in particular, you say that Schofield
14 is what discloses an imaging sensor module, correct?

15 A. It says that in paragraph 102.

16 Q. Okay. And so -- and then starting
17 paragraph 103 through 107, you provide your reasons
18 why you believe it would be obvious to combine
19 Schofield's imaging sensor module 14 with Gallagher?

20 Is that correct?

21 A. 103, 104, 105, 106, 107. That's correct.

22 Q. So essentially, this section, you're
23 saying one of skill in the art would be motivated to
24 add Schofield's camera to Gallagher's system.

25 Is that right?

1 A. It is more than Schofield's camera. It's
2 Schofield's system and Gallagher's system. The
3 Schofield system includes processing and algorithms
4 as well as the camera.

5 Q. Well, just talking about 1A, what things
6 in Schofield are you identifying other than the
7 camera as being taken from Schofield and added to
8 Gallagher?

9 MR. HIGH: Objection, form.

10 A. For instance, in paragraph 103, for
11 example, Schofield discloses applying pattern
12 recognition to assist in the detection of objects of
13 interest. So it is the pattern recognition and the
14 algorithms as well as the camera itself.

15 Q. Anything else?

16 A. In paragraph 104, the complementary ways
17 of Gallagher's identification system and Schofield's
18 identification for road signs and road markers using
19 different characteristics.

20 Q. Anything else in limitation 1A that you're
21 suggesting taking from Schofield and adding to
22 Gallagher?

23 A. Paragraph 105, we are using Schofield's
24 imaging sensor module for an observer to look at
25 Gallagher's results.

1 Q. Anything else?

2 A. Paragraph 107, we were talking about using
3 the same computer to do both. So there's a variety
4 of different ways these could be combined.

5 Q. 107, you're saying you could use
6 Gallagher's computer to handle the incoming data
7 from Schofield's sensor module, right?

8 A. That is correct.

9 Q. So anything else that you opined in
10 limitation 1A for taking from Schofield and adding
11 to Gallagher?

12 A. We talked about the camera. We talked
13 about the algorithms. Talked about the computer.
14 Talked about complementary ways to verify things.
15 We talked about the visualization capabilities.

16 To this point, that is a good list.

17 Q. I'd like to turn to paragraph 108 now, and
18 that's on page 70. Let me know when you're there.

19 A. I'm there.

20 Q. So that's your paragraph where you compare
21 or where you analyze limitations 1B, 1C, and 1D.

22 Is that right?

23 A. The active light sensor, the light source
24 illuminating the area, and a light sensor that
25 measures light intensity values, all of which are

1 done by Gallagher.

2 Q. So in paragraph 108, you're pointing back
3 up to your analysis of Gallagher as compared to
4 claim 9, limitations 9A, 9B, and 9C, correct?

5 A. That is correct.

6 Q. And so in limitation 1D, you're relying on
7 Gallagher's photodiode array? Is that correct?

8 MR. HIGH: Objection, form.

9 A. 1B is relying on Gallagher who in his
10 preferred implementation uses a photodiode array but
11 could use other sensors.

12 Q. But you cite to the photodiode array in
13 your analysis of limitations 9A, 9 -- 9C, correct?

14 A. I could go back and take a look.

15 Q. Well, go ahead. I'm trying to confirm
16 here for -- that when you're in your report in
17 limitation 1D, you're relying on Gallagher's
18 photodiode array. Is that correct?

19 A. So in my analysis of 9A, B, and C, I refer
20 to Gallagher using an array of light sensors. I
21 don't know that I speak about which specific light
22 sensors he uses. But in any case, for Gallagher
23 it's a linear array of light source, of light
24 sensors.

25 Q. And the only embodiment that Gallagher

1 specifically discloses is where that array is
2 photodiodes, correct?

3 MR. HIGH: Objection, form.

4 A. Again, Gallagher, in his paragraph 33,
5 talks about a wide variety of things that you could
6 sense and saying the apparatus could be adapted to
7 do different things.

8 So while Gallagher's preferred embodiment
9 that he describes is a linear array of photodiodes,
10 I don't view his teaching to be limited to that. It
11 would be straightforward, for instance, to take a
12 standard video camera and extract one row from that,
13 and that has the same push broom sensing across the
14 road as Gallagher's array of photodiodes.

15 Q. I'm going to object to nonresponsive to
16 that. I do want you to focus on specifically the
17 opinions in your report when I'm asking about that.
18 And so in your --

19 MR. HIGH: You didn't ask about his
20 opinions in his reports. You asked whether
21 Gallagher discloses it, so --

22 Q. Let me ask the question clearly. I
23 believe it was clear. But in your report, do you
24 say that Gall- -- do you point to a disclosure in
25 Gallagher of an embodiment other than a photodiode

1 array?

2 A. And I point to where Gallagher says,
3 "For simplicity, the description of the preferred
4 embodiment will be limited to raised pavement
5 markers. However, it will be appreciated by those
6 skilled in the art that the apparatus 1 can be
7 adapted to measure other types of reflective
8 markings on or adjacent the road."

9 So the particular embodiment here is an
10 array of photodiodes, but I believe Gallagher and my
11 analysis contemplates other types of sensors than
12 the array of photodiodes.

13 Q. And is there some specific paragraph in
14 your report that you could point to that conveys
15 that?

16 MR. HIGH: Objection, form.

17 A. "Gallagher discloses an automated system
18 for assessing reflective surfaces disposed along a
19 roadway using its reflectivity measuring apparatus.
20 Gallagher 33 to 35."

21 So this is paragraph 62 of my report. So
22 that is pointing to the part of Gallagher where he
23 discusses the possibilities of a much wider range of
24 applications.

25 Q. Anywhere else you can point to in your

1 report?

2 MR. HIGH: Objection, form.

3 A. Page 38 of my report. "The sensors may be
4 photodiodes mounted precisely on the module 6a at a
5 height and angle to properly detect reflected
6 light." The phrase "may be" indicates the
7 possibility of other types of sensors.

8 Q. Well, let's get more specific. In your
9 analysis of limitation 9C of your report, that
10 section that you've dedicated your report comparing
11 limitation 9C to Gallagher, do you have some
12 statement indicating that you're relying on some
13 embodiment of Gallagher other than photodiodes?

14 MR. HIGH: Objection, form.

15 A. "A light sensor that measures a plurality
16 of light intensity values within a field of view
17 which includes at least a portion of the area
18 illuminated by the light source."

19 That is a general description -- I'm in
20 paragraph 67 -- of light sensors which could be
21 implemented in a variety of different ways.

22 Q. Anything else?

23 MR. HIGH: Objection, form.

24 A. Paragraph 68. "POSITA would have
25 understood that Gallagher's light sensor module

Page 99

1 measures a plurality of light intensity values
2 within the area A."

3 So a person of ordinary skill in the art
4 would understand that there are multiple ways to
5 measure plurality of light intensity values within
6 the area A.

7 Q. Anything else in your report's analysis of
8 9C that indicates you're relying on an embodiment of
9 Gallagher other than photodiodes?

10 MR. HIGH: Objection, form.

11 A. I don't believe that I am relying on an
12 embodiment of photodiodes. I believe that is an
13 example embodiment but not a limitation.

14 Q. Let's turn back to claim 1, limitation 1E.
15 Or actually let's go back to paragraph 108 of your
16 report on page 70.

17 So am I correct that in your analysis of
18 claim 1, you're proposing that the combination of
19 Gallagher and Schofield use both an image sensor
20 from Schofield and a sensor array from Gallagher?

21 Is that correct?

22 A. If you're in paragraph 108, that's
23 referring to claim 1B, C, and D, which is an active
24 light sensor including a light source and the light
25 sensor. Those are rendered obvious by Gallagher.

1 Q. So in the combined system for claim 1,
2 you're opining as to 1D we're getting Gallagher's
3 light sensor and in 1A we're getting Schofield's
4 camera? Is that right?

5 A. Well, A includes both Gallagher and
6 Schofield.

7 Q. So the proposed combined system that
8 you're opining about has both a camera and a light
9 sensor array, correct?

10 A. For 10A -- for 1A, we're using both
11 Gallagher and Schofield.

12 Q. Well, that's not my question.

13 My question is, for claim 1, the
14 combination that you're proposing has both a camera
15 and a separate light sensor array, correct?

16 A. We've not said that. We've said we will
17 combine the ideas and the techniques from Gallagher
18 and the ideas and the techniques from Schofield. So
19 we are not saying necessarily that you have to have
20 two systems with two different sensors bolted
21 together. One of the ways of doing a combination is
22 to use Gallagher's processing with Schofield's
23 sensor. Another way of doing the combination is to
24 use Schofield's processing with Gallagher's sensor.
25 We are talking about multiple ways of doing the

1 combination.

2 Q. So paragraph 108 for limitation 1D, you're
3 relying on Gallagher's sensor, correct?

4 A. Paragraph 108 says that 1D is obvious
5 because Gallagher has a light sensor that measures
6 light intensity values.

7 Q. And in paragraph -- or sorry. In your
8 analysis of 1A, you're relying on Schofield's
9 imaging sensor module 14, right?

10 A. Remember that in 1A we used both Gallagher
11 and Schofield.

12 Q. You don't contend that Gallagher itself
13 discloses an image capture system, right?

14 MR. HIGH: Objection, form.

15 Q. Let me withdraw.

16 In your report, you opine that Schofield
17 is what is contributing the disclosure of an image
18 capture system that captures images within a field
19 of view along the roadway, correct?

20 A. Gallagher and Schofield build images in
21 different ways. Schofield builds it with a single
22 capture of a 2D sensor. Gallagher builds it by
23 push-brooming the sensor along the roadway. Both of
24 those produce data which can be treated as an image.
25 The geometries of the images are different. The

1 processing techniques are somewhat different because
2 they are both susceptible to image processing
3 technologies.

4 Q. I want to focus very specifically about
5 the opinions in your declaration. You look at the
6 paragraph 102, it begins with, "Schofield discloses
7 1A because." Do you see that?

8 A. I see that.

9 Q. You don't have any similar sentence about
10 Gallagher in your analysis of limitation 1A, right?

11 A. I do not have the identical sentence about
12 Gallagher.

13 Q. Is there anywhere in your analysis of
14 claim 1 that you explain why one of skill in the art
15 would be motivated to create a system having both
16 Gallagher's array of light sensors and Schofield's
17 image module 14?

18 MR. HIGH: Objection, form.

19 Q. Let me withdraw because I think I
20 misspoke.

21 Nowhere in your analysis of claim 1 do you
22 offer an opinion as to why one of skill in the art
23 would be motivated to use both Schofield's imaging
24 sensor module 14 and Gallagher's array of light
25 sensors in a single system, correct?

1 MR. HIGH: Objection, form.

2 A. For instance, paragraph 105 is running the
3 Gallagher sensor and the Gallagher processing in
4 parallel with the Schofield imaging sensor. So that
5 is running both.

6 Q. Anywhere else?

7 MR. HIGH: Objection, form.

8 A. Paragraph 106 talks about the two
9 measuring apparatus being complementary. If they're
10 complementary, you can run them both and combine the
11 results at a variety of levels. You can combine the
12 results at an image level. You can combine the
13 results at an interpretation level.

14 Q. Anywhere else?

15 MR. HIGH: Objection, form.

16 A. Paragraph 104, performing Schofield's
17 pattern recognition using Gallagher's computer based
18 on data from Gallagher's light sensor module and
19 Schofield's imaging sensor module. There you have
20 both systems.

21 Q. Anywhere else?

22 MR. HIGH: Objection, form.

23 A. Paragraph 103, Gallagher's reflectivity
24 measuring apparatus which measures reflectivity and
25 Schofield's imaging sensor module which enables the

1 identification of objects.

2 We say repeatedly there are different ways
3 of combining Schofield and Gallagher, that these are
4 obvious to a person of ordinary skill in the art.
5 They can be combined at the sensor level. They can
6 be combined at the algorithm level. They could be
7 combined at the system level.

8 Q. Where do you discuss in your report's
9 analysis of claim 1 combining Gallagher and
10 Schofield at the sensor level?

11 MR. HIGH: Objection, form. Asked and
12 answered.

13 THE WITNESS: Did you say not to answer?

14 MR. HIGH: No, said asked and answered.
15 Sorry.

16 A. 103, "POSITA would have found it obvious
17 to incorporate Schofield's imaging sensor module
18 into Gallagher's reflectivity measuring apparatus."

19 So there's using the sensor from one to
20 feed into the processing and the algorithms of the
21 other.

22 Q. Is there somewhere in your declaration
23 where you identify a benefit of keeping Gallagher's
24 sensor array around if you're using Schofield's
25 camera?

1 MR. HIGH: Objection, form.

2 A. For instance, in 104, could have used data
3 from Gallagher's light sensor and Schofield's
4 imaging sensor to improve the identification of what
5 you're looking for.

6 Q. Are you referring to the first sentence of
7 paragraph 104?

8 A. No, I'm down -- I guess that is one long
9 sentence. I'm at the end of that sentence. Saying
10 that combining them, referring to Schofield's
11 pattern recognition using Gallagher's computer,
12 using data from Gallagher's light sensor and
13 Schofield's imaging sensor would further improve the
14 identification.

15 Q. So what -- how is Gallagher's light sensor
16 helping when you're getting a lot more data from
17 Schofield's camera?

18 A. Gallagher's light sensor is synced to the
19 light source, so the headlight's pointing down and
20 the photodetectors are calibrated and are pointed in
21 the same location. Schofield is looking out at the
22 world in general. Could you point Schofield's
23 camera down to match the illumination from
24 Gallagher's lights? Yes, that's one way you could
25 do things.

1 Q. How is -- how is that -- how is it better
2 to have Gallagher's light sensor module and
3 Schofield's imaging sensor module rather than just
4 having Schofield's imaging sensor module pointed
5 down at the roadway?

6 MR. HIGH: Objection, form.

7 A. For instance, Schofield could detect a
8 potential object at some distance further than where
9 Gallagher is scanning, and Gallagher could add to
10 the confidence of the detection when the vehicle
11 became close enough to scan it.

12 Q. So you'd have to track the object as it's
13 getting closer to the vehicle and passing from one
14 sensor to another?

15 A. A person of ordinary skill in the art
16 would have five different ways of doing that,
17 tracking it from image to image to image, localizing
18 it in 3D and then watching the vehicle motion,
19 et cetera, et cetera, et cetera. Strike that. Not
20 five different ways of doing it. Would have
21 multiple ways of doing it.

22 Q. Is there some disclosure in either
23 Schofield or Gallagher of how to track an image to
24 pass between two different types of sensors?

25 MR. HIGH: Objection, form.

1 A. Between two different types of sensors.
2 Schofield certainly talks about tracking objects.

3 What is your question?

4 Q. Do either Gallagher or Schofield disclose
5 tracking an object as it passes between two
6 different sensors?

7 A. Each of them deal with an individual
8 sensor. Gallagher in particular talks about
9 determining a location in the world, and a location
10 in the world allows you to track things between
11 different sensors.

12 Q. How would having the data from Schofield's
13 camera saying that there is a marker up ahead help
14 Gallagher detect road markers?

15 MR. HIGH: Objection, form.

16 A. Having multiple observations of the same
17 object with different sensors and different
18 algorithms increases the confidence of your
19 detection. It's pretty elementary image processing.

20 Q. When did that become pretty elementary?

21 A. There's a whole series of -- when did that
22 become elementary. Probably in about 1972 on Shakey
23 the Robot when it was trying to go down a hallway
24 using both a laser rangefinder and a video camera
25 looking for the black cove molding along the side of

1 the hallway. This is old technology.

2 Q. Have you heard the phrase "sensor fusion"
3 before?

4 A. Of course.

5 Q. What is sensor fusion?

6 A. It's combining the data from multiple,
7 disparate sensors. And it can be done at a variety
8 of levels.

9 Q. So is your example of your proposed
10 combination of Gallagher and Schofield an example of
11 sensor fusion?

12 A. One embodiment of this is sensor fusion at
13 the object detection level where a hypothesized
14 object with some level of confidence from one sensor
15 is combined with a hypothesized object with some
16 level of confidence from another sensor. So this is
17 doing sensor fusion at a object level.

18 There's other versions of sensor fusion
19 which are doing it at the raw sensor level. For
20 instance, in about 1988 we had one of the world's
21 first scanning laser rangefinders and we calibrated
22 it with a color camera. Now, as the laser scanner
23 scanned across the scene, it was recording 3D
24 shapes, and we could project the color data onto
25 there. So now each pixel had an XYZ location and an

1 RGB color. That's sensor fusion at a very low
2 level, and there's everything in between there.

3 Q. So object-based sensor fusion of Gallagher
4 and Schofield would require modifying the
5 algorithms, right?

6 MR. HIGH: Objection, form.

7 A. I'm not sure it would require modifying
8 the algorithms.

9 Q. Well, Gallagher's algorithms don't
10 disclose taking any input other than the input from
11 the light sensor array and the GPS and the gearbox,
12 correct?

13 A. So what it would require is another module
14 that sits on top of these two and takes recognition
15 data from the two and fuses them appropriately.

16 Q. By "from the two," you mean Gallagher's
17 image sensor and Schofield's camera?

18 A. From the output of the processing that
19 both of them do.

20 (Reporter Clarification)

21 A. From the output of the processing of the
22 two systems. But these are just examples. There's
23 lots of ways to combine these two systems.

24 Q. I'm just trying to understand exactly what
25 you're proposing in your declaration for combining

1 Gallagher and Schofield. So is there something that
2 says we're using this object-based sensor fusion
3 approach?

4 A. I'm saying there's multiple ways to
5 combine them.

6 Q. I know you're saying that right now, but
7 I'm trying to see what was in your declaration, you
8 know, back when you submitted it.

9 So back when you submitted it, what are
10 the different ways you enumerated in your
11 declaration for combining Gallagher and Schofield
12 for claim 1?

13 A. "A POSITA would have found it obvious to
14 incorporate Schofield's imaging sensor module into
15 Gallagher's reflectivity measuring apparatus." So
16 there's one example. "Schofield discloses applying
17 pattern recognition." "A POSITA would have seen
18 Gallagher's reflectivity measurement apparatus, which
19 measures reflectivity, and Schofield's imaging
20 sensor module, which enables the identification of
21 objects, as complementary systems that, through
22 pattern recognition, would advantageously work
23 together to improve the identification of objects of
24 interest." So there's one example.

25 Goes on, "would have been motivated to

1 incorporate the data from Schofield's imaging sensor
2 module into the processing performed by Gallagher's
3 powerful computer." Goes on to say these are
4 complementary as further supported by the fact that
5 Gallagher's reflectivity measurment apparatus and
6 Schofield's sensor both identify road signs and road
7 markers using different characteristics.

8 Q. Let's just start with that first sentence
9 of paragraph 103 that you read.

10 A. Okay.

11 Q. Is there somewhere in your declaration's
12 analysis for claim 1 where you provide the details
13 of how a POSITA would have incorporated Schofield's
14 imaging sensor module 14 into Gallagher's
15 reflectivity measuring apparatus?

16 MR. HIGH: Objection, form.

17 A. Again, for a person of ordinary skill in
18 the art, you look at what Gallagher is doing and you
19 look at what Schofield is doing and you say you are
20 complementary systems that through pattern
21 recognition would advantageously work together.
22 They're saying for a person of ordinary skill in the
23 art, this would be an obvious combination to make.

24 Q. Well, earlier today you've talked about
25 various different ways one could have integrated

1 Schofield's imaging sensor module into Gallagher.
2 And what I'm trying to ascertain is if in your
3 declaration you identified which of those particular
4 ways you were proposing to use in a combination.

5 I didn't see those different ways spelled
6 out in your declaration. So is there somewhere you
7 could point me to where you spell out the ways that
8 you're actually proposing that the combination be
9 implemented?

10 MR. HIGH: Objection, form. Asked and
11 answered.

12 A. The fact that the declaration says "for
13 example," the third sentence of 103, means there's a
14 variety of ways of doing this. One of the examples
15 is running them as parallel systems and combining
16 the results.

17 Q. Well, let's go to that part of 103 that
18 starts on the top of 67.

19 You say, "Accordingly, a POSITA would have
20 seen Gallagher's reflectivity measuring apparatus,
21 which measures reflectivity, and Schofield's imaging
22 sensor module 14, which enables the identification
23 of objects through things like their shape and
24 spectral characteristics, as complementary systems
25 that, through pattern recognition, would

1 advantageously work together to improve the
2 identification of objects of interest."

3 Do you see that?

4 A. Yes.

5 Q. So how are you proposing Gallagher's
6 reflectivity measuring apparatus to use pattern
7 recognition in the proposed combination with
8 Schofield?

9 MR. HIGH: Objection, form.

10 A. One example would be, as we've discussed,
11 Schofield detecting a potential reflector, Gallagher
12 detecting a potential reflector, and saying two
13 potential detections of a reflector using different
14 sensing and different algorithms increases the
15 confidence that it's a reflector.

16 MR. HIGH: Counsel, are we getting pretty
17 close to a break point?

18 MR. SAUNDERS: Yeah, a couple questions on
19 this line and then we'll take a break.

20 MR. HIGH: Okay.

21 Q. So in that sentence that begins at the top
22 of page 67 in paragraph 103, what do you mean by
23 "pattern recognition"?

24 A. "Complementary systems that, through
25 pattern recognition, would advantageously work

1 together to improve the identification of objects of
2 interest."

3 So an example of this is Gallagher running
4 independently and producing a report of here's where
5 I think I've seen something and here's the
6 confidence of it, Schofield running independently
7 and saying here's where I think something, I've seen
8 something, and here's my confidence in it, and then
9 using standard pattern recognition techniques that
10 involve the confidence and involve the description
11 of the sensors, put those two confidences together
12 to come up with a higher confidence or lower
13 confidence.

14 Q. Is there a name for those standard pattern
15 recognition techniques?

16 A. There are so many different ways to reason
17 about probabilities in evidence. There are lots of
18 such techniques.

19 MR. SAUNDERS: Let's go off the record for
20 a break.

21 THE VIDEOGRAPHER: Okay. We're going off
22 the record. The time now is 3:01 p.m.

23 (Recess from 3:01 to 3:12)

24 THE VIDEOGRAPHER: We are back on the
25 record. The time now is 3:12 p.m.

1 BY MR. SAUNDERS:

2 Q. All right. Dr. Thorpe, before the break I
3 was asking you some questions about 103. And I'm
4 going to ask you again a question about that first
5 sentence on page 67 which is in paragraph 103.

6 Do you see the reference to Gallagher's
7 reflectivity measuring apparatus?

8 A. Yes.

9 Q. Is that referring to Gallagher's light
10 sensor array, Gallagher's algorithms, or both?

11 A. Referring to the entire system.

12 Q. And Gallagher's system measures
13 reflectivity from using intensity data from its
14 sensor array, correct?

15 A. He has the raw signal data in his
16 photodiodes which he then digitizes to turn into
17 numbers and then has a calibration factor,
18 et cetera.

19 Q. You could also get intensity information
20 from a camera, right?

21 A. You can get intensity information from a
22 camera, and I believe Schofield specifically talks
23 about that.

24 Q. And so you could also measure reflectivity
25 using intensity information from a camera, correct?

Page 116

1 A. Using the reflectivity -- using the
2 intensity information from a camera, correct, with
3 all of the caveats about knowing the light source
4 and knowing the distance, et cetera.

5 Q. Let's move on to limitation 1F that starts
6 on paragraph 112. Let me know when you're there.

7 A. Paragraph 112. 1F, "determine whether the
8 object of interest includes a reflective surface
9 based on the light intensity values."

10 Q. So for limitation 1F, you're relying on
11 Gallagher alone, correct?

12 A. That is correct.

13 Q. And what -- we discussed earlier the
14 various labeled steps in Gallagher, step A, step B,
15 et cetera. Which of those steps are you opining in
16 here corresponds to the "determine whether the
17 object of interest includes a reflective surface
18 based on the light intensity values"?

19 A. Well, you can see I cite paragraphs 33,
20 34, 55, 56, 65, 66, 33 and 23.

21 Q. I think we --

22 A. I cite lots of parts of Gallagher.

23 Q. Okay. And I think earlier when we were
24 going through Gallagher's steps in relation to claim
25 9, we saw that the steps start with step A in

1 paragraph 56. Is that right?

2 A. Start with -- I'm sorry?

3 Q. Step A in paragraph 56 of Gallagher.

4 A. Let me see what the cites are to 33 and
5 34. 33 and 34 are saying there's a wide variety of
6 things you could sample, you could sense. And 55,
7 56 is really starting to talk about how you do the
8 sensing.

9 Q. Okay. And so 56, which is getting the
10 data from the output of the ADC, that doesn't yet
11 perform a determination whether an object of
12 interest includes a reflective surface, correct?

13 A. Those are just numbers.

14 Q. And similarly, 65, that's the next
15 paragraph you cite in Gallagher in step 1F?

16 Is that right?

17 A. Let's see. 55, 56, 65, 66. Okay.

18 Q. So paragraph 65 of Gallagher, "Step F
19 involves determining the background reflectance
20 levels on the road and establishing non-marker
21 reflectance levels." That does not yet involve a
22 determination whether an object of interest includes
23 a reflective surface, correct?

24 A. And paragraph 66 is looking for road
25 markers.

1 Q. So when we get to 66, is that where you're
2 opining that there's a determination whether the
3 object of interest includes a reflective surface as
4 recited in limitation 1F?

5 A. Recall, if you look on page 72, starting
6 partway down, "For simplicity, Gallagher only
7 describes the details of his process for raised
8 pavement markers, but Gallagher also discloses the
9 same process is used to measure other types of
10 reflective markings on the road like the reflective
11 surfaces of painted lines."

12 So 65 and 66, now you're specific to the
13 retroreflectors, but that should not ignore what's
14 happening in other steps, either as contemplated by
15 Gallagher or as described in paragraph 60 for
16 determining steering information.

17 Q. Okay. Well, I'm just trying to understand
18 in your report where you've rendered an opinion that
19 in Gallagher's disclosures that the actual step of
20 determining whether the object of interest includes
21 a reflective surface occurs.

22 So have you opined that it's in the
23 paragraph 66, step G?

24 MR. HIGH: Objection, form.

25 A. "Whether the object of interest includes a

1 reflective surface based on the light intensity
2 values." It certainly occurs in step G, but the
3 sentence about "for simplicity" also opens the
4 discussion to the other ways of detecting surfaces
5 other than raised pavement markers.

6 Q. And then let's go to limitation 1G
7 starting in paragraph 114. So for limitation 1G in
8 your report, you're relying on Gallagher alone,
9 correct?

10 A. That is correct.

11 Q. And in paragraph -- let me withdraw.
12 The only citations to Gallagher you have
13 in 1G are to paragraph 66 of Gallagher, correct?

14 A. That is the only citation, correct.

15 Q. So what is the assessment of the
16 reflective surface that's occurring in paragraph 66
17 of Gallagher?

18 A. So you have to take Gallagher in context
19 with Figure 5 on page 5 showing the thresholds.
20 What Gallagher is doing in 66 is looking for the
21 peak response and then checking to see if the peak
22 response is higher than the thresholds as indicated
23 in Figure 5.

24 Q. So something is highly reflective if it's
25 over that B threshold in Figure 5?

1 MR. HIGH: Objection, form.

2 A. In paragraph 79, "The threshold minimum
3 acceptable reflectance level B is displayed for easy
4 reference of the defective markers 2 measured."

5 So, yes, there is this threshold B.

6 Q. And that's a threshold of intensity, light
7 intensity, correct?

8 A. Well, it's reflectance levels. And the
9 reflectance levels are related through calibration
10 to light intensity.

11 Q. Let's move on to -- let me introduce
12 another exhibit. One second.

13 All right. I have uploaded to Exhibit
14 Share what has been previously marked as
15 Exhibit 1007. Is that the Frank reference you
16 analyzed?

17 A. "Laser Radar for a Vehicle Lateral
18 Guidance System." And I have a hard copy of Frank.

19 Q. Okay. So what is the purpose of the
20 system of the Frank reference?

21 MR. HIGH: Objection, form.

22 A. You mean what is the purpose that Frank
23 set out to do?

24 Q. Yes.

25 A. So it comes right out of the title, on

1 lateral control of highway vehicles guided by a
2 forward-looking sensor. Wait. I'm sorry. Laser
3 radar for a vehicle lateral guidance system. He is
4 steering a vehicle based on laser radar, otherwise
5 referred to as LIDAR.

6 Q. And how does Frank do that?

7 A. There's a variety of ways of doing LIDAR,
8 either a single beam steered back and forth in 1D or
9 2D across the scene or a flood illumination and then
10 an array of detectors.

11 The way you measure distance with LIDAR,
12 if you could pulse the laser and count nanoseconds
13 until that laser pulse comes back at you, roughly a
14 foot is a nanosecond, 30 centimeters every
15 nanosecond. So if you could count in intervals of a
16 nanosecond, you could do a pulse, count how many
17 nanoseconds, you would know how far away that object
18 is. Move the beam by means of a mirror or something
19 and count and see how many nanoseconds it takes.
20 And now you're building up an image of range
21 measurements.

22 In the early 1990s, it was generally not
23 possible to count a billion times a second, so they
24 had to do more sophisticated signal processing,
25 which he shows a variety of ways of doing that.

1 Amplitude modulate the signal, look at the returned
2 amplitude modulated signal, and see how far the
3 wavelengths have shifted. That -- and how far the
4 wavelengths have shifted then tells you how far away
5 the object is.

6 More modern LIDARs, if you could have an
7 array of photodetectors with counters, you can put
8 out a pulse to cover the entire scene, and each of
9 your photodetectors is counting nanoseconds and
10 recording when the data is received. So he goes
11 through a lot of discussion of scanning with
12 mirrors, scanning with a single mirror, scanning
13 with a pair of mirrors, pulsing, et cetera,
14 et cetera, et cetera.

15 His role in all of this is to get ranges
16 back from reflective surfaces. So in his Figure 11,
17 he is creating a range image where he sees -- and a
18 magnitude image where he says here are the bright
19 spots which are reflecting my laser data and here is
20 the angle, angle, and bearing to each one of them.
21 So now he knows where each one of those dots are in
22 3 space.

23 The rest of it, I could go into professor
24 mode and explain more of how it works, but that's
25 the general principle. Ping the laser out, measure

1 how much energy comes back and measure how long it
2 is until that energy comes back. So you have
3 reflectance, you have range, and because you know
4 the angle at which you're looking, you have two
5 bearing angles.

6 Q. Turning to paragraph 130 of your
7 declaration on page 79, you say that Frank is in the
8 field of automated object recognition. Is that
9 right?

10 A. Let me get it. 130. "Same field of
11 endeavor, namely, automated object recognition."
12 Good.

13 Q. So what objects is Frank detecting?

14 A. A retroreflector located ahead, at, or
15 near the road surface at some distance ahead of the
16 vehicle from paragraph 127.

17 Q. Does Frank disclose detecting -- let me
18 withdraw.

19 Does Frank disclose differentiating among
20 different retroreflectors?

21 A. Differentiating, you mean, for instance,
22 by color?

23 Q. Or any other way of telling different
24 types of retroreflectors apart.

25 A. Frank does talk about the retroreflectors

1 may be embedded in the roadway or may be mounted on
2 another location such as on posts.

3 Q. So Frank has some data about where a
4 retroreflector may be located, but beyond that,
5 doesn't tell you what type of retroreflector it is?

6 MR. HIGH: Objection, form.

7 A. Frank refers to retroreflectors may be
8 standard roadway retroreflectors which are mounted
9 at regular intervals, typically 44 feet apart.

10 Q. So is that saying that Frank is
11 distinguishing among those retroreflectors or not?

12 A. I believe he is detecting retroreflectors.
13 I don't believe that he discusses distinguishing
14 among them.

15 Q. So I believe the first place you apply
16 Frank to the claims is claim 15 starting on
17 paragraph 131. Let me know when you're there.

18 A. I'm describing Frank before that.
19 Describing Frank starting at 127. But you're
20 looking for 131. Okay.

21 Q. Was this -- is this the section where you
22 first describe how you are proposing to combine
23 Frank with Gallagher and Schofield?

24 A. This is the first time we do the
25 combination, yes.

1 Q. And so what are you taking from Frank to
2 add to Gallagher and Schofield?

3 A. Frank, again, has a light source, a
4 variety of ways of doing it. Has a receiver, which
5 is a photodiode array or other type of photo
6 sensitive array. Can directly measure the distance
7 to each retroreflector.

8 So Gallagher and others are making an
9 assumption that the world is flat, so when you
10 observe at this angle from this height and you see a
11 retroreflector, you know where it is. What you can
12 do with Frank is you can directly measure the 3D
13 location so you know exactly where this is in space.

14 Q. Schofield's camera will also tell you how
15 far up an object is in space, right?

16 A. Will tell you how far up it is in the
17 image. And if the road is curving this way or
18 curving this way, where that spot is in the image
19 can be further away or closer. With the LIDAR, you
20 get a direct range measurement so you are highly
21 accurate.

22 Q. So in your combination of claim 15, you're
23 combining Gallagher's system with Frank's LIDAR and
24 algorithms for measuring distance and Schofield's
25 camera? Is that right?

1 A. Well, paragraph 135, "A POSITA would have
2 been motivated to implement Frank's laser diode to
3 outputs of pulse-modulated floodlight beam as
4 Gallagher's light source and to implement Frank's
5 determination of the distance to each identified
6 retroreflector to improve Gallagher's determination
7 of the observation angle."

8 So Frank's direct measurement of range
9 gets the actual distance to the target.

10 Q. But you're still using Schofield's camera
11 in the combination. Is that right?

12 MR. HIGH: Objection, form.

13 A. In our response to claim 15, we are
14 working on Gallagher and Frank.

15 Q. Well, let's back up. Do you see on --
16 let's go to page 76. Do you see that?

17 A. Okay. Yes.

18 Q. Do you see it says in the middle of that
19 page, "Ground 2: Gallagher, Schofield, and Frank
20 render obvious claims 15 through 16, 19, and 21
21 through 22"? Do you see that?

22 A. And which of those claims do we not have
23 to worry about?

24 Q. Oh, I think all of these ones you do.
25 It's the seven- -- well, 17 and dependents are the

1 ones you don't worry about, but --

2 A. Okay.

3 Q. If you look at claim 15 on page 80, it's
4 depending from claim 9, so claim 15's still at
5 issue.

6 A. Okay.

7 Q. And so, I mean, we discussed claim 9
8 earlier and you had relied on Gallagher and
9 Schofield. I don't see you analyzing claim 9 again.

10 So are you, in connection with claim 15,
11 still relying on the same, you know, combination of
12 Gallagher and Schofield that you provided for claim
13 9 for that part of claim 15 that is all the
14 limitations of claim 9?

15 A. So on page 80 under claim 15, we start out
16 with Gallagher and Frank. There's a mention buried
17 in paragraph 137, "using a photodiode array, like
18 the one disclosed in Gallagher, or any other type of
19 photosensitive array, like Schofield's array."

20 But I believe that's just sort of side
21 mention of Schofield and it's not bringing Schofield
22 into the main analysis of claim 15.

23 Q. So have you rendered an opinion as to why
24 one of skill in the art would be motivated to
25 combine Frank's LIDAR with a system with a camera?

Page 128

1 MR. HIGH: Objection. Mischaracterizes.

2 A. I was motivated to do this because I did
3 this on my own robot systems using a video system to
4 detect the direction toward an object and using a
5 LIDAR to detect its location in 3D space. It gives
6 you much more accurate localization of the things
7 you've seen in the image.

8 Now, do I render this other than my own
9 personal experience?

10 Q. In your report have you offered an opinion
11 about it being obvious to combine Frank's LIDAR with
12 a system that has a camera?

13 A. Well, toward the top of page 81, "A POSITA
14 would have found it obvious to incorporate Frank's
15 pulse-modulated light source as Gallagher's light
16 source to enable Gallagher's computer to determine
17 distance." So now you've got the pulsed light
18 source. You've got the flood- -- floodlight going
19 on in paragraph 134.

20 Q. What about Schofield's camera?

21 A. We'll get there. "It was well known to
22 implement techniques to determine the actual
23 distance to the target, e.g., using a laser
24 rangefinder" -- this is halfway down paragraph
25 135 -- "and take measurements within a distance

1 window to maintain sufficient accuracy."

2 If you really, really know how far away an
3 object is, it greatly increases the accuracy of your
4 math. If you really know how far away an object of
5 interest is, now you can calculate the true
6 observation angle, et cetera, et cetera.

7 The only reference to Schofield is to say
8 Gallagher has one kind of an array, Schofield has a
9 different kind of an array. Frank talks about using
10 either kinds of array.

11 Q. So in one of your prior answers you
12 mentioned you developed a system which used both
13 LIDAR and a camera. Is there a name for that
14 system?

15 A. We call that the colored range image.

16 Q. And when did you develop that system?

17 A. Oh, in the background where I talk about
18 my qualifications, there's a reference to a book
19 which I edited, "Vision and Navigation: The
20 Carnegie Mellon Navlab." And there's an article in
21 there on the colored range image. The work was done
22 by Dr. Martial Hebert, currently the dean of the
23 school of computer science at Carnegie Mellon
24 University and an expert in both computer vision and
25 3D range sensing.

1 Q. And do you remember when that colored
2 range image project was taking place?

3 A. We could go look up the date. My guess
4 would be prior to 1990.

5 Q. So in connection with claim 15, how is
6 Frank helping Gallagher detect road markers?

7 A. Well, Frank can help Gallagher detect road
8 markers in two ways. One way is that Frank can
9 detect high reflectance points with his LIDAR. The
10 second point -- way he could detect them is once he
11 knows where an object is, now he can report the
12 location of that object and Gallagher can do his
13 regular processing with much better accuracy of
14 where that reflective object is located. And that
15 much better accuracy can refine the math for things
16 like observation angles.

17 Q. What is --

18 A. You will recall that the reflectance of a
19 surface depends, among other things, on the angle
20 between the light source and the observation angle.
21 You can set up the system so that those angles are
22 at angles fairly small if you're looking at a
23 distance. And as you come closer and closer to that
24 object, that angle necessarily gets larger. And
25 that larger angle will influence how much

1 reflectance you get.

2 If you know the range, then you can
3 calculate how much that reflectance will drop off
4 and, in turn, use that to say is this a properly
5 functioning marker that I'm looking at from an odd
6 angle or is this a poorly reflecting, poorly
7 operating marker.

8 Q. So you talked about earlier how
9 Gallagher's system kind of swept along the road as
10 a broom when it's going along, right?

11 A. That's correct, a push broom.

12 Q. And so as it's moving along and a road
13 marker enters the field of view of the sensor array,
14 it will be at one observation angle. Is that
15 correct?

16 A. It depends. If the vehicle is bouncing,
17 if the road is curving and vertically, then the
18 distance may vary somewhat. Furthermore, because of
19 the width of the field of view of each sensor, it
20 may vary from being here to being here and still be
21 within the same sensor.

22 With Frank you can determine all those
23 parameters to a much higher level of precision.

24 Q. But in general, as Gallagher's system is
25 moving along the roadway, it's going to have a range

1 of observation angles while the object is within the
2 field of view of Gallagher's sensors? Is that
3 right?

4 A. If you're moving along a perfectly flat
5 road without the vehicle bouncing, then as you see
6 objects, you will be -- you will know how far away
7 they are, and that will simplify part of the math.

8 You may not know exactly where it is left
9 and right because of the size of the field of view
10 of the sensor, and that will have some effect on the
11 observation angle. The bigger effect on the
12 observation angle is bumping or road curvature, and
13 that's where having Frank determine exemplary
14 angular displacements and incident light for each
15 light intensity measurement can tell that very
16 accurately. So if it is necessary to tell that very
17 accurately, systems like Frank teach how to do it.

18 Q. Is there a discussion of bumping or road
19 curvature in your analysis of the motivation to
20 combine Frank with Gallagher?

21 A. That actually shows up in Gallagher where
22 he talks about the need to average because of
23 vehicle bumps, et cetera.

24 Q. I'm specifically talking about your
25 opinions regarding motivation to combine in your

1 declaration. Did you mention bumping or road
2 curvature somewhere in there?

3 A. More important factor discussed in
4 paragraph 135 is as you get closer to the object,
5 the observation angle will change. And as Gallagher
6 points out, he's averaging over multiple views.
7 Each of those views will have a slightly different
8 observation angle.

9 "It is well known that the observation
10 angle changes as the distance between the vehicle
11 and the reflective surface changes. For example,
12 the observation angle changes rapidly once the
13 vehicle gets close to the retroreflective surface."

14 So just tracking it as it goes through the
15 field of view of the sensor will be useful. That's
16 what's described in paragraph 135.

17 Q. Well, Gallagher already discloses that it
18 can -- you can angle its light sensor module to
19 obtain an observation angle of about 0.2 degrees,
20 correct?

21 A. Does Gallagher say the 0.2 degrees?

22 Q. I'm reading, for example, paragraph 41 of
23 Gallagher.

24 A. Good. So it's about .2 degrees at some
25 point, but as it passes through the field of view,

1 of course it will change. This is just adding more
2 precision to the process.

3 Q. So in paragraph 136, you mention road
4 authority standards require measurement of
5 retroreflective paved -- raised -- withdraw.

6 Paragraph 136, you cite the ASTM standard
7 as part of your motivation to combine Frank with
8 Gallagher, right?

9 A. Yes, yes.

10 Q. Okay. And you mention that standard as
11 providing an observation angle of 0.2 degrees,
12 right?

13 A. That is -- that is the ASTM standard.

14 Q. Does the ASTM standard require the
15 additional precision in regards to observation angle
16 provided by Frank as opposed to the ability to
17 control observation angle provided in Gallagher
18 itself?

19 A. Now you're into details of the exact
20 implementation of Gallagher which are not disclosed,
21 and I would be speculating, which I would rather not
22 do. This certainly does determine exemplary angular
23 displacements very accurately, as is required in
24 claim 15.

25 Q. And what are exactly the exemplary

1 angular -- let me try that again.

2 What exactly are you identifying in Frank
3 as being the exemplary angular displacements?

4 MR. HIGH: Objection, form.

5 A. "Exemplary angular displacements of
6 incident light for each light intensity measurement
7 from a reference position relative to the field of
8 view is part of the assessment of the discrete
9 location of the road marker within the field of
10 view."

11 Given Frank, we know to within the
12 precision of the LIDAR, which is, oh, probably a
13 fraction of a centimeter, exactly where that
14 retroreflector is located. And so we can calculate
15 exactly what the angles are between the light source
16 and the light sensor, should that be important to
17 know.

18 Q. And do you see the end part of claim 15
19 says, "as part of the assessment of the discrete
20 location of the road marker within the field of
21 view"?

22 A. Yes.

23 Q. So you're relying on Frank for that
24 disclosure?

25 A. This is analogous to a question we had on

1 an earlier claim, "within the field of view." Does
2 that mean within the sensor field of view, or does
3 it mean in the world?

4 In either case, since Frank can tell you
5 exactly where the spot is, exactly how far away it
6 is, we can calculate within the sensor field of view
7 where that object should appear. Are you dealing
8 with sensor coordinates or are you dealing in road
9 coordinates or are you dealing in vehicle
10 coordinates?

11 Q. Well, which -- for claim 15, which sense
12 of the meaning of the phrase "within the field of
13 view" did you analyze?

14 A. We can convert from one to the other to
15 the other. It's all geometry, fairly
16 straightforward.

17 Q. Well, just point me to where they are in
18 the paragraphs of your declaration.

19 MR. HIGH: Objection, form. Declaration
20 speaks for itself.

21 A. So, for instance, in paragraph 134, "The
22 apparatus calculates the distance D between vehicle
23 101 and each retroreflector." Paragraph 135, "well
24 known to implement techniques to determine the
25 actual distance to the target, take measurements

1 within a distance window."

2 Q. Where do you explain where those precise
3 distances that Frank gives you helps as part of the
4 assessment of the discrete location of the road
5 marker within the field of view?

6 A. Well, starting at the bottom of page 83,
7 "Accordingly, a POSITA would have only needed to
8 apply conventional data processing techniques and
9 simple well-known trigonometry to determine distance
10 and corresponding observation angle based on the
11 light intensity values for each light intensity
12 measurement using the time delay between the
13 transmitted and received pulses which was well known
14 at the time," referring back to Frank.

15 So there's your simple trigonometry.

16 Q. Is that trigonometry giving us the
17 perspective in the field of view, or is it giving us
18 the perspective in the 3D world?

19 A. Once you have angle, angle, range from
20 your sensor, from your LIDAR sensor, now you know
21 exactly where that point is relative to the LIDAR
22 sensor. Now it is straightforward to either say
23 where that is relative to the vehicle or to say
24 where that should appear in either a linear field of
25 view like Gallagher or a 2D field of view like

1 Schofield.

2 This is basic projective geometry.
3 Requires calibration. It's probably too difficult
4 for me to draw in the air, but this is the first
5 lesson in computer vision or in computer graphics,
6 as far as that goes, projecting a point into the
7 scene.

8 With a camera you can't do that. With a
9 camera all you know is it's this array in space.
10 With the LIDAR you know it's this array in space and
11 this distance, so bam, you've got a location.

12 Q. Let's turn to paragraph 154.

13 A. 154. Now we are in claim 14.

14 Q. And so this is part of your ground which
15 has Gallagher, Frank, Schofield, and the ASTM
16 reference, correct?

17 A. Although for claim 14 we're referring to
18 Gallagher, Frank, and ASTM.

19 Q. And so in paragraph 154 you mention,
20 "Frank's determination of its angle alpha depicted
21 in Figure 2A below." Do you see that?

22 A. Yes, and the picture with the alpha is on
23 the next page.

24 Q. So what is the angle alpha in Frank?

25 A. So let's go look at Frank. Angle theta.

1 That is one particular implementation of a LIDAR.
2 So the angle is the yaw angle from dead center ahead
3 pointing in the direction of the object.

4 Q. So in that embodiment of Frank that
5 mentions the angle alpha, that's the extent of sweep
6 of the LIDAR from dead ahead to the right, the
7 maximum it can sweep? Is that correct?

8 A. No. The -- it is the sweep from dead
9 ahead to the detected object.

10 Q. How does angle alpha in Frank relate to
11 angle theta in Frank?

12 A. Let's go look at Figure 2A and see where
13 Figure 2A gets described.

14 I believe you may be correct that alpha
15 may be the full sweep and I should, instead of using
16 Figure 2A, should have used Figure 2 to indicate
17 theta which is the angle to the retroreflector.

18 Q. Okay. Now, in this claim you cite the
19 ASTM standard as part of the motivation to
20 combine -- well, actually let me withdraw.

21 Can you just explain to me how you're
22 using the ASTM standard as part of this proposed
23 combination in claim 14?

24 A. So the biggest effect on retroreflectivity
25 has to do with the angle between the light source

1 and the observation. The second biggest effect has
2 to do with the angle between the light source and
3 the normal to the surface. So it is often assumed
4 that retroreflective objects, like signs or
5 retroreflectors, are built perpendicular to the
6 road. At long distance it is almost perpendicular
7 to the direction of travel, and as you get closer,
8 the reflectivity falls off. Not as quickly as it
9 falls off with increasing angle of observation, but
10 increasing entrance angle.

11 So if you really want to be accurate, you
12 really want to know what that angle is. If these
13 objects are perpendicular to the road, you can see
14 as you get closer, the angle is bigger. If you're
15 further away, the angle is smaller. So if you know
16 the distance to these objects, then you can estimate
17 what your angles are.

18 Q. So you --

19 A. This is the entrance angle that we discuss
20 in paragraph 155.

21 Q. So you cite ASTM in paragraph 152 as
22 teaching that "the minimum reflectance level for a
23 road marker varied depending on both the observation
24 angle and the entrance angle." Is that correct?

25 A. Yes, yes.

1 Q. And the language of claim 14 recites that
2 "determine an entrance angle and an observation
3 angle of the road marker as part of the assessment
4 of the discrete location of the road marker within
5 the field of view." Do you see that?

6 A. I see that.

7 Q. So I understand your point that the ASTM
8 is saying you may want to know the -- both the
9 observation angle and the entrance angle. But what
10 I don't understand is why are you saying there's a
11 motivation then to use both of those angles as part
12 of the assessment of the discrete location?

13 MR. HIGH: Objection, form.

14 Q. Could you explain that?

15 A. You're assessing, in the larger context,
16 the location of the marker, the angles to the
17 marker, and the reflectance of the marker. To do
18 that requires knowing the range to the marker and it
19 requires knowing those two angles. We're
20 calculating all of that, the location, the discrete
21 location and the entrance angle and the observation
22 angle and the reflectivity by this process.

23 Q. Well, back when we were discussing claim
24 15 and the combination that had Gallagher,
25 Schofield, and Frank but not ASTM, we talked -- you

1 talked about how, you know, determining that
2 observation angle would be useful, correct?

3 A. That's correct.

4 Q. And you said that could be determined with
5 simple trigonometry based on the data that Frank
6 provided, right?

7 A. That's correct.

8 Q. And so Frank is telling you the angle
9 theta and the distance to the object from the --
10 from the sensor, correct?

11 A. That is correct.

12 Q. So what additional role is the entrance
13 angle playing in that trigonometry that's giving you
14 a benefit of the proposed combination that you have
15 in claim 14 above and beyond what you've already
16 discussed in connection with claim 15?

17 A. So if you go look at the ASTM manual -- do
18 you have that?

19 Q. I mean, do you want me to put it up? I
20 can -- yeah, let me go ahead and --

21 A. So just summarizing, they have lots of
22 tables in here. When they get to the
23 retroreflectors, they have different observation
24 angles and they have different entrance angles. It
25 would be Table 1 on page 453 of the ASTM reference.

1 You can look that up later.

2 So whether a retroreflector is reflecting
3 enough or not will depend on how much light you're
4 getting back and what all those angles are.

5 Q. Okay.

6 A. So if you just want to know is there a
7 retroreflector there, it doesn't matter. If you
8 want to know is it bright enough, now you better
9 know what the angles are.

10 Q. So the entrance and observation angles are
11 helping you determine the quality of the
12 reflectivity of the retroreflector.

13 A. That is correct.

14 Q. Do they play a role in telling you the
15 location of the retroreflector beyond the distance
16 and theta value that Frank's already giving you?

17 A. I read claim 14, "the assessment of the
18 discrete location of the road marker," to mean,
19 taking into account the location of the road marker,
20 let's calculate all the rest of this stuff.

21 So Frank is certainly telling you the
22 location of the road marker very accurately. And
23 your motivation for doing so is to calculate the
24 angles and calculate the reflectance.

25 Q. If we go back to claim 9, you have 9F as,

1 "analyze the at least one light intensity value to
2 determine an assessment of the discrete location of
3 the road marker within the field of view."

4 That's right?

5 A. Where is 9F?

6 Q. I think you have it on page 54.

7 A. Yes.

8 Q. And --

9 A. That's seeing a high reflective spot and
10 saying that must be where the road marker is.

11 Q. Well, let's -- let's see.

12 A. What's your interpretation of claim 14?

13 Q. I'm asking the questions right now,
14 Dr. Thorpe. Let's -- let's look at --

15 A. A good professor is also a student and is
16 willing to ask questions.

17 Q. I mean, in your proposed combination in
18 claim 14, including all of the limitations of claim
19 9 that it depends from, when is the assessment of
20 the reflectivity of the retroreflector made?

21 A. So, for instance, in paragraph 152,
22 Gallagher has detected a reflectivity, but the
23 reflectance level of the road marker and a value of
24 millicandela per Lux, according to ASTM, that
25 minimum reflectance level for a road marker varied

1 depending on both the observation angle and entrance
2 angle.

3 For example, the minimum coefficient of
4 luminous intensity for a red road marker is 70 for
5 an observation of .2 degrees, but it drops to 28
6 when the entrance angle changes to 20 degrees.

7 So to be really accurate at this, either
8 you need to look so far forward that your entrance
9 angle is practically zero or you need to know where
10 that reflector is and calculate the angle and use
11 that to say is this bright enough.

12 A brightness of 30 would not be good -- a
13 reflectivity of 30 would not be good enough for a
14 marker seen head on but would be good enough for one
15 seen at 20 degrees angle.

16 MR. HIGH: Think we're pretty close to a
17 breaking point soon?

18 MR. SAUNDERS: Yeah, let's go ahead and
19 take another break.

20 THE WITNESS: How much longer do you think
21 we need to go?

22 MR. SAUNDERS: Let's go off the record.

23 THE VIDEOGRAPHER: Okay. We're going off
24 the record. The time now is 4:13 p.m.

25 (Recess from 4:13 to 4:25)

1 THE VIDEOGRAPHER: We are back on the
2 record. The time now is 4:25 p.m.

3 BY MR. SAUNDERS:

4 Q. Welcome back, Dr. Thorpe. I've introduced
5 as exhibits what's previously been marked
6 Exhibit 1009, which is the Leonard reference, and
7 1010, the Popovich reference. Please feel free to
8 look at your paper copies if you have them. I
9 believe you start talking about those references on
10 page 93 of your report.

11 So let's start with the Leonard reference.
12 What is the purpose of the system of the Leonard
13 reference?

14 A. Again, where did you say that I start
15 talking about that?

16 Q. Page 93 of your declaration.

17 A. Page 93 where I bring Leonard in.

18 Well, the title of Leonard, "Systems and
19 Methods for Object Detection Using Beam Widening
20 Optics." So he's playing with a variety of
21 different techniques to expand his field of view.
22 And because he's worried that near objects may be
23 too bright, he's got ways of dealing with that also.

24 Does that help?

25 Q. Okay. So first of all, why is Leonard

Page 147

1 expanding the field of view?

2 A. So, in general, he's detecting objects
3 from a vehicle and he's using a low-powered laser
4 diode and he's talking about the problem of if you
5 need a really wide field of view, how do you do it,
6 how do you split it into a variety of beams. And if
7 you split it into beams or you defocus it, how do
8 you have enough brightness in the far field and not
9 too much brightness in the near field.

10 Does that help?

11 Q. Yes. So let's go to Popovich. What is
12 the purpose of the system in the Popovich reference?

13 A. Well, Popovich is doing some really
14 interesting image processing to determine the
15 location of objects, and that image processing is
16 using a variety of illumination techniques as well
17 as a variety of the image processing techniques.

18 Q. And in your combination, the Ground 4
19 starting on page 61, you're combining Gallagher,
20 Schofield, Leonard, and Popovich. Is that correct?

21 A. Starting on page which?

22 Q. Starting on page 61.

23 A. Starting on my page 61?

24 Q. Yeah, page 61 in your declaration, I think
25 the very top of that page is the heading "Ground 4:

1 Gallagher, Schofield, Leonard, and Popovich Render
2 Obvious Claims 5-7." See that?

3 A. On my page 61?

4 Q. You know what? You got me. I'm wrong.
5 It's your page 93. On your page 93 you're starting
6 the section combining Gallagher, Schofield, Leonard,
7 and Popovich, correct?

8 A. Page -- under -- okay. Ground 4,
9 Gallagher, Schofield, Leonard, and Popovich. Yes.

10 Q. Okay. So first of all, claims 5 through
11 7, they depend from claim 1. Are you starting as a
12 baseline from this ground the combination of
13 Gallagher and Schofield you discussed in claim 1?

14 A. We've already discussed those for claim 1.

15 Q. Okay. And so how are you modifying that
16 system you discussed in claim 1 with Leonard and
17 Popovich?

18 A. So let's go look at the claims which we're
19 trying to take on here. Claim 5, "The automated
20 system of claim 1 wherein the computer processing
21 system is configured to determine the location of a
22 road marker using the light intensity values for the
23 reflective surface by using a location and heading
24 of the active sensor and a location of the object of
25 interest to determine a light vector emanating from

Page 149

1 the light source responsible for one of the light
2 intensity values and comparing the light vector to
3 one of a plurality of predetermined vectors based on
4 the light source angle characterization."

5 We are just adding other ways of doing
6 exactly that. So Leonard is trying to detect
7 retroreflectors and is spreading out his beams where
8 he has a higher intensity beam looking forward and
9 lower intensity beams looking at closer objects.

10 Popovich is showing how you can determine
11 the location of an object by playing with the
12 intensity of the light source and determining
13 whether the object is near the center of your light
14 source beam or near one of the edges of the light
15 source beam and a variety of sophisticated means to
16 play with that.

17 So these are all other ways of tracking
18 reflectors, other ways of generating the beams,
19 other ways of identifying the angles.

20 Q. So in paragraph 177, you cite that
21 Leonard's expanded field of view includes subfields
22 of varying intensity that can be used to detect the
23 distance and angular orientation of any number of
24 objects located within the subfield.

25 Is that right?

1 A. Page 177?

2 Q. Yeah, paragraph 177.

3 A. "Expanded field of view that can identify
4 multiple reflective road markers at once. Expanded
5 field of view includes subfields of varying
6 intensity that can be used to detect the distance
7 and angular orientation of any number of objects
8 located within the subfield." Yes.

9 Q. So what is the benefit of that over
10 Schofield's camera?

11 A. It's a very interesting tweak that
12 Schofield's camera puts a uniform headlights out
13 there in the world. And you can run into the
14 problem of not being bright enough to see a distant
15 object but too bright so that you overwhelm a near
16 object.

17 So what's happening here is a way of
18 creating a light intensity which is brighter looking
19 further ahead and dimmer looking close. The way
20 Leonard does it, he gets the brighter further away
21 and the dimmer close, and he automatically broadens
22 out his beam without having to use additional
23 optics.

24 Q. So obviously claim 5 has got a lot of
25 words in that claim language there. Which of those

1 words are you matching onto disclosures of Leonard?

2 A. "Determine the location of the road marker
3 using the light intensity values for the reflective
4 surface by using a location and heading of the
5 active sensor and a location of the object of
6 interest to determine a light vector emanating from
7 the light source responsible for one of the light
8 intensity values and comparing the light vector to
9 one of a plurality of predetermined vectors based on
10 a light source angle characterization."

11 That is a very long sentence. And Leonard
12 is helping with all of this. Leonard is helping by
13 adding a broad field of view. Leonard is helping by
14 being able to see more distant objects and closer
15 objects. And Leonard helps us to determine the
16 light vector.

17 For instance, "Leonard discloses an
18 expanded field of view that can identify multiple
19 reflective road markers at once." That's one of the
20 things Leonard does for you.

21 Q. All right. Let's break up some of the
22 language then. Which of the references disclose
23 using a location and heading of the active sensor?

24 MR. HIGH: Objection, form.

25 A. Location and heading of the active sensor.

1 Gallagher knows the location of the sensor
2 and the heading as mapped from one of the sensors.
3 Leonard knows the location and is measuring the
4 angle. And Popovich is doing the same thing by
5 different means.

6 Q. So which of the references are you relying
7 on to disclose "to determine a light vector
8 emanating from the light source responsible for one
9 of the light intensity values"?

10 MR. HIGH: Objection, form.

11 A. So halfway down through paragraph 177,
12 "A POSITA would have understood this to disclose
13 using a heading of the active sensor and a location
14 of the object of interest to determine a light
15 vector emanating from the light source responsible
16 for one of the light intensity values because, due
17 to the speed of light, the angle of the incident
18 light on the light sensor array corresponds to the
19 angle of the light vector emanating from the light
20 source relative to the light-source heading that is
21 responsible for one of the light intensity values."

22 I'm explaining a long sentence with a long
23 sentence.

24 Q. Well, that long sentence you just read
25 follows a citation to Popovich, correct?

1 A. There's a citation to Popovich.

2 Q. And then earlier on in that same
3 paragraph, you also have citations to Leonard,
4 right?

5 A. That is correct.

6 Q. Okay. So maybe you could break it down
7 for little me and explain in a little bit simpler
8 language what the contribution each from Leonard and
9 Popovich are in this combination.

10 MR. HIGH: Objection, form.

11 A. This goes back to Ground 4 on page 93 and
12 what the two different systems which we have just
13 introduced do. We've already covered Gallagher.
14 We've already covered Schofield.

15 Leonard, Figure 3 reproduced on page 95,
16 has his laser diode generating a beam of light which
17 he is splitting out into a variety of subfields.
18 Each subfield can be used to detect the distance and
19 angular orientation of any number of objects located
20 within the subfield. Any type of light-detecting
21 element may be used for receiving the reflected
22 subfields from the markers.

23 So Leonard's genius is just in spreading
24 out the light and making the far light bright and
25 making the near light not as bright and then

1 detecting the reflectance off of each one of those
2 and using that to generate a position.

3 Popovich is a little bit trickier, that
4 page 96, the reproduction of Popovich Figure 3A. If
5 you have a non-uniform light distribution, now you
6 can start to tell where the object is based on is it
7 near the center of the light distribution or is it
8 near the edge of the light distribution.

9 If you know the range and you know the
10 angle, now the brightness of the reflection has to
11 do with the brightness of the incident light. And
12 if the incident light drops off in brightness toward
13 the side, then you would get a dimmer reflection and
14 you would be able to tell where it is along that
15 profile.

16 Q. Both of those descriptions you said of
17 Leonard and Popovich make sense to me. I think the
18 difficulty I'm having is understanding how you're
19 mapping their disclosures to the different parts of
20 the language of claim 5, especially because in
21 paragraph 177 you have citations to just different
22 parts of Leonard and Popovich followed by a sentence
23 that is equally long as claim 5.

24 And so I'm trying to understand how the
25 relative contributions of Leonard and Popovich that

1 you just described what those systems have, how
2 those contribute together to result in that system
3 that's recited in claim 5.

4 MR. HIGH: Objection, form.

5 A. Let's take claim 5 word by word or phrase
6 by phrase.

7 "Computer processing system configured to
8 determine the location of the road marker." Okay.
9 That is very directly what Leonard is doing. And
10 Popovich, in his implementation, doesn't talk about
11 road markers, but he's talking about reflective
12 markers. So it's very much the same thing.

13 "Using the light intensity values for the
14 reflective surface." Both Leonard and Popovich are
15 using the light intensity values of the reflective
16 surface.

17 "By using a location and heading of the
18 active sensor." Both of them know where their
19 active sensor is.

20 "A location of the object of interest."
21 They are -- in order to determine the location of
22 the object of interest, they are determining the
23 light vector and measuring the light intensity
24 values when it comes back and comparing the light
25 vector to one of multiple vectors. How they do it

1 is different between the two of them. But it is
2 doing stuff which is very analogous to the claim of
3 5.

4 Q. So in claim 5 where you say you could have
5 relied on Popovich or Leonard, either of them, you
6 know, satisfies what's in claim 5?

7 MR. HIGH: Objection, form.

8 A. I'm relying on them both and on the
9 combination of them.

10 Q. Maybe -- maybe ask it this way.

11 If you didn't have Leonard, what would be
12 missing from claim 5?

13 MR. HIGH: Objection, form, scope.

14 A. Let's go take a look at exactly what
15 Leonard does. Leonard is building the system to
16 have different brightnesses at different locations,
17 a light separating means to permit plural objects to
18 be detected simultaneously. Subfields associated
19 with distant objects are set to greater intensity to
20 ensure reflection of the subfields.

21 One of the big contributions of Leonard is
22 that he puts bright light out distant and dimmer
23 light up closer.

24 Separating the beam into plural
25 transmitted subfields, each pointed toward a

1 different expected location of an object. Got this
2 wonderful example where if your markers are every
3 8 meters, one is 8 meters away, one is 16 meters
4 away, one is 24 meters away, and the 24-meter-away
5 one will be much dimmer than the 8-meter-away one.

6 The light emitted at the marker varies as
7 a square and the reflected light varies as a square
8 of a square. Therefore, the required intensity
9 which must be emitted toward the third marker is 81
10 times stronger than the closer one. And he points
11 out that if you illuminated the closer one with
12 that, you may blind your sensor.

13 So that's one of the big contributions
14 that he makes.

15 Q. Which of what you just said is something
16 that you're opining is part of what's recited in
17 claim 5?

18 MR. HIGH: Objection, form.

19 A. Leonard 462 to 562 is the description of
20 spreading out the beam so as to be able to see as
21 wide an area as you need.

22 Q. So which part of that language of claim 5
23 relates to that spreading out the beam that you just
24 talked about?

25 MR. HIGH: Objection, form.

1 A. "The light source responsible for one of
2 the light intensity values and comparing the light
3 vector to one of a plurality of predetermined
4 vectors based on a light source angle
5 characterization."

6 Q. So what -- which of the references
7 discloses a plurality of predetermined vectors?

8 MR. HIGH: Objection, form.

9 A. That's directly what Leonard is doing is
10 saying this area needs this illumination, this area
11 needs this illumination, et cetera.

12 Q. What does Leonard call those predetermined
13 vectors?

14 A. One of the references of Leonard is
15 subfields.

16 Q. Is the subfield in Leonard a predetermined
17 vector?

18 A. A subfield is an area which would be
19 enclosed by vectors. The four corners of the
20 subfield would each be a vector.

21 Q. So in the proposed combination, which of
22 the -- one of the plurality of predetermined vectors
23 within a subfield would the light vector emanating
24 from the light source be compared to?

25 A. This is a complicated claim. Ask that

1 again?

2 Q. Yeah. So the claim 5 recites, "comparing
3 the light vector to one of a plurality of
4 predetermined vectors." And so I'm trying to
5 understand which of the plurality of predetermined
6 vectors in a subfield of Leonard is getting compared
7 to that "a light vector emanating from the light
8 source."

9 MR. HIGH: Objection, form.

10 A. So the subfield will be a region of the
11 sensor field of view, and a vector within that will
12 have a given light intensity value.

13 Q. The last bit of claim 5 recites, "based on
14 a light source angle characterization."

15 Do you see that?

16 A. Yes.

17 Q. Which reference is disclosing that?

18 MR. HIGH: Objection, form.

19 A. "Based on a light source angle
20 characterization." So both Leonard and Popovich are
21 characterizing the light source angles.

22 Q. So in this proposed combination, that of
23 Gallagher, Leonard, Popovich, and Schofield, which
24 sensors are being used for the techniques of Leonard
25 that you're relying on?

1 MR. HIGH: Objection, form.

2 A. If you read Leonard, "a light receiving
3 means is preferably mounted on the vehicle for
4 receiving the reflected subfields from the markers.
5 Any type of light detecting element may be
6 employed."

7 So Leonard is ecumenical in his choice of
8 how to sense the returned light. Those skilled in
9 the art will recognize that any desired subfield
10 and/or composite field shape can be used to detect
11 objects. So Leonard is flexible as to how this
12 actually works.

13 Q. So your understanding is Leonard could
14 work with the photodiode array of Gallagher?

15 A. I don't want to speculate on that without
16 having really analyzed the guts of what Leonard
17 needs to do.

18 Q. What about Popovich? What sensor in the
19 proposed combination would be used to practice the
20 techniques of Popovich that you're relying on?

21 A. Popovich is very interesting. The first
22 interesting bit -- we've talked a lot about
23 observation angle, trying to keep that within
24 .2 degrees. Popovich settles that problem by having
25 a beam splitter. So there's illumination goes out,

1 and the returned light bounces off to his sensor.
2 So now he's got his sensor looking right down the
3 bore sight of his illumination. So his observation
4 angle is always zero.

5 Now, what kind of a sensor does he use?
6 "Light detection means may each comprise a
7 2-dimensional detector array, a CCD video camera, a
8 position-sensing detector, and/or any type of
9 detector which can detect the position of a light
10 spot in two dimensions."

11 So he is, again, very general in what kind
12 of a detector he would use.

13 Q. Something like a camera though, right?

14 A. Not necessarily. There are ten diodes
15 which will tell you where the centroid of the light
16 lining -- light illuminating the diode heads. So if
17 the light is up here, you get voltages coming out of
18 it proportional to that and so you can directly read
19 out X and Y without having to have a camera and
20 digitize an image process.

21 Q. Looking at the image on the first page of
22 Popovich, it appears that there's two light
23 detection devices 20. Is that correct?

24 A. In this implementation there are two light
25 detection devices, correct.

1 Q. Is that the implementation of Popovich
2 that you're relying on for your --

3 MR. HIGH: Objection, form.

4 Q. -- for your opinions?

5 A. So Popovich is determining a location in
6 3D space and therefore needs two detections to
7 determine where that location is. If you only had
8 one of those two, you would have to have an
9 additional constraint. The additional constraint
10 could be projection onto a flat road, or it could be
11 projection onto an object of known distance as, for
12 instance, measured with a LIDAR.

13 Q. Well, in your combination that you have
14 for claim 5, which of those scenarios are you
15 opining?

16 A. I am us- --

17 MR. HIGH: Dr. Thorpe, just make sure you
18 give me time to object. Thanks. Objection, form.

19 A. I am using the techniques taught by
20 Popovich without using his exact -- his exact setup.

21 Q. Well, how does that work then in your
22 combination? I mean, does your proposed combination
23 have two light detection devices that have a 2D grid
24 of elements?

25 MR. HIGH: Objection, form.

1 A. So, for instance, in the middle of
2 paragraph 177 we keep coming back to, "By measuring
3 the location of the intensity peak within the sensor
4 array, the imaging processing system defines a ray
5 vector that passes through the center of the
6 retroreflector."

7 So once you know that ray vector, "A
8 POSITA would have understood that to disclose using
9 a heading of the active sensor and a location of the
10 object," et cetera, now you've got the angle which
11 is the angle that you're looking for.

12 So I am using Popovich, a single one of
13 Popovich's sensors because I'm looking for a
14 direction. I'm not looking for the full 3D space
15 that is shown in his patent.

16 Q. All right. And in paragraphs 165 through
17 174 of your declaration, you provide rationales for
18 combining Gallagher, Leonard, and Popovich.

19 Is that correct?

20 A. Paragraph 164 is talking about analogous
21 art. Paragraph 165, '6, '7, '8, '9, '70, '1, '2,
22 '3, '4 are talking about combinations.

23 Q. I don't see Schofield mentioned there in
24 paragraphs 165 going on. Do you have an explanation
25 of why it would be obvious to combine Leonard and

1 Popovich with the system of Gallagher and Schofield
2 that you described in regards to claim 1?

3 MR. HIGH: Objection, form.

4 A. I do not think it necessary to bring
5 Schofield in at this point.

6 Q. Well, you understand that claim 5 depends
7 from claim 1, right?

8 A. That is correct.

9 Q. So that means that to satisfy claim 5, you
10 need to satisfy all of the limitations of claim 1,
11 correct?

12 A. You're the lawyer here.

13 Q. Okay. Well, I'm just trying to understand
14 your opinions. You know, how I read it is you've
15 rendered an opinion about claim 1, and then in this
16 ground you don't go back and analyze claim 1 again.
17 So I'm assuming you're relying on Schofield for all
18 the reasons that you describe above in claim 1.

19 Is that accurate?

20 A. The specific limitations of claim 5, we
21 are using Gallagher, Leonard, and Popovich.

22 Q. Is there somewhere where you explain how
23 the additional techniques of Leonard and Popovich
24 are beneficial over the system of Gallagher and
25 Schofield that you already described in connection

1 with claim 1?

2 A. As you point out, we've already described
3 Gallagher and Schofield in claim 1.

4 Q. Well, when we talked about claim 1, we
5 already talked about, you know, your opinion that
6 Gallagher and Schofield disclosed detecting the
7 location of road markings, correct?

8 A. That is correct.

9 Q. So what did Popovich and Leonard, what
10 benefits are they conveying above that technique
11 that we already discussed in claim 1?

12 MR. HIGH: Objection, form.

13 A. The additional comments in claim 5 about
14 using light intensity values, determine a light
15 vector emanating from the light source, comparing
16 the light vector to one of a plurality of
17 predetermined vectors, those were not recited in
18 claim 1. Those are the additional claims in claim
19 5, and so we bring in these additional references to
20 deal with those additional claims.

21 Q. Yeah, I understand that. I'm just trying
22 to understand, what is your opinion as to why one of
23 skill in the art would have recognized that Leonard
24 and Popovich and specifically the techniques that
25 you're relying on those references for are providing

1 a benefit, you know, beyond the technique that you
2 described in claim 1 for detecting the location of
3 the road markers?

4 A. The whole business about "a light vector
5 emanating from the light source responsible for one
6 of the light intensity values and comparing the
7 light vector to one of a plurality of predetermined
8 vectors based on a light source angle
9 characterization," that subphrase is exactly what
10 Popovich does and is the subject matter of which
11 Leonard is cognizant and relevant.

12 Q. I guess another way to explain it is why
13 would one of skill in the art, at the time of the
14 invention of the '328 patent, want to use those
15 techniques of Leonard and Popovich as opposed to the
16 other techniques for determining the location of a
17 road marker that we've already talked about?

18 MR. HIGH: Objection, form.

19 A. One would use Gallagher and Schofield to
20 determine the location of the road marker. If one
21 wanted to determine a light vector emanating from a
22 light source responsible for one of the light
23 intensity values and comparing that to the
24 predetermined vectors, that is a different level of
25 detail and a different specificity that is not in

1 claim 1 and which are more directly answered by
2 Leonard and Popovich.

3 Q. All right. One of your prior answers, I
4 think you referred to Leonard disclosing different
5 subfields associated with different distances?

6 Is that correct?

7 A. If you look at the Leonard patent -- first
8 of all, if you look at the Leonard patent, page 1,
9 you can see that he is using a light source, he is
10 detecting markers, he is recording the range and the
11 bearing to each of those markers.

12 So his system is directly relevant -- or
13 the Figures 1C, Figure 3, Figure 4 are all -- Figure
14 6, are all different ways of showing this business
15 of putting brighter light out here and progressively
16 dimmer light closer in to make the system more
17 effective. That, in effect, plays with the light
18 vector emanating from the light source.

19 Q. So when Leonard's talking about distant
20 objects getting a different subfield, how far out,
21 distance wise, is he talking about?

22 MR. HIGH: Objection, form.

23 A. The example that Leonard gives, purely as
24 an example, is looking at objects at 8 meters,
25 16 meters, and 24 meters. But that is just a

1 pedagogical example to show that the far object is
2 three times further and therefore is 81 times
3 dimmer. It would be straightforward to extend this
4 out to objects at a greater range.

5 Q. So if Gallagher's light sensor array is
6 looking downwards, as you said, sweeping a broom,
7 you know, about a little over 2 meters in front of
8 it on the roadway, how is Gallagher's system able to
9 use Leonard's disclosures about using different
10 subfields for distances that are a lot greater than
11 that?

12 MR. HIGH: Objection. Calls for
13 speculation.

14 A. So Gallagher is one way of doing it. It
15 is selecting from its sensors which reflectance
16 level indicates a road marker. Leonard is able to
17 do so at greater ranges. So these are, in that
18 sense, complementary ways of achieving the same
19 purpose.

20 Q. So in your proposed combination that has
21 Gallagher and Leonard and Popovich, how many
22 different sensors are there?

23 MR. HIGH: Objection, form.

24 A. The three of them together, each of them
25 is teaching determining a light vector emanating

1 from the light source. They're doing so by
2 different methods.

3 Q. Each one of them has different sensors in
4 their disclosures, right?

5 A. Each one of them is using different
6 physical principles and different sensors.

7 Q. And so in your proposed combination that
8 you're saying satisfies claim 5 of the particular
9 system, what are the actual sensors in that system
10 that you're saying will be motivated by the
11 combination of these references?

12 A. Remember we're combining the teachings of
13 these systems. We may not be combining the nuts and
14 bolts or silicon and wiring of these systems.

15 Q. Okay. You understand that the teachings
16 have to be at least compatible to be capable of
17 being combined in some way, right?

18 MR. HIGH: Objection, form. Calls for a
19 legal conclusion.

20 A. We have to have a way to use the teachings
21 together.

22 Q. I'm just trying to figure out how can we
23 use these teachings from these different references
24 that have different sensors in one system. And I
25 guess a question at the top of my mind is, how many

1 different sensors do you need for that system that
2 is using all of these different teachings?

3 MR. HIGH: Objection, form, scope.

4 A. So Popovich has one method for generating
5 a varying light field. Leonard has a different
6 method for generating a varying light field.

7 Leonard has a sensing method. Popovich has a
8 sensing method. Gallagher has a sensing method.

9 Q. Have you opined that there's one sensor
10 that could do all of those jobs?

11 MR. HIGH: Objection, form.

12 A. From paragraph 178. "For example,
13 Gallagher discloses selecting, from the light
14 intensity values, which reflectance levels indicate
15 a road marker. But it was known that the received
16 intensity will be a function of the angular bearing
17 with respect to the light source and the distance of
18 the retroreflector from each light source.
19 Popovich.

20 "Accordingly, to determine whether the
21 light intensity values correspond to a road marker,
22 a POSITA would have been motivated to compare the
23 determined light vector to known angular intensity
24 distribution profile to determine whether a
25 particular light intensity value received at the

1 determined angle corresponds to a road marker."

2 This is not saying that you have to have
3 three different detectors. It's saying that you
4 have to have combined the physics described in these
5 three systems in order to have the most accurate
6 possible measurement.

7 Q. Are you -- is it possible to compare the
8 determined light vector to the known angular
9 intensity distribution profile for the light source
10 if your sensor is just an array of photodiodes?

11 MR. HIGH: Objection, form.

12 A. Even an array of photodiodes are pointing
13 at discrete locations and will be at different
14 angles and therefore would benefit from knowing the
15 intensity of the light and knowing the geometry of
16 the situation.

17 Q. But with the level of granularity of five
18 or ten photodiodes, what improvement are you getting
19 from using that technique?

20 A. First of all, that is an exemplary
21 implementation for Gallagher, and we could implement
22 it with more photodiodes or with a line from a
23 camera.

24 Even then, the difference between looking
25 almost straight ahead and looking off at an angle,

1 that is a significant change in the entrance angle
2 and therefore would be a significant change in the
3 light intensity values and comparing the light
4 vector to plurality of predetermined vectors based
5 on light source angle characterization.

6 Q. Now, Leonard uses laser radar a/k/a LIDAR,
7 right?

8 A. That is correct.

9 Q. In the proposed combination you'd have to
10 use a LIDAR to obtain the benefits of Leonard?

11 Is that correct?

12 MR. HIGH: Objection, form.

13 A. Using the LIDAR is great, but you can use
14 the laser as purely an illumination. And many of
15 these sources cite using a laser as one of the ways
16 of doing illumination along with headlights,
17 et cetera, et cetera, et cetera.

18 So you could do the illumination with the
19 laser diode without using the laser as a
20 rangefinder.

21 Q. Is that -- well, which of the techniques
22 are you proposing in your proposed combination?

23 MR. HIGH: Objection, form.

24 A. If I were doing it myself? Now I'm
25 lapsing into professor mode. The business about the

1 light intensity values and the light vector to one
2 of a plurality of predetermined vectors, the most
3 significant part of Leonard is being able to project
4 different patterns at different locations.

5 The fact that Leonard also measures
6 distances makes it even more accurate because now
7 you know not only the illumination in this pattern
8 but the distance, and now you can calculate all of
9 these angles, as we've discussed previously.

10 Q. So if Leonard needs a light source that's
11 going to provide a pattern, that's distinct from a
12 normal light source that you'd want for headlights,
13 for example. Is that right?

14 MR. HIGH: Objection, form.

15 A. What Leonard is trying to do is to produce
16 a brighter spot further away and a dimmer spot
17 closer so that you have enough illumination to see
18 what you need to see out there without having so
19 much illumination here that you overwhelm and
20 saturate your sensor.

21 Q. That's not something provided by the
22 existing headlights of a conventional vehicle,
23 right?

24 MR. HIGH: Objection. Calls for
25 speculation.

1 A. I actually have never characterized the
2 headlight pattern of an existing vehicle. I don't
3 know.

4 Q. If you illuminate a scene as disclosed in
5 Leonard and you looked at that with a camera, is
6 that going to cause things further away to look --
7 look relatively brighter and things closer to look
8 relatively darker?

9 MR. HIGH: Objection, scope.

10 A. Relatively compared with what?

11 Q. To a camera using a illumination pattern
12 that's not adjusted as described in Leonard.

13 A. Leonard is trying to make distant objects
14 appear approximately as bright as near objects. And
15 in order to do that, this is the light vectors,
16 plurality of predetermined vectors based on light
17 source angle characterization.

18 Q. All right. Just a few random quick
19 questions. If you could go back to the Frank
20 reference, could you just tell me how the theta
21 angle in Frank is defined?

22 A. So this is the theta angle example on, for
23 example, on Figure 2?

24 Q. I believe -- well, there's multiple Figure
25 2s. Yes, Figure 2 without the "A."

1 A. Yes, "A" has the alpha angle, "2" has the
2 theta angle.

3 Q. Yeah. So how is that theta angle Frank
4 defined?

5 A. Referring to Figure 2, the reflected
6 signal laser radar apparatus 103 calculates distance
7 D between vehicle 101 to the retroreflector and the
8 angle theta formed between axis 104 and an imaginary
9 line drawn between vehicle 101 and a retroreflector.

10 So you're driving straight, you've seen
11 the object over here. That's the theta angle.

12 Q. So it's a angle determined from a top-view
13 perspective?

14 A. I believe that that's what he's doing
15 here.

16 Q. And is theta the same as the entrance
17 angle?

18 A. If the reflector is mounted perpendicular
19 to the road and if the road is straight, then theta
20 would be the entrance angle also. Entrance angle.

21 Q. But if either of those conditions are not
22 satisfied, then theta would not be the entrance
23 angle?

24 A. That would be correct.

25 Q. All right. And does the Frank system --

1 A. You can see that in Figure 2, that if
2 reflector 114 were drawn as a perpendicular line,
3 now by similar triangles it's the same angle.

4 Q. Does the Frank system require calibration?

5 A. Any system requires calibration. It
6 requires knowing where the mirrors are pointing,
7 requires knowing what the frequency is of the
8 modulation of the system. Depending on how the
9 system was constructed, these may be calibrations
10 which you can do once and then have set.

11 Q. Is the calibration going to differ based
12 on the type of light source you have; for example,
13 headlights versus a LIDAR?

14 MR. HIGH: Objection. Calls for
15 speculation.

16 A. For Frank you're dealing with LIDAR.

17 Q. So the calibration of Frank which has
18 LIDAR would be different than the calibration of
19 Gallagher which does not have LIDAR?

20 A. That is correct.

21 MR. SAUNDERS: All right. I will pass the
22 witness.

23 MR. HIGH: Let me take about a 15-minute
24 break.

25 MR. SAUNDERS: Sure.

1 THE VIDEOGRAPHER: Okay. We're going off
2 the record. The time now is 5:21 p.m.

3 (Recess from 5:21 to 5:30)

4 THE VIDEOGRAPHER: We are back on the
5 record. The time now is 5:30 p.m.

6 E X A M I N A T I O N

7 BY MR. HIGH:

8 Q. Okay. Just a few questions of redirect.

9 Dr. Thorpe, do you recall being asked
10 about how you've mapped the various limitations of
11 claim 5?

12 A. Various limitations of claim 5? That was
13 what we were just working on, yes.

14 Q. Yes. Can you look at your declaration
15 starting at paragraph 175 on page 103 and continuing
16 through paragraph 179.

17 A. "Gallagher, Leonard, and Popovich render
18 obvious the additional limitations of claim 5."

19 Q. Yes. Do you stand by what you said in the
20 declaration at paragraphs 175 to 179?

21 MR. SAUNDERS: Objection, form, leading.

22 A. Gallagher discloses a computer processing
23 system, uses a GPS. Light source is fixed on
24 Gallagher's vehicle, so the -- yes, I stand by 176.

25 177, "The combination of Leonard and

Page 178

1 Popovich discloses the known techniques for
2 determining the location of markers detected by a
3 moving vehicle." So this is Leonard expanding the
4 field of view, and this is Popovich using a
5 symmetrical intensity profile. "Defining a ray
6 vector that passes through the center of the
7 reflector, retroreflector." I stand by 177.

8 178, "Because the intensity of the light
9 source varies relative to its heading, a POSITA
10 would have found it obvious to compare the
11 determined light vector to one of a plurality of
12 predetermined vectors based on a light source angle
13 characterization." That's what claim 5 is talking
14 about. Gallagher talks about this. Popovich talks
15 about this. "Determined light vector to be the
16 known angular intensity distri-" -- I stand by 178.

17 179 refers back to VIII.D.4., "motivated
18 to combine Gallagher, Leonard, and Popovich." So
19 that is VIII.D.4., rationale for combining
20 Gallagher, Leonard, and Popovich. "Would have had a
21 reasonable expectation of success in doing so, to
22 use the light source's position as determined by the
23 GPS interface and the angle of the road marker
24 relative to the light source's heading, as
25 determined through analysis of light intensity

1 values, at multiple locations to determine the
2 location of the road marker using the light
3 intensity values through triangulation."

4 Yes, I stand by that.

5 MR. HIGH: Pass the witness.

6 MR. SAUNDERS: Nothing further.

7 THE VIDEOGRAPHER: Okay. Before we go off
8 the record, Mr. High, would you like a video copy?

9 MR. HIGH: No, I don't need a video.

10 THE VIDEOGRAPHER: Okay. Mr. Saunders,
11 would you still like your video copy?

12 MR. SAUNDERS: No, I don't think we need a
13 video at this time.

14 THE VIDEOGRAPHER: Madam Reporter, do you
15 take orders on the record or no?

16 THE REPORTER: I can. Mr. High, would you
17 like to purchase a copy of the transcript?

18 MR. HIGH: I think we want a final. We
19 don't need the rough. And standard delivery is
20 okay.

21 THE REPORTER: Mr. Saunders, do you need
22 anything other than a regular turnaround time?

23 MR. SAUNDERS: Can we get a rough and a
24 three-day, three-day final?

25 THE REPORTER: Okay.

1 THE VIDEOGRAPHER: Okay. If we're ready
2 to conclude, then we are off the record at
3 5:34 p.m., and this concludes today's testimony
4 given by Dr. Charles Thorpe, Ph.D. The total number
5 of media used was six and will be retained by
6 Veritext Legal Solutions.

7

8 (Deposition concluded at 5:34 p.m. EDT)

9 -oOo-

10

11

12

13

14

15

16

17

18

19

20

21

22

23

24

25

1 UNITED STATES PATENT AND TRADEMARK OFFICE
2 BEFORE THE PATENT TRIAL AND APPEAL BOARD
3 MOBILEYE GLOBAL, INC.)
)
4 Petitioner,) Inter Partes Review
) No. IPR2024-01111
5 vs.)
) U.S. Patent No.
6 FACET TECHNOLOGY CORP.,) 9,671,328
)
7 Patent Owner.)
_____)

8
9 REPORTER'S CERTIFICATE
10 REMOTE VIDEOTAPED DEPOSITION OF
11 CHARLES E. THORPE, PH.D.
12 MAY 29, 2025
13

14 I, KAREN L. SHELTON, Texas CSR No. 7050,
15 RDR, CRR, do hereby certify;

16 That CHARLES E. THORPE, PH.D., the witness
17 whose deposition is hereinbefore set forth, was duly
18 sworn by me and that this transcript is a true
19 record of the testimony given by the witness;
20

21 That examination and signature of the
22 witness to the deposition transcript was waived by
23 agreement of the parties at the time
24 of the deposition;
25

Page 182

1 That the amount of time used by each party
2 at the deposition is as follows:

3 MR. ROBERT K. HIGH - 0:03

4 MR. MICHAEL D. SAUNDERS - 5:22

5
6 I further certify that I am neither
7 counsel for, related to, nor employed by any of the
8 parties or attorneys in the action in which this
9 proceeding was taken. Further, I am not a relative
10 or employee of any attorney of record in this cause,
11 nor am I financially or otherwise interested in the
12 outcome of the action.

13
14 Certified to by me on this the 2nd day of
15 June, 2025.

16
17
18 
19

20 Karen L. Shelton, CSR, RDR, CRR
21 Texas CSR 7050 Exp: 10/31/25
22 Veritext Legal Solutions
23 Firm No. 571
24 300 Throckmorton Street
25 Suite 1600
 Fort Worth, Texas 76102
 (817) 336-3042 (800) 336-4000

[& - 165]

&	1003 3:12 8:8	102:2,4	137 128:17
& 2:5	8:16	10:35 1:16 4:3	14 46:25 47:2,4
0	1005 3:14 8:8	10a 101:10	93:19 102:9
0.2 134:19,21 135:11	9:4	11 48:18 54:8	103:17,24
0.5 38:25 39:1	1006 3:15 8:9	123:16	112:14 113:22
0033 59:8	9:7 44:2	1110 5:17	139:13,17
1	1007 3:17	112 117:6,7	140:23 142:1
1	121:15	114 120:7	143:15 144:17
1 4:11 31:19	1008 3:18	177:2	145:12,18
43:6 49:4,7	1009 3:20	11:35 38:3,4	1400 2:6
92:11,17,19	147:6	11:46 38:4,6	143 3:18
98:6 100:14,18	101 77:22,23	11a 53:9,11,18	147 3:20,21
101:1,13	137:23 176:7,9	53:21 54:3	15 11:23 55:10
103:14,21	1010 3:21	55:1 80:2,5,11	125:16 126:22
105:9 111:12	147:7	11b 54:5,12,24	127:13,20
112:12 143:25	102 93:15	11c 54:24	128:3,10,13,15
149:11,13,14	103:6	12 45:8,21 46:5	128:22 131:5
149:16,20	103 93:17,21	49:24 50:2	135:24 136:18
164:21 165:2,7	94:10 104:23	51:22 52:1	137:11 142:24
165:10,15,16	105:16 112:9	121 3:17	143:16 177:23
165:18 166:1,3	113:13,17	12566 183:19	15's 128:4
166:4,11,18	114:22 116:3,5	127 124:16	152 141:21
167:2 168:1,8	176:6 178:15	125:19	145:21
10 33:1,9 47:1	104 93:21	13 12:12,17	154 139:12,13
47:8 48:6 54:8	94:16 104:16	41:3,5 47:2	139:19
55:10,12	106:2,7 176:8	130 124:6,10	155 141:20
10,000 33:1,8	105 93:21	131 125:17,20	16 11:23
10/31/25	94:23 104:2	134 129:19	127:20 158:3
183:20	106 93:21	137:21	168:25
100 93:1,9	104:8	135 127:1	1600 183:22
1001 3:11 8:8	107 93:17,21	129:25 134:4	164 164:20
9:1	95:2,5	134:16 137:23	165 164:16,21
	108 95:17 96:2	136 135:3,6	164:24
	100:15,22		

[17 - 3rd]

17 11:23 41:4,9 55:12 127:25 174 164:17 175 178:15,20 176 178:24 177 150:20 151:1,2 153:11 155:21 164:2 178:25 179:7 178 3:6 171:12 179:8,16 179 178:16,20 179:17 17th 2:6 18 11:23 16:18 182 3:7 19 127:20 1972 108:22 1988 109:20 1990 131:4 1990s 122:22 1997 3:19 1:05 79:13,14 1:53 79:14,16 1a 93:10 94:5 94:20 95:10 101:3,10 102:8 102:10 103:7 103:10 1b 95:21 96:9 100:23 1c 95:21 168:13 1d 62:23 95:21 96:6,17 101:2	102:2,4 122:8 1e 100:14 1f 117:5,7,10 118:15 119:4 1g 120:6,7,13 1p 93:1,8	2500 2:12 255 8:1 271 2:6 28 146:5 29 1:12 58:7 182:12 29th 1:15 4:3 2a 139:21 140:12,13,16 2d 61:14 62:18 62:23 70:9 102:22 122:9 138:25 163:23 2nd 183:14 2s 175:25	98:20 117:19 117:20 118:4,5 336-3042 183:23 336-4000 183:23 34 117:20 118:5,5 35 37:19 38:13 39:11 55:14 98:20 36 10:21 39:24 40:1 41:19 73:13 37 10:21 49:5,7 38 28:11,15,21 73:20,21 99:3 39 27:21,22 28:22 35:22 36:15 66:18 3:01 115:22,23 3:12 115:23,25 3a 155:4 3d 62:24 76:2 77:5 78:7 79:1 79:4,7 107:18 109:23 126:12 129:5 130:25 138:18 163:6 164:14 3rd 2:12
	2		
	2 3:3 13:18,19 31:19 73:13 84:10 121:4 127:19 134:24 140:16 146:5 161:24 162:7 164:21 169:7 175:23,25 176:1,5 177:1 2.3 37:18,21 39:7 20 146:6,15 162:23 2002/0063638 3:14 8:7 2025 1:12,15 4:3 182:12 183:15 21 24:19 127:20 22 127:21 23 26:10 27:13 117:20 24 53:19 158:4 158:4 168:25	3	
		3 8:20 33:9,9 33:10,12 38:14 38:15 39:9 75:3 123:22 154:15 164:22 168:13 30 33:6,7,8 122:14 146:12 146:13 300 183:21 30363-6209 2:7 328 7:25 8:5,18 8:22 9:3 67:19 167:14 33 59:12 64:24 81:3,23,24 83:5 85:5 97:4	

[4 - 70]

4	158:17,22 160:2,13 163:14 165:6,9 165:20 166:13 166:19 170:8 178:11,12,18 179:13	58 19:1,13 55:11 86:3 582-6889 2:13 59 19:2,15 20:8 23:7 34:5 77:1 5:21 178:2,3 5:30 178:3,5 5:34 1:16 181:3 181:8	64 14:1 92:13 65 14:6 20:22 20:22 21:10 59:2,5,7 68:21 81:23 82:2 87:21 88:5,6 89:5 117:20 118:14,17,18 119:12
4 39:5 58:7 148:18,25 149:8 154:11 164:22 168:13 40 28:23,25 46:6 51:22 52:1 404 2:7 41 47:4 73:13 134:22 42 47:12 43 67:14 44 125:9 45 68:9 83:6 85:5 453 143:25 462 158:19 47 32:25 59:3 83:6 85:5 4:13 146:24,25 4:25 146:25 147:2	5,202,742 3:17 5,313,262 3:20 5,796,094 3:16 5-7 149:2 51 48:6 80:15 512 2:13 58:8,8 64:17,17 53 81:11 54 67:24 84:14 84:23,24,25 145:6 55 81:23 82:1 82:25 83:6,6 84:22 85:4,6,7 85:12 117:20 118:6,17 56 12:6,11 19:3 81:23 82:1 85:14,19 117:20 118:1,3 118:7,9,17 562 158:19 57 19:3,11 32:6 32:9 33:17 85:22,25 571 183:21	6 6 3:5 17:3 68:23 69:1,5,7 86:25 164:21 168:14 60 12:25,25 13:9,22 14:17 14:25 15:12 16:4 20:13 21:6 33:4,5 60:10,12 81:4 81:5 83:18 86:7,23 87:20 88:10,11 89:3 92:3,3 119:15 607 2:12 61 13:5 15:12 16:4 67:14,15 148:19,22,23 148:24 149:3 62 15:12 16:5 98:21 63 68:3 87:23 87:25 88:1	653-6400 2:7 66 14:10,15 15:8 16:8,10 20:22,23 21:15 68:21 81:7,23 82:2,7,8,16,18 82:21,25 83:6 83:6 87:22 90:1 91:16 92:6 117:20 118:17,24 119:1,12,23 120:13,16,20 67 68:19,21 99:20 113:18 114:22 116:5 68 99:24 6a 68:25 99:4
5	5 23:16,16,18 23:19 24:2,4,7 34:3 39:8 65:15 120:19 120:19,23,25 149:10,19 151:24 155:20 155:23 156:3,5 157:3,4,6,12	7 7 30:22 149:11 164:21 70 80:15 95:18 100:16 146:4 164:21	

[7050 - active]

7050 182:14 183:20 71 83:5 72 119:5 73 81:10 74 12:7 75 67:24 76 127:16 76102 183:22 78 23:19 72:12 78701 2:13 79 72:3,7,8 73:4 77:7,7 121:2 124:7 7d 69:5,7	71:20 72:10 74:17 80:14 81:10 96:4,13 117:25 128:4,7 128:9,13,14 144:25 145:19 164:21 9,671,328 1:7 3:11 8:14,24 182:6 93 147:10,16,17 149:5,5 154:11 95 154:15 96 155:4 96/17258 3:22 98a 54:12 98b 54:12 98c 54:12 99 92:12,14 93:1,9 9a 68:2,4,5,10 96:4,13,19 9b 68:5,10,21 96:4 9c 68:5,10,12 68:18,21,24 96:4,13 99:9 99:11 100:8 9d 80:14,16 82:6,8,19,25 83:1,4 85:3,5 91:12,17 9e 81:10 82:8 82:19 91:12,17	9f 67:23 69:7 78:13 79:8 144:25 145:5 a a.m. 1:16 4:3 38:3,6 aashto 40:16 52:25 ability 135:16 able 25:15 28:8 42:19 43:17 57:16 74:8 152:14 155:14 158:20 169:8 169:16 174:3 above 1:17 17:11,20 20:24 20:25 24:4,10 26:2,19,21 27:5,8,10 35:11 47:18 54:23 65:14 67:4,5 92:5 143:15 165:18 166:10 absence 24:15 25:17 abstract 43:1,3 acceptable 12:4 16:21,25 23:25 24:3,17,18,23 25:1,19 121:3	accepted 64:21 access 8:3 accomplished 54:10,15 account 40:3 144:19 accumulating 47:6 69:23 accuracy 76:23 130:1,3 131:13 131:15 accurate 19:8 27:9 126:21 129:6 141:11 146:7 165:19 172:5 174:6 accurately 18:8 133:16,17 135:23 144:22 achieve 44:14 73:10 74:8 achieving 169:18 act 51:9 action 4:22 183:8,12 activating 24:20 active 80:17 95:23 100:23 149:24 152:5 152:23,25 153:13 156:18 156:19 164:9
8			
8 3:12 73:20 158:3,3,5 164:21 168:24 80 62:7 74:24 77:25 78:2,12 78:19 128:3,15 800 183:23 81 129:13 158:9 169:2 817 183:23 83 138:6			
9			
9 3:11,14,15 29:19 30:20 42:21 53:18 55:11,13 67:19 67:22 69:4			

[actual - angle]

actual 119:19 127:9 129:22 137:25 170:9 actually 14:22 43:11 53:12 54:19 68:5 77:4 79:21 80:21 100:15 113:8 133:21 140:20 161:12 175:1 adapted 60:1 97:6 98:7 adc 12:12,17 14:23 17:10,17 17:20 23:2 28:9,10 31:4 85:15 118:10 adcs 85:17 add 93:24 107:9 126:2 added 94:7 adding 94:21 95:10 135:1 150:5 152:13 additional 135:15 143:12 151:22 163:9,9 165:23 166:13 166:18,19,20 178:18 additionally 34:24 73:24	adds 49:1 adjacent 47:16 48:8,11 60:3 98:8 adjust 46:1 adjustable 76:23 adjusted 175:12 adjusting 40:2 advance 34:8 advantage 33:23 advantageous... 29:4,19 76:22 111:22 112:21 114:1,25 affiliations 5:3 ago 14:21 agree 4:10 7:18 45:23 agreed 5:17 agreement 182:23 ahead 25:6 37:15,22,25 53:7 75:7 96:15 108:13 124:14,15 140:2,6,9 143:20 146:18 151:19 172:25 air 139:4	algorithm 84:17 85:1 88:14 105:6 algorithms 94:3,14 95:13 105:20 108:18 110:5,8,9 114:14 116:10 126:24 aligned 76:22 allow 83:23 allowable 40:14 allowed 41:13 allows 108:10 alpha 139:20 139:22,24 140:5,10,14 176:1 alternate 79:7 alternatively 73:23 ambiguous 75:19 american 40:16 amount 27:7 28:1 183:1 amplitude 123:1,2 analog 12:15 12:18 31:5 analogous 31:15 136:25 157:2 164:20	analysis 62:13 63:2 80:14 87:21 92:11 96:3,13,19 98:11 99:9 100:7,17 102:8 103:10,13,21 105:9 112:12 128:22 133:19 179:25 analyze 55:2 78:13 95:21 137:13 145:1 165:16 analyzed 9:5,8 121:16 161:16 analyzing 54:25 128:9 angle 11:5 38:17 39:2,2 39:15 40:3 41:20,20 76:12 76:21 77:15 80:9 99:5 123:20,20 124:4 126:10 127:7 130:6 131:19,20,24 131:25 132:6 132:14 133:11 133:12 134:5,8 134:10,12,18 134:19 135:11 135:15,17
--	---	---	--

[angle - array]

138:10,19,19 139:20,24,25 140:2,2,5,10,11 140:17,25 141:2,9,10,12 141:14,15,19 141:24,24 142:2,3,9,9,21 142:22 143:2,8 143:13 146:1,2 146:6,9,10,15 150:4 152:10 153:4,17,19 155:10 159:4 160:14,19 161:23 162:4 164:10,11 167:8 172:1,25 173:1,5 175:17 175:21,22 176:1,2,3,8,11 176:12,17,20 176:20,23 177:3 179:12 179:23 angles 39:24 124:5 131:16 131:21,22 133:1 136:15 141:17 142:11 142:16,19 143:24,24 144:4,9,10,24 150:19 160:21	172:14 174:9 angular 133:14 135:22 136:1,3 136:5 150:23 151:7 154:19 171:16,23 172:8 179:16 annual 3:19 answer 12:8 23:8 30:7 44:11 51:20 64:10 105:13 answered 46:4 105:12,14 113:11 168:1 answering 20:4 answers 7:1 14:25 130:11 168:3 anyways 25:22 apart 52:22,23 52:24 124:24 125:9 aperture 61:15 apologies 59:13 apparatus 10:7 10:12 13:8 43:8 60:1 64:24 70:22 83:23 97:6 98:6,19 104:9 104:24 105:18 111:15,18 112:5,15	113:20 114:6 116:7 137:22 176:6 apparently 24:5 appeal 1:2 8:13 182:2 appear 26:17 36:22 51:19 71:1 137:7 138:24 175:14 appearance 4:25 appearances 3:3 5:2 appearing 1:17 6:10 64:6 appears 8:20 9:9 162:22 applicable 44:23 applications 44:17 98:24 apply 67:23 125:15 138:8 applying 72:12 72:21 94:11 111:16 appreciate 60:8 appreciated 59:25 98:5 approach 111:3	appropriate 49:1 appropriately 110:15 approximately 12:6,7 33:5 175:14 area 29:22,24 38:13 39:9,22 55:19 68:15 83:25 84:2 87:4 95:24 99:17 100:2,6 158:21 159:10 159:10,18 arranged 11:3 11:4 31:18,20 31:25 array 28:12,20 29:8,11,17 30:2 31:9,14 31:17,22 47:5 47:6,9,9,11 54:11 61:23 64:11 68:25 69:16,24 72:18 73:1,7,11,14,21 73:24,24 75:21 96:7,10,12,18 96:20,23 97:1 97:9,14 98:1 98:10,12 100:20 101:9 101:15 103:16
---	--	---	---

[array - back]

103:24 105:24 110:11 116:10 116:14 122:10 123:7 126:5,6 128:17,19,19 130:8,9,10 132:13 139:9 139:10 153:18 161:14 162:7 164:4 169:5 172:10,12 array's 75:5 78:8 79:5 arrays 29:3 76:21 art 29:7 43:21 52:5 57:2 60:1 60:25 63:20 67:18 74:13 77:13 92:17,20 93:23 98:6 100:3 103:14 103:22 105:4 107:15 112:18 112:23 128:24 161:9 164:21 166:23 167:13 article 130:20 artisans 56:17 ascertain 113:2 asked 46:4 82:6 91:8 97:20 105:11,14 113:10 178:9	asking 7:11 9:12 14:21 25:25 30:12 45:21 62:21,25 75:8 91:5,17 97:17 116:3 145:13 aspect 57:21 assessing 43:8 98:18 142:15 assessment 69:25 78:14 120:15 136:8 136:19 138:4 142:3,12 144:17 145:2 145:19 assist 46:7 48:23 65:20 94:12 associated 19:9 81:14,21 82:12 92:1 157:18 168:5 association 40:16 assume 19:3 assumed 57:3 141:3 assuming 165:17 assumption 126:9	assumptions 76:6 astm 3:19 135:6,13,14 139:15,18 140:19,22 141:21 142:7 142:25 143:17 143:25 145:24 atlanta 2:7 attached 1:22 attempting 10:8 attention 79:19 attorney 5:4 6:19,19 183:10 attorneys 6:19 183:8 audio 4:8 83:20 austin 2:13 authority 135:4 automated 60:14,17,20 61:2,8,20,21 62:19,22 64:15 65:12 93:3 98:17 124:8,11 149:19 automatically 151:21 automotive 44:10 autonomous 60:25	average 19:7 32:11 34:2 133:22 averages 33:17 averaging 19:10 85:24 134:6 axis 54:1 55:14 55:16,20,21 56:2,5,6,8 77:8 77:9,10 176:8 b b 23:16,25 24:11 26:2,5 26:21 27:5,8 27:10 32:9,18 34:3 65:14 66:11 80:22 83:15 85:22,25 88:23 90:9,11 90:14,21,23 96:19 117:14 120:25 121:3,5 back 16:18 19:1 32:6,21 38:5,8 45:20 49:24 55:13 67:13 68:2 77:25 79:15,18 84:9 89:2 90:18 96:2,14 100:14,15 111:8,9 115:24
---	--	--	---

[back - break]

122:8,13 123:16 124:1,2 127:15 138:14 142:23 144:4 144:25 147:1,4 154:11 156:24 164:2 165:16 175:19 178:4 179:17 background 14:7 17:4 18:16,16,19,23 20:14,23,24 21:7 25:24 82:2 84:3 86:13 87:5 88:6,7 89:4,6 89:19 92:5 118:19 130:17 bam 139:11 bands 47:8 based 17:19 22:4,10 23:8 48:19 54:1 104:17 110:3 111:2 117:9,18 120:1 122:4 138:10 143:5 150:3 152:9 155:6 159:4 160:13,19 167:8 173:4 175:16 177:11 179:12	baseline 149:12 basic 139:2 bazrod 2:4 5:9 6:20 beam 39:7 41:21 122:8,18 127:3 147:19 150:8,14,15 151:22 154:16 157:24 158:20 158:23 161:25 beams 51:19 148:6,7 150:7 150:9,18 bearing 123:20 124:5 168:11 171:16 beginning 5:3 53:18 67:16 78:9 begins 63:17 103:6 114:21 behalf 2:3,10 5:8 believe 9:21 21:24 34:4 35:6 37:23 39:10,14 51:23 54:3 59:9 66:15 75:15 76:16 92:12 93:18 97:23 98:10 100:11 100:12 116:22	125:12,13,15 128:20 140:14 147:9 175:24 176:14 belt 19:18 beneficial 165:24 benefit 105:23 143:14 151:9 167:1 172:14 benefits 166:10 173:10 best 53:20 better 19:11 76:18 107:1 131:13,15 144:8 beyond 40:12 125:4 143:15 144:15 167:1 big 157:21 158:13 bigger 133:11 141:14 biggest 140:24 141:1 billion 122:23 bit 22:22,24 27:17 36:24 59:1 60:9 62:21,25 154:7 155:3 160:13 161:22	black 108:25 blind 41:16 158:12 blue 36:2 board 1:2 8:14 75:1 78:24 182:2 bolted 36:20 101:20 bolts 170:14 book 3:19 130:18 books 60:20 bore 162:3 boston 1:18 6:15 bother 77:24 bottom 72:4,8 72:11 80:3,5 138:6 bounce 55:13 bounces 162:1 bouncing 19:5 132:16 133:5 box 85:8,10 bracket 59:8,8 break 7:10,11 38:1,10 78:3,5 79:11 114:17 114:19 115:20 116:2 146:19 152:21 154:6 177:24
--	--	---	---

[breaking - camera]

breaking 146:17 bright 36:2 37:11 49:19 57:7,8 87:16 123:18 144:8 146:11 147:23 151:14,15 154:24,25 157:22 175:14 brighter 151:18,20 168:15 174:16 175:7 brightest 15:22 16:3 87:14,14 87:19 brightness 47:22 57:1 77:2 146:12 148:8,9 155:10 155:11,12 brightnesses 157:16 bring 147:17 165:4 166:19 bringing 128:21 broad 30:1,25 74:3 152:13 broadens 151:21 broadly 44:23	broken 10:20 59:21 65:3 broom 18:1 37:20 61:13 97:13 132:10 132:11 169:6 brooming 16:15 32:3 43:22 63:25 102:23 brooms 61:25 build 54:19 102:20 building 70:8 122:20 157:15 builds 102:21 102:22 built 141:5 bump 33:18 bumping 133:12,18 134:1 bumps 133:23 buried 128:16 business 167:4 168:14 173:25	132:3 136:14 137:6 144:20 144:23,24 146:10 174:8 calculated 19:16,17 calculates 137:22 176:6 calculating 32:11 77:9,10 142:20 calculation 32:22 41:7 51:16 77:17,20 calculation's 51:21 calibrate 34:25 35:1 57:16 77:1 calibrated 75:24 106:20 109:21 calibrating 11:25 19:13 86:4 calibration 12:2 19:14,16 20:8 23:6,9 34:6 35:13 56:10,19,22,23 56:25 57:6,10 57:20 58:2 70:25 76:25 77:11 116:17	121:9 139:3 177:4,5,11,17 177:18 calibrations 177:9 call 32:2 130:15 159:12 called 61:1,4 calls 169:12 170:18 174:24 177:14 camcorders 47:10 camera 4:6 30:3,18 31:2,5 31:8,16 33:23 46:17,19,23 47:13 49:17 51:5,14 53:4 53:16 56:2,5 56:23 57:9,11 57:12,22 58:2 58:6 61:14 63:24 70:9,16 70:18,23,25 75:24,25 93:24 94:1,4,7,14 95:12 97:12 101:4,8,14 105:25 106:17 106:23 108:13 108:24 109:22 110:17 116:20 116:22,25
	c		
	c 2:1 4:1 86:3 90:10,11,14,22 90:23 96:19 100:23 calculate 19:20 19:21 130:5		

[camera - cite]

117:2 126:14 126:25 127:10 128:25 129:12 129:20 130:13 139:8,9 151:10 151:12 162:7 162:13,19 172:23 175:5 175:11 cameras 30:4,9 30:14 73:23 capabilities 95:15 capability 64:22 capable 170:16 capture 102:13 102:18,22 captures 102:18 care 33:17 careful 23:10 carefully 30:7 cargo 36:19 carnegie 130:20,23 carry 11:24 case 4:15 17:23 21:15 23:24 24:2 35:23 56:12 70:10 79:6 84:10 96:22 137:4	casting 74:3 75:23 cause 175:6 183:10 caused 25:9 causing 33:18 caution 45:13 45:16,17 caveats 117:3 ccd 73:25 162:7 center 56:2 140:2 150:13 155:7 164:5 179:6 centered 13:7 18:5 centimeter 136:13 centimeters 122:14 central 54:1 56:1 centroid 162:15 certain 17:11 27:7 51:6 57:22,23 90:13 certainly 15:9 23:13 28:23 37:4 39:21 51:1 58:1 66:20 81:4 90:10,22 93:6 108:2 120:2	135:22 144:21 certificate 3:7 182:9 certified 183:14 certify 182:15 183:6 cetera 53:2 80:22 83:16 107:19,19,19 116:18 117:4 117:15 123:13 123:14,14 130:6,6 133:23 159:11 164:10 173:17,17,17 change 46:9 53:1 67:8 134:5 135:1 173:1,2 changes 67:11 134:10,11,12 146:6 characteristic 52:8,9 characteristics 48:21 52:11 94:19 112:7 113:24 characterizati... 150:4 152:10 159:5 160:14 160:20 167:9 173:5 175:17	179:13 characterized 53:25 84:17 175:1 characterizing 160:21 charge 47:9 73:21 charles 1:11 3:4,13 4:12 6:1 6:9 181:4 182:11,16 charts 56:17 check 62:9 checking 120:21 checks 34:24 35:2,5 choice 161:7 cid 74:2 cie 56:16 circuit 47:2,14 citation 59:6 120:14 153:25 154:1 citations 120:12 154:3 155:21 cite 83:5 84:13 85:3 96:12 117:19,22 118:15 135:6 140:18 141:21 150:20 173:15
---	---	---	---

[cites - combined]

cites 118:4 claim 67:19,22 71:20 72:10 74:17 80:14 81:10 92:11,17 92:19,22 96:4 100:14,18,23 101:1,13 103:14,21 105:9 111:12 112:12 117:24 125:16 126:22 127:13 128:3,4 128:4,7,9,10,12 128:13,14,15 128:22 131:5 135:24 136:18 137:1,11 139:13,17 140:18,23 142:1,23 143:15,16 144:17,25 145:12,18,18 149:11,13,14 149:16,19,20 151:24,25 155:20,23 156:3,5 157:2 157:4,6,12 158:17,22 159:25 160:2 160:13 163:14 165:2,6,7,9,10	165:15,16,18 165:20 166:1,3 166:4,11,13,18 166:18 167:2 168:1 170:8 178:11,12,18 179:13 claims 91:4 125:16 127:20 127:22 149:2 149:10,18 166:18,20 clarification 7:8 15:24 59:2 60:8 110:20 clarify 7:6 classes 61:1,4 clear 92:3,6 97:23 clearly 46:13 89:24 97:22 clever 49:22 close 33:15 55:15,17 80:10 107:11 114:17 134:13 146:16 151:19,21 closely 48:9,11 closer 107:13 126:19 131:23 131:23 134:4 141:7,14 150:9 152:14 157:23 158:10,11	168:16 174:17 175:7 cmos 73:24,25 coefficient 146:3 cognizant 167:11 collected 19:2 32:15,16,19 71:25 collecting 20:13 35:7 62:17 72:24,25 82:1 collisions 41:17 color 11:10 47:13,21,24 48:15 50:13 52:18,21 56:25 67:1,8,11 70:9 109:22,24 110:1 124:22 colored 35:23 130:15,21 131:1 colors 66:22 column 45:8,21 48:18 49:4,24 50:2 51:22 52:1 53:18 54:8 55:10,11 55:12,13 58:7 58:10 75:20	columns 58:8 combination 52:18 72:4 74:19 100:18 101:14,21,23 102:1 109:10 112:23 113:4,8 114:7 125:25 126:22 127:11 128:11 140:23 142:24 143:14 145:17 148:18 149:12 154:9 157:9 159:21 160:22 161:19 163:13,22,22 169:20 170:7 170:11 173:9 173:22 178:25 combinations 164:22 combine 71:17 71:23 93:18 101:17 104:10 104:11,12 110:23 111:5 125:22 128:25 129:11 133:20 133:25 135:7 140:20 164:25 179:18 combined 95:4 101:1,7 105:5 105:6,7 109:15
--	--	---	---

[combined - contend]

170:17 172:4 combining 50:10 70:3,20 71:6,18 76:18 105:3,9 106:10 109:6 110:25 111:11 113:15 126:23 148:19 149:6 164:18 170:12,13 179:19 come 115:12 131:23 comes 23:6 85:16 121:25 122:13 124:1,2 156:24 coming 41:11 73:1 162:17 164:2 comma 59:8 comment 64:14 comments 166:13 commonly 47:10 73:22 communicate 7:18,20 compare 17:17 95:20 171:22 172:7 179:10 compared 34:2 96:3 159:24 160:6 175:10	comparing 13:2 86:13 92:19 99:10 150:2 152:8 156:24 159:2 160:2 166:15 167:6,23 173:3 comparison 67:18 92:17 compatible 170:16 complementary 94:16 95:14 104:9,10 111:21 112:4 112:20 113:24 114:24 169:18 complete 7:14 7:16 12:8 44:11 completely 26:1 complicated 51:16 159:25 component 23:20,21 composite 161:10 comprise 162:6 compute 74:13 computer 8:4 11:12,14,15,21 11:23 12:20,22 17:2 46:19,21	56:21 61:5,7 61:10,11 62:14 63:1,1,4,13,15 63:17,21 77:22 80:16 84:5 85:8 86:24 95:3,6,13 104:17 106:11 112:3 129:16 130:23,24 139:5,5 149:20 156:7 178:22 computers 64:15,19 concern 56:7 conclude 181:2 concluded 48:10 181:8 concludes 181:3 conclusion 170:19 conditions 176:21 conducted 4:4 4:17 62:10 confidence 107:10 108:18 109:14,16 114:15 115:6,8 115:10,12,13 confidences 115:11	configuration 49:1 configured 80:17 149:21 156:7 confirm 96:15 confirmation 71:4 connected 80:17 connection 4:6 15:7 72:10 81:7 128:10 131:5 143:16 165:25 consideration 48:7 constant 39:6 41:21 constraint 163:9,9 constructed 177:9 containing 29:4 contemplate 15:19 contemplated 37:13 119:14 contemplates 98:11 contemplating 46:11 contend 102:12
---	--	--	--

[contends - court]

contends 75:1 78:23	convert 137:14	39:3,4 40:13	149:7 153:25
context 14:21 87:3 91:3 120:18 142:15	converter 12:18	42:14 46:3,19	154:5 162:23
continue 4:9	converters 33:2	46:20 47:25	162:25 164:19
continues 55:12	converting 75:22	51:8 56:4	165:8,11 166:7
continuing 178:15	conveying 166:10	58:11,14,20	166:8 168:6
continuous 10:20 52:17 59:21 65:3	conveyor 19:18	59:14 63:3,11	173:8,11
continuously 18:15	conveys 98:14	63:12,14 64:12	176:24 177:20
contribute 156:2	coordinates 137:8,9,10	64:13 65:15	correction 48:15
contributing 102:17	copies 7:23,24 7:24 8:2 147:8	66:4,6,14,15	correspond 54:25 171:21
contribution 154:8	copy 9:14 121:18 180:8 180:11,17	67:2,20,21,25	corresponding 138:10
contributions 155:25 157:21 158:13	corners 159:19	68:10,16,17,19	corresponds 70:7 78:6 79:3 117:16 153:18 172:1
control 47:1,14 65:6 85:8,10 122:1 135:17	corp 1:7 4:14 182:6	69:18 73:2,7,8	counsel 4:13 5:1,12,15,19 114:16 183:7
controlled 19:18	correct 6:11,12 6:21 7:3 8:15 8:25 9:5,20,22 10:3 11:12 12:21 16:7 22:5,11,12,18 22:19 23:5,9 26:25 27:19 28:7,16 29:12 29:18 30:5,9 30:15,19 31:4 31:10,11,13 32:20 34:9 37:12,23 38:18	73:11 74:9,20 75:16 85:4,13 85:16,20 86:2 86:6 88:5 90:8 92:18 93:11,12 93:14,20,21 95:8 96:4,5,7 96:13,18 97:2 100:17,21 101:9,15 102:3 102:19 103:25 110:12 116:14 116:25 117:2 117:11,12 118:12,23 120:9,10,13,14 121:7 132:11 132:15 134:20 139:16 140:7 140:14 141:24 143:2,3,7,10,11 144:13 148:20	count 122:12 122:15,16,19 122:23 counters 123:7 counting 123:9 couple 47:9 73:22 76:6 114:18 course 56:7 61:6 109:4 135:1 court 4:20 5:11 6:25

[cove - degraded]

cove 108:25 cover 29:20 39:9 42:22 123:8 covered 23:13 25:2,8,17 26:7 78:7 79:4 154:13,14 covering 13:19 13:21 covers 83:25 create 31:6 80:6,8 103:15 created 65:22 creates 32:4,5 creating 62:18 123:17 151:18 crest 41:11 cresting 40:10 crr 1:20 182:15 183:19 csr 1:20 182:14 183:19,20 current 30:12 currently 130:22 curvature 40:15,22 53:1 133:12,19 134:2 curve 41:5 53:1 curving 126:17 126:18 132:17	cut 61:18	86:4 88:2 90:3 90:7,12,18,21 90:23,25 91:20 91:22 95:6 102:24 104:18 106:2,12,16 108:12 109:6 109:24 110:15 112:1 116:13 116:15 118:10 123:10,19 125:3 138:8 143:5 date 131:3 day 1:15 180:24,24 183:14 dead 140:2,6,8 deal 108:7 166:20 dealing 137:7,8 137:9 147:23 177:16 dean 130:22 decide 12:23 14:23 17:8,18 declaration 3:13 7:23 8:6 8:12,17,21 9:19 10:22 17:1 58:24,25 67:13,17 68:6 68:19 71:19 72:2 73:5	74:17,24 75:14 79:20 80:13 91:10 92:15 103:5 105:22 110:25 111:7 111:11 113:3,6 113:12 124:7 134:1 137:18 137:19 147:16 148:24 164:17 178:14,20 declaration's 112:11 decrease 55:21 dedicated 99:10 def 63:22 defective 24:13 24:15 121:4 defects 33:18 define 61:10 defined 175:21 176:4 defines 164:4 defining 179:5 definitely 45:20 63:22 64:7 definition 30:1 58:21 75:4 deflect 11:3 defocus 148:7 degraded 25:16 26:22 27:15
	d d 2:11 3:1 4:1 15:1,3,7 16:4 33:2 75:3 83:18 86:7 87:10 88:20 89:2,3 90:7,15 90:18 91:1,20 100:23 137:22 176:7 183:4 damaged 23:12 darker 175:8 darpa 61:18 dash 65:10,10 65:11,11 dashed 65:6 84:10 data 11:24 12:1 12:1,19 13:2 14:11 15:7,8 17:2,6 19:2,13 19:14 29:23 32:10,12,14,14 32:16,19 33:24 33:25 35:7,8,8 35:10 46:22 47:2 61:11,12 63:23 64:4,20 71:25 72:13,17 72:23,25 73:1 81:17 82:1 83:25 85:15		

[degree - determine]

degree 22:4 41:9 degrees 41:4,5 134:19,21,24 135:11 146:5,6 146:15 161:24 delay 138:12 deliberately 37:17 40:18 delivery 180:19 demarcate 10:15 denser 33:13 depend 57:10 57:12,13 144:3 149:11 dependents 127:25 depending 52:11 128:4 141:23 146:1 177:8 depends 4:5 131:19 132:16 145:19 165:6 depicted 55:1 139:20 depicting 53:15 54:5 depiction 53:9 deponent 2:3 deposed 6:21 deposition 1:10 1:17 4:4,12,16	7:19 181:8 182:10,17,22 182:24 183:2 describe 29:10 125:22 165:18 described 43:20 119:15 134:16 140:13 156:1 165:2,25 166:2 167:2 172:4 175:12 describes 53:17 97:9 119:7 describing 125:18,19 description 3:10 23:17,18 48:1 59:23 63:16 98:3 99:19 115:10 158:19 descriptions 155:16 desirably 29:2 desired 52:17 161:9 detail 12:5,10 35:6 52:13 54:17 56:13 68:18 167:25 details 54:6 88:14 112:12 119:7 135:19	detect 10:23 11:4,21 20:5 20:17 22:10 23:14 29:11,16 30:18 33:13 35:9,10,11 37:16 39:15 42:19 44:25 45:24 46:7,16 52:2,5 55:20 57:16 66:12 67:10,11 79:23 80:18 81:1 84:5 86:24 99:5 107:7 108:14 129:4,5 131:6,7,9,10 150:6,22 151:6 154:18 161:10 162:9 detected 17:3 52:14 76:14 86:1,4,14 87:7 87:20 140:9 145:22 157:18 179:2 detecting 15:20 20:7 29:21 36:25 45:2 48:8,10 49:19 56:14,15 69:18 69:20 81:3,6,8 82:10,21 83:7 83:8,8,9 86:11	114:11,12 120:4 124:13 124:17 125:12 148:2 154:20 155:1 161:5 166:6 167:2 168:10 detection 15:15 36:16 37:3 57:19,20 61:21 85:11,19 92:4 92:6 94:12 107:10 108:19 109:13 147:19 162:6,23,25 163:23 detections 24:4 114:13 163:6 detector 162:7 162:8,9,12 detectors 122:10 172:3 detects 46:1 69:1 93:3 determination 13:12 26:23 27:6 69:11 83:2 118:11,22 119:2 127:5,6 139:20 determinations 27:3 determine 10:9 11:15 13:3
---	---	---	---

[determine - direct]

16:16 17:10 18:8,18 37:3 46:21 47:15 53:12 58:13,15 58:19,22 64:2 64:3,5 69:25 70:10 77:5 78:14 81:12 89:18 117:7,16 129:16,22 132:22 133:13 135:22 137:24 138:9 142:2 144:11 145:2 148:14 149:21 149:25 150:10 152:2,6,15 153:7,14 156:8 156:21 163:7 166:14 167:20 167:21 171:20 171:24 180:1 determined 17:24 21:1,17 24:21 35:12 38:15 39:1 87:10,13 143:4 171:23 172:1,8 176:12 179:11 179:15,22,25 determines 70:4 83:9 93:4 determining 12:2 14:7	16:20 17:4 20:22 26:11 53:19 79:2 81:19 82:2,11 82:22 83:19 84:18 88:7 89:5 91:24 108:9 118:19 119:16,20 143:1 150:12 156:22 163:5 167:16 169:25 179:2 develop 130:16 developed 130:12 develops 50:21 device 47:5,9 72:6 73:22 devices 162:23 162:25 163:23 dickinson 2:11 5:6 dickinsonwri... 2:14 differ 177:11 difference 25:21 172:24 different 11:8 15:21 19:22 20:1 22:5,9,10 28:3 29:22 34:12 35:24 36:17 37:5	38:22 39:23 42:5 44:19 52:10 54:25 55:2 56:14 57:17,23 61:5 62:25 64:23 66:12,17,20,21 67:10 69:13 70:14 72:10 91:13 92:21 94:19 95:4 97:7 99:21 101:20 102:21 102:25 103:1 105:2 107:16 107:20,24 108:1,6,11,17 108:17 111:10 112:7,25 113:5 114:13,14 115:16 124:20 124:23 130:9 134:7 143:23 143:24 147:21 153:5 154:12 155:19,21 157:1,16,16 158:1 167:24 167:25 168:4,5 168:14,20 169:9,22 170:2 170:3,5,6,23,24 171:1,2,5 172:3,13 174:4	174:4 177:18 differentiate 66:13 differentiating 66:21 83:16 124:19,21 differentiation 54:9,14 55:5,9 66:24 difficult 51:21 70:14 75:23 76:7 139:3 difficulty 49:19 155:18 digital 12:18 digitize 162:20 digitized 31:6 digitizes 116:16 dimensional 162:7 dimensions 53:13 162:10 dimmer 49:20 56:15 151:19 151:21 155:13 157:22 158:5 168:16 169:3 174:16 diode 127:2 148:4 154:16 162:16 173:19 diodes 162:14 direct 49:4 79:19 126:20
--	--	---	---

[direct - document]

127:8 direction 56:6 129:4 140:3 141:7 164:14 directly 90:20 90:21 126:6,12 156:9 159:9 162:18 168:1 168:12 dirt 23:13 25:2 25:8,17 26:7 disclose 11:2 16:24 50:6 66:7 77:4,24 108:4 110:10 124:17,19 152:22 153:7 153:12 164:8 disclosed 38:25 71:19 76:9 77:14,17 128:18 135:20 166:6 175:4 discloses 10:12 10:13 11:7,9 17:2 49:21 73:5 77:10 79:2 91:6 93:6 93:14 94:11 97:1,21 98:17 102:13 103:6 111:16 119:8 134:17 152:17 159:7 171:13	178:22 179:1 disclosing 43:16 84:15 160:17 168:4 disclosure 29:16 30:17 42:19 97:24 102:17 107:22 136:24 disclosures 52:4 119:19 152:1 155:19 169:9 170:4 discovered 53:22 discrete 70:1 75:1,16 78:6 78:15,16,24 79:4 136:8,19 138:4 142:4,12 142:20 144:18 145:2 172:13 discuss 8:12 105:8 141:19 discussed 28:21 36:15 85:23 91:11 114:10 117:13 128:7 134:3 143:16 149:13,14,16 166:11 174:9 discusses 34:6 41:19 42:3 81:3 98:23	125:13 discussing 62:13 68:18 142:23 discussion 13:9 51:24 120:4 123:11 133:18 disparate 109:7 displacement 54:1 displacements 133:14 135:23 136:3,5 displayed 121:3 displaying 84:20 displays 62:8 disposed 98:18 disqualifying 48:24 distance 23:21 26:23 27:7 49:9 51:6 55:17 58:16 80:9 107:8 117:4 122:11 124:15 126:6 126:24 127:5,9 129:17,23,25 131:23 132:18 134:10 137:22 137:25 138:1,9 139:11 141:6	141:16 143:9 144:15 150:23 151:6 154:18 163:11 168:21 171:17 174:8 176:6 distances 34:13 55:15 138:3 168:5 169:10 174:6 distant 151:14 152:14 157:19 157:22 168:19 175:13 distinct 174:11 distinguish 24:14 25:7,15 35:14 36:4,10 36:16 37:7,10 69:13 distinguishing 18:11 35:20 125:11,13 distri 179:16 distribution 73:19 155:5,7 155:8 171:24 172:9 divide 33:4,4 73:16 divided 33:8,9 document 20:21 47:4 79:25
---	--	---	--

[documents - embraced]

documents 7:25 9:12 dog 90:7,18 91:1,20 doing 19:18 30:22 34:11 44:9 52:19,20 56:24 64:14 66:23 75:8 77:6 81:5,5 101:21,23,25 107:16,20,21 109:17,19 112:18,19 113:14 120:20 122:7,25 126:4 144:23 148:13 150:5 153:4 156:9 157:2 159:9 169:14 170:1 173:16 173:24 176:14 179:21 dots 52:17 123:21 downwards 169:6 dr 4:12 6:5 38:8,9 79:18 116:2 130:22 145:14 147:4 163:17 178:9 181:4	draw 40:21 139:4 drawn 176:9 177:2 drive 32:4 driven 16:9 34:9 52:25 driver 46:9 65:21 drivers 10:16 driving 16:5,11 40:19 176:10 drop 18:7 132:3 drops 146:5 155:12 due 153:16 duly 6:2 182:17 dunner 2:5	early 61:17 122:22 easy 52:8 53:2 77:1 121:3 ecumenical 161:7 edge 67:6 155:8 edges 150:14 edited 130:19 editorial 64:14 edt 1:16,16 181:8 effect 133:10 133:11 140:24 141:1 168:17 effective 168:17 either 24:12 26:20 27:15 36:1,14 46:7 66:15 71:23 75:20 76:15 81:6 86:15 107:22 108:4 119:14 122:8 130:10 137:4 138:22,24 146:7 157:5 176:21 electrical 19:6 19:8 electronics 27:25 33:20	element 47:12 154:21 161:5 elementary 108:19,20,22 elements 163:24 emanating 149:25 152:6 153:8,15,19 159:23 160:7 166:15 167:5 167:21 168:18 169:25 embedded 125:1 embodiment 28:14,18,19 29:3 31:1 34:16 38:19 42:9,12,12,15 43:14,17 44:20 57:14 59:24 60:5 66:22,23 66:25 74:11 76:17 84:16 85:2 96:25 97:8,25 98:4,9 99:13 100:8,12 100:13 109:12 140:4 embodiments 42:6 62:3 embraced 61:19
	e e 1:11 2:1,1,1,1 3:1,4,13 4:1,1 6:1,3,9 87:24 178:6 182:11 182:16 e.g. 129:23 earlier 16:19 37:20 49:25 51:23 80:20 112:24 117:13 117:23 128:8 132:8 137:1 154:2		

[emitted - expanded]

emitted 158:6,9 employed 73:25 161:6 183:7 employee 183:10 employs 84:16 enable 49:23 129:16 enables 83:21 104:25 111:20 113:22 encased 76:22 enclosed 159:19 endeavor 60:14 124:11 ends 61:7 65:10 65:11 energy 124:1,2 ensure 157:20 enter 18:3 enters 132:13 entire 16:14 30:6 64:16 83:7 116:11 123:8 entirely 90:13 90:14 entitled 60:20 entrance 141:10,19,24 142:2,9,21 143:12,24	144:10 146:1,6 146:8 173:1 176:16,20,20 176:22 enumerated 111:10 envelope 32:21 equally 155:23 especially 155:20 essence 32:1 essentially 93:22 establish 18:13 18:16 establishing 17:5 21:11 82:3 88:8 89:7 118:20 estimate 80:4 141:16 estimating 56:16 et 53:2 80:22 83:16 107:19 107:19,19 116:18 117:4 117:15 123:13 123:14,14 130:6,6 133:23 159:11 164:10 173:17,17,17 evidence 49:2 115:17	exact 33:6 135:19 163:20 163:20 exactly 65:7 110:24 126:13 133:8 135:25 136:2,13,15 137:5,5 138:21 150:6 157:14 167:9 examination 3:5,6 182:21 examined 15:17 examining 16:17 35:8,10 35:11 example 10:18 11:1,6 19:16 22:16 25:16,22 25:23 27:21 38:24,25 45:8 45:12,19 47:13 48:10,13,21 50:19 53:20 54:3 59:20 63:9 65:1 74:6 74:11 83:14 94:11 100:13 109:9,10 111:16,24 113:13 114:10 115:3 134:11 134:22 146:3	158:2 168:23 168:24 169:1 171:12 174:13 175:22,23 177:12 examples 46:12 73:3 110:22 113:14 except 74:11 exclusively 43:7 exemplary 133:13 135:22 135:25 136:3,5 172:20 exhibit 3:11,12 3:14,15,17,18 3:20,21 8:4,8 8:16,20 9:1,2,4 9:7 44:2 121:12,13,15 147:6 exhibits 3:9 8:20 147:5 exist 53:22 existing 26:13 70:22 174:22 175:2 exit 67:7,9,12 exp 183:20 expand 147:21 expanded 150:21 151:3,4 152:18
---	---	---	--

[expanding - filtering]

expanding	f	123:4 126:15	138:17,24,25
148:1 179:3	f 14:7 21:10,21	126:16 130:2,4	142:5 145:3
expect 52:22	88:5,11,19	133:6 137:5	147:21 148:1,5
expectation	89:1,12,14,16	139:6 146:8	148:8,9 150:21
179:21	89:20 118:18	148:8 154:24	151:3,5 152:13
expected 27:14	face 23:22,23	168:20 169:1	152:18 160:11
64:6 65:25	24:10	farabow 2:5	161:10 171:5,6
158:1	facet 1:7 4:14	faster 33:22	179:4
experience	182:6	feed 105:20	figure 13:18
129:9	fact 48:21	feel 9:13,13	23:16,18,19
expert 17:1	62:17 112:4	147:7	24:1,2,4,7,8
91:9 130:24	113:12 174:5	feet 125:9	27:11 31:19,19
explain 35:4	factor 12:2	field 13:7,8,19	34:3 49:15
103:14 123:24	19:14 23:6,9	18:3,5,6 29:20	53:7,9,11,18,21
138:2 140:21	34:6 116:17	38:11 39:10,12	54:5,11 55:1
142:14 154:7	134:3	39:17 40:11	65:15 80:2,5
165:22 167:12	factors 19:16	42:22 47:16	80:10 84:9,10
explained	40:3	51:14 53:4,10	120:19,23,25
71:22	fair 39:20	53:13,15 54:4	123:16 139:21
explaining	44:24 45:3	56:1,25 60:13	140:12,13,16
153:22	55:1	60:18 61:17	140:16 154:15
explanation	fairly 47:20	63:21 68:14	155:4 168:13
164:24	53:2 75:23	69:12 70:1,11	168:13,13
explicitly 43:20	90:13 131:22	74:14 75:2,5	170:22 175:23
exposure 56:16	137:15	75:17 78:8,16	175:24,25
extend 169:3	fall 49:16	78:17,25 79:5	176:5 177:1
extended 37:5	falls 141:8,9	80:18 81:15,22	figures 54:24
50:21	fan 31:25	99:16 102:18	76:11 168:13
extensively	far 8:5 33:13	124:8,10	filed 4:14 8:13
10:14	37:15 49:14,15	132:13,19	filter 33:24
extent 74:25	55:15 76:13	133:2,9 134:15	36:1 47:6
78:23 140:5	80:4 88:3	134:25 136:7,9	filtered 19:3,7
extract 97:12	122:17 123:2,3	136:20 137:1,2	filtering 19:4
		137:6,12 138:5	19:12 32:10,18

[filtering - frank]

36:15 48:6 85:23 filters 19:4,6 67:9 final 180:18,24 financially 4:22 183:11 find 20:21 23:18 40:21 45:5 65:8,9,25 finding 20:23 71:13,14 finds 75:1 78:24 finish 41:2 78:4 finnegan 2:5 5:7,9 6:16 finnegan.com 2:8,8 firm 4:20 183:21 first 6:2 12:25 59:1 60:13 64:14 67:22 81:2 86:18 87:15 106:6 109:21 112:8 116:4 125:15 125:22,24 139:4 147:25 149:10 161:21 162:21 168:7 172:20	five 28:12,16 28:17 83:24 107:16,20 172:17 fixed 178:23 flashlight 35:16 flashlights 36:7 flat 41:10 75:23 76:1,7 77:24 126:9 133:4 163:10 flexible 161:11 flipped 55:8 flood 122:9 129:18 floodlight 127:3 129:18 flows 89:25 focal 75:24 focus 91:15 97:16 103:4 followed 155:22 follows 6:2 153:25 183:2 foot 122:14 form 9:25 10:25 11:18 13:15 14:18 17:13 21:3 22:6 25:11 27:1 29:13 32:5 35:17 42:2 44:7,15	45:4 51:12 56:11 57:18 60:22 61:3 62:5 65:17,19 66:5 69:19 71:21 72:20 75:18 76:10 77:19 78:22 80:7 81:16 82:9,20 87:12 88:13,21 89:22 90:19 91:2,21 94:9 96:8 97:3 98:16 99:2,14 99:23 100:10 102:14 103:18 104:1,7,15,22 105:11 106:1 107:6,25 108:15 110:6 112:16 113:10 114:9 119:24 121:1,21 125:6 127:12 136:4 137:19 142:13 152:24 153:10 154:10 156:4 157:7,13 158:18,25 159:8 160:9,18 161:1 163:3,18 163:25 165:3 166:12 167:18 168:22 169:23	170:18 171:3 171:11 172:11 173:12,23 174:14 178:21 formed 176:8 fort 183:22 forth 122:8 182:17 forward 47:1,7 47:17 53:23 73:16 122:2 146:8 150:8 found 69:10 105:16 111:13 129:14 179:10 four 159:19 fraction 136:13 frank 121:15 121:18,20,22 122:6 124:7,13 124:17,19,25 125:3,7,10,16 125:18,19,23 126:1,3,12 127:14,19 128:16 130:9 131:6,7,8 132:22 133:13 133:17,20 135:7,16 136:2 136:11,23 137:4 138:3,14 139:15,18,24 139:25 140:4
---	---	--	---

[frank - gallagher]

140:10,11 142:25 143:5,8 144:21 175:19 175:21 176:3 176:25 177:4 177:16,17 frank's 126:23 127:2,4,8 128:25 129:11 129:14 139:20 144:16 free 9:13,13 147:7 frequency 177:7 front 18:20 23:22 39:8 55:24 76:14 169:7 full 6:7 140:15 164:14 fully 86:21 function 171:16 functionality 35:19 57:5,16 functioning 26:3 27:12 66:10 86:22 132:5 funded 61:18 funny 33:17,19 further 24:19 26:11 35:10	46:5 87:21 106:13 107:8 112:4 126:19 141:15 151:19 151:20 169:2 174:16 175:6 180:6 183:6,9 furthermore 132:18 fuses 110:15 fusion 109:2,5 109:11,12,17 109:18 110:1,3 111:2	18:21,24 19:24 20:9,11,19 22:9,20 23:3 24:14,16,24 25:7,14 26:6,9 27:4,18,18 28:8,11,19 29:10,16 30:4 30:9,14,17 31:17 32:1,7 35:4,14,19 36:4,9 37:7,9 37:13,15,17 38:10,11 39:1 39:12,23 41:19 41:24 42:3,18 44:1 48:3 59:12,13,16 62:6,17 63:20 64:10,22,24 65:13 66:2,7,8 66:12,16,25 68:1,11,24 70:3,4,24 71:1 71:17,18,25 72:23,25 74:19 74:22 76:9,11 77:4,9,14,18 79:2,8 80:21 80:22,25 81:2 81:11,23 82:19 83:16 84:12,13 84:14,14 85:1 86:23 87:8,11	88:18,25 89:12 89:25 90:16,25 91:6,6,7,13,19 92:9,23 93:2,5 93:11,19 94:8 94:22 95:11 96:1,3,9,20,22 96:25 97:4,21 97:25 98:2,10 98:17,20,22 99:11,13 100:9 100:19,20,25 101:5,11,17 102:5,10,12,20 102:22 103:10 103:12 104:3,3 105:3,9 107:9 107:9,23 108:4 108:8,14 109:10 110:3 111:1,11 112:18 113:1 114:11 115:3 117:11,14,22 118:3,15,18 119:6,8,15 120:8,12,13,17 120:18,20 125:23 126:2,8 127:14,19 128:8,12,16,18 130:8 131:6,7 131:12 133:20 133:21 134:5
	g		
	g 4:1 14:11,15 15:3,8 16:10 17:21 21:14,21 82:15,18 90:1 90:2,6,12,17,25 91:19 119:23 120:2 gain 56:14 gall 97:24 gallagher 9:4,6 9:17,23 10:2,8 10:17,23 11:11 11:20,22 13:1 13:18 14:1,15 14:22 15:9 16:6,11,13,24 17:1,9,16,17 18:10,13,15,18		

[gallagher - go]

134:17,21,23 135:8,17,20 138:25 139:15 139:18 142:24 145:22 148:19 149:1,6,9,13 153:1 154:13 160:23 161:14 164:18 165:1 165:21,24 166:3,6 167:19 169:14,21 171:8,13 172:21 177:19 178:17,22 179:14,18,20	105:18,23 106:3,11,12,15 106:18,24 107:2 110:9,16 111:15,18 112:2,5,14 113:20 114:5 116:6,9,10,12 117:24 119:19 126:23 127:4,6 129:15,16 132:9,24 133:2 169:5,8 178:24	generating 62:1,7 150:18 154:16 171:4,6 generation 62:15 63:3 genius 154:23 geometric 45:11 49:1 56:22 58:2 geometries 102:25 geometry 77:11 137:15 139:2 172:15 georgia 2:7 gesturing 7:2 getting 11:24 63:23 75:11 85:15 88:1 101:2,3 106:16 107:13 114:16 118:9 144:4 160:6 168:20 172:18 give 13:5 14:20 19:11 31:19 33:24 55:6 56:18 64:13 74:10,18,21 83:3 163:18 given 13:4 20:14 84:2 87:4 136:11 160:12 181:4	182:19 gives 33:9,10 50:10 76:1 129:5 138:3 168:23 giving 69:22 81:7 138:16,17 143:13 144:16 global 1:4 4:14 76:5 182:3 go 4:10 16:18 22:4,22 23:17 25:6 30:2 32:6 37:25,25 40:6 40:12 49:24 53:7,17 56:12 58:24 59:9 60:9 67:13 69:4 73:12 79:10 80:12 81:2 87:23 88:16 90:1 92:11,21 96:14 96:15 100:15 108:23 113:17 115:19 120:6 123:23 127:16 131:3 139:25 140:12 143:17 143:20 144:25 146:18,21,22 148:11 149:18 157:14 165:16 175:19 180:7
gallagher's 12:22 13:11 21:25 31:22 36:23,25 40:10 40:25 61:13,23 62:23 64:11 69:16,24 70:16 70:21 71:3 72:6,13,16,18 73:1 80:25 81:12 93:24 94:2,17,25 95:6 96:7,17 97:8,14 99:25 101:2,22,24 102:3 103:16 103:24 104:17 104:18,23	gap 24:11 gaps 24:6,8 64:7 garrett 2:5 gearbox 88:2 110:11 general 30:20 42:9 60:6 63:13 66:23 99:19 106:22 123:25 132:24 148:2 162:11 generally 28:12 39:20 122:22 generate 61:23 155:2 generated 14:16 15:7 88:20 89:2 90:7,18 91:1 91:20		

[goal - high]

goal 40:25 44:13 goes 11:12 12:20 22:22,24 46:19 49:18 59:3 111:25 112:3 123:10 134:14 139:6 154:11 161:25 going 4:3 14:20 21:25 22:1,4 22:17,20 23:14 33:6 37:24 38:2 47:21 50:24 51:9 54:7 56:6 57:10 68:2 79:12 83:1 97:15 115:21 116:4 117:24 129:18 132:10 132:25 146:23 164:24 174:11 175:6 177:11 178:1 good 4:2 6:5,6 35:15 51:13 56:12 60:12 92:14 95:16 124:12 134:24 145:15 146:12 146:13,14 gps 76:16 110:11 178:23	179:23 grade 41:9,10 granularity 172:17 graphical 62:8 65:21 graphics 63:15 77:23 139:5 great 8:3 56:13 173:13 greater 157:19 169:4,10,17 greatly 130:3 grid 163:23 ground 9:19,21 41:6 43:23 77:16 127:19 139:14 148:18 148:25 149:8 149:12 154:11 165:16 group 68:5 groups 48:9 grungy 54:6 guaranteeing 23:14 guess 106:8 131:3 167:12 170:25 guidance 121:18 122:3 guided 122:1 guts 161:16	h	headlight's 106:19 headlights 40:18 41:15 44:22 45:1,25 46:12 48:12,22 48:24 49:3,8 49:20 50:20,25 51:3 52:16 53:24 55:18 56:15 151:12 173:16 174:12 174:22 177:13 heads 162:16 heard 4:8 109:2 hebert 130:22 height 39:15 99:5 126:10 held 41:21 help 108:13 131:7 147:24 148:10 helping 106:16 131:6 144:11 152:12,12,13 helps 138:3 152:15 henderson 2:5 hereinbefore 182:17 hereto 1:22 hierarchy 61:8 high 2:4 3:6 5:7 5:7,20 6:19
		half 38:14 39:9 halfway 129:24 153:11 hallway 108:23 109:1 halo 48:16 handful 11:6 handle 95:6 hanging 70:21 happen 16:8 happening 34:14 71:5 89:9 119:14 151:17 happens 16:5 hard 74:13 121:18 harder 58:13 58:15,18 head 7:2 73:20 146:14 heading 148:25 149:23 152:4 152:23,25 153:2,13,20 156:17 164:9 179:9,24 headlamps 46:1,2 headlight 11:1 45:2 49:16 51:6 175:2	

[high - illumination]

9:25 11:18 13:15 14:18 17:13 20:16 21:3 22:6 23:4 23:11 25:11 27:1 29:13 32:22 35:9,17 41:1 42:2 44:7 44:15 45:4 46:4 51:12,18 56:11 57:18 60:22 61:3 62:5 65:17,19 66:5 69:19 71:21 72:20 75:18 76:10 77:19 78:22 80:7 81:16 82:9,20 84:5 87:6,12 88:13 88:21 89:22 90:19 91:2,21 94:9 96:8 97:3 97:19 98:16 99:2,14,23 100:10 102:14 103:18 104:1,7 104:15,22 105:11,14 106:1 107:6,25 108:15 110:6 112:16 113:10 114:9,16,20 119:24 121:1	121:21 125:6 127:12 129:1 131:9 136:4 137:19 142:13 145:9 146:16 152:24 153:10 154:10 156:4 157:7,13 158:18,25 159:8 160:9,18 161:1 163:3,17 163:25 165:3 166:12 167:18 168:22 169:12 169:23 170:18 171:3,11 172:11 173:12 173:23 174:14 174:24 175:9 177:14,23 178:7 180:5,8 180:9,16,18 183:3 higher 18:6 21:7 22:17 28:24 29:1 52:15 115:12 120:22 132:23 150:8 highest 13:4,4 15:11,16 20:17 83:10 84:6 86:12,25 87:9 89:13,16,18	92:4 highly 17:24 21:17 120:24 126:20 highway 40:17 122:1 hill 40:11 41:11 hit 41:6 66:10 67:9 hits 77:16 horizon 54:23 horizontal 31:9 horizontally 31:23,25 38:16 57:23 hour 32:25 33:4 37:25 human 36:23 65:21 hundred 32:24 33:3 hybrid 73:24 hypothesized 109:13,15 hypothetical 25:5 i ideas 101:17,18 identical 36:22 103:11 identification 94:17,18 105:1 106:4,14	111:20,23 113:22 114:2 115:1 identified 14:25 20:1 45:12 73:18 82:7 113:3 127:5 identifies 48:19 72:2 identify 14:2 45:9 52:9 72:23 92:22 105:23 112:6 151:3 152:18 identifying 50:6 94:6 136:2 150:19 ignore 54:22 119:13 illuminate 175:4 illuminated 39:22 50:24 68:15 99:18 158:11 illuminating 40:19 95:24 162:16 illumination 11:3 22:5 25:9 51:11 56:17 106:23 122:9 148:16 159:10
---	--	--	---

[illumination - indicator]

159:11 161:25 162:3 173:14 173:16,18 174:7,17,19 175:11 illustrated 42:7 54:11 image 32:2,5 44:9 52:6 54:21,22 57:19 61:13,16,19,20 61:21,24 62:1 62:2,3,18 63:5 63:6,10,16,17 64:1,7,16,17 65:9,22 70:8 71:2 75:6,21 77:21,22 100:19 102:13 102:17,24 103:2,17 104:12 107:17 107:17,17,23 108:19 110:17 122:20 123:17 123:18 126:17 126:18 129:7 130:15,21 131:2 148:14 148:15,17 162:20,21 images 62:11 62:14,15 63:2 63:3,7,8,14	102:18,20,25 imaginary 176:8 imagine 22:1 23:13 imaging 46:25 47:1,3,4,14 61:12 73:14 93:14,19 94:24 102:9 103:23 104:4,19,25 105:17 106:4 106:13 107:3,4 111:14,19 112:1,14 113:1 113:21 164:4 imperfect 48:15 implement 69:11 89:24 92:8 127:2,4 129:22 137:24 172:21 implementati... 96:10 135:20 140:1 156:10 162:24 163:1 172:21 implemented 73:6 92:10 99:21 113:9 implied 90:10 implies 90:22 90:25 91:19	important 134:3 136:16 improve 72:5 106:4,13 111:23 114:1 115:1 127:6 improvement 172:18 incident 40:3 41:20 76:21 133:14 136:6 153:17 155:11 155:12 include 47:11 47:17 62:22 63:8 74:2 83:7 includes 10:25 24:19 26:11 30:21 46:24 47:5 68:14 81:13,20 82:11 83:8 91:25 94:3 99:17 101:5 117:8,17 118:12,22 119:3,20,25 150:21 151:5 including 5:1 40:3 44:17 83:1 100:24 145:18 incoming 95:6 incorporate 105:17 111:14	112:1 129:14 incorporated 112:13 increase 76:23 increases 108:18 114:14 130:3 increasing 55:19 63:4 141:9,10 independently 115:4,6 indicate 11:10 14:13 15:4 17:7,22 22:25 22:25 81:18 90:4,20,21 91:23 140:16 171:14 indicated 120:22 indicates 11:16 80:11 99:6 100:8 169:16 indicating 52:15 90:16 99:12 indication 50:11 65:23,24 89:10 indicator 13:10 14:16 15:1 83:20 86:8,10 89:20
---	--	--	--

[individual - k]

individual 51:15 65:8 108:7 induced 19:5 influence 131:25 informal 48:1 information 10:16 14:2 26:14 84:8 87:1 88:19,23 89:1 116:19,21 116:25 117:2 119:16 input 63:10,14 110:10,10 instance 1:19 24:9 42:21 52:14 57:21 65:5 69:22 72:3,11 94:10 97:11 104:2 106:2 107:7 109:20 124:21 137:21 145:21 152:17 163:12 164:1 instances 71:16 instantaneous 41:14 integrated 112:25 integrity 43:9 84:18	intensity 28:5,9 29:8 31:7 39:6 47:18 68:13 78:14 81:13,21 82:12 91:25 95:25 99:16 100:1,5 102:6 116:13,19,21 116:25 117:2,9 117:18 120:1 121:6,7,10 133:15 136:6 138:11,11 145:1 146:4 149:22 150:2,8 150:9,12,22 151:6,18 152:3 152:8 153:9,16 153:21 156:13 156:15,23 157:19 158:8 159:2 160:12 164:3 166:14 167:6,23 171:14,16,21 171:23,25 172:9,15 173:3 174:1 179:5,8 179:16,25 180:3 inter 1:5 182:4 interest 13:7 33:14 48:12,19 53:23,25 55:14	55:17,19,21 64:3 70:11 80:18 81:1,13 81:20 82:10,11 82:22 85:11,20 86:1,5 91:25 93:4 94:13 111:24 114:2 115:2 117:8,17 118:12,22 119:3,20,25 130:5 149:25 152:6 153:14 156:20,22 interested 4:23 183:11 interesting 148:14 151:11 161:21,22 interface 179:23 international 3:22 internet 4:6 interpretation 79:8 104:13 145:12 intersect 75:25 intersection 58:9 77:23 intervals 122:15 125:9 introduce 121:11	introduced 147:4 154:13 invention 30:24 42:6 43:7 45:9 46:6 49:22 52:2 53:19 84:16 167:14 invisible 25:3 involve 63:10 115:10,10 118:21 involves 14:7 14:11 17:21 30:21 62:15 63:2 83:18 86:3 90:2 118:19 ipr 9:19 ipr2024-01110 4:16 ipr2024-01111 1:5 5:16,18 8:13 182:4 issue 37:14 128:5 issued 45:17
			j
			jobs 171:10 june 183:15
			k
			k 2:4 173:6 183:3

[karen - leonard]

karen 1:19 4:20 182:14 183:19 keep 13:7 161:23 164:2 keeping 105:23 kilohertz 33:1 kilometers 32:25 33:3 kind 52:11,16 75:10 77:20,21 130:8,9 132:9 162:5,11 kinds 11:2,8 28:3 45:6 130:10 know 21:23 23:4 24:24 25:21 26:5,16 28:3 32:8 44:2 49:5 50:1,13 51:20 54:22 56:12 57:7,21 58:1 59:4 60:10 67:7 68:3 69:5 70:22 71:12,14 76:19 77:15,16 88:14 92:13 95:18 96:21 111:6,8 117:6 122:17 124:3 125:17 126:11 126:13 128:11 130:2,4 132:2	133:6,8 136:11 136:17 138:20 139:9,10 141:12,15 142:8 143:1 144:6,8,9 146:9 149:4 155:9,9 156:18 157:6 164:7 165:14 166:5 167:1 169:7 174:7 175:3 knowing 57:9 117:3,4 142:18 142:19 172:14 172:15 177:6,7 known 26:15 56:17 57:2 72:5 129:21 134:9 137:24 138:9,13 163:11 171:15 171:23 172:8 179:1,16 knows 76:12,13 76:15,20 123:21 131:11 153:1,3	labeled 80:21 92:25 117:14 labels 63:7 lamp 22:16,18 22:23 landing 28:2 lane 46:7,9 51:24 52:3,5,9 52:11,21,22,24 lanes 10:15 language 67:19 89:8 142:1 151:25 152:22 154:8 155:20 158:22 lapsing 173:25 larger 131:24 131:25 142:15 laser 61:14 62:24 108:24 109:21,22 121:17 122:2,4 122:12,13 123:19,25 127:2 129:23 148:3 154:16 173:6,14,15,19 173:19 176:6 lateral 15:12 77:2 81:5,7 83:2 121:17 122:1,3 lawyer 165:12	lays 12:5 46:13 leading 53:24 178:21 leaping 75:7 leave 18:6 leaves 74:12 left 65:20 76:19 76:20 133:8 legal 4:19,21 170:19 181:6 183:20 lens 47:5 56:24 58:2 80:9,10 leonard 147:6 147:11,12,17 147:18,25 148:20 149:1,6 149:9,16 150:6 151:20 152:1 152:11,12,13 152:15,17,20 153:3 154:3,8 154:15 155:17 155:22,25 156:9,14 157:5 157:11,15,15 157:21 158:19 159:9,12,14,16 160:6,20,23,24 161:2,7,11,13 161:16 164:18 164:25 165:21 165:23 166:9 166:23 167:11
	I		
	I 1:19 2:4 182:14 183:19 lab 34:25		

[leonard - light]

167:15 168:2,4	172:17	29:20,21,22	117:3,9,18
168:7,8,23	levels 14:12	30:2,21,23,25	120:1 121:6,10
169:16,21	15:4 17:5,7,22	35:21,23 36:2	126:3 127:4
171:5,7 173:6	18:11,12,14,23	36:5,11 37:5	129:15,15,17
173:10 174:3,5	18:25 19:25	37:11 38:21	131:20 133:14
174:10,15	20:3,12,14,15	39:5,5,11,15,19	133:15 134:18
175:5,12,13	20:20 21:11	41:10 42:22	136:6,6,15,16
178:17,25	22:10,25 23:22	46:16,22,25	138:11,11
179:3,18,20	25:19 31:7	47:6,7,11,17,25	140:25 141:2
leonard's	81:18 82:3,4	48:8,11,16	144:3 145:1
150:21 154:23	84:2,3 86:14	49:10,13 51:10	149:22,25
168:19 169:9	87:4,5 88:6,8,9	53:22 54:11	150:1,1,2,4,12
lesson 139:5	89:4,7 90:4	55:14,16 58:19	150:13,14
level 11:25 12:4	104:11 109:8	58:20,22,22	151:18 152:3,6
13:4,5 14:8	118:20,21	66:17,19 68:12	152:7,7,8,10,16
16:21,25 17:4	121:8,9 171:14	68:13,15,23,25	153:7,8,9,14,15
18:17,19 20:23	lidar 122:5,7	69:1,2,12,24	153:16,17,18
20:24 21:1,8	122:11 126:19	73:14,17 77:3	153:18,19,19
21:20 22:15,17	126:23 128:25	78:14 80:17	153:20,21
23:23,25 24:3	129:5,11	81:13,20 82:12	154:16,20,24
24:17,18,22,23	130:13 131:9	83:24 84:1,6	154:24,25
25:1,9 32:11	136:12 138:20	85:16,17 86:11	155:5,7,8,11,12
34:2 41:21	138:21 139:10	86:24 91:25	156:13,15,23
47:19 61:7	140:1,6 163:12	95:23,23,24,25	156:23,24
77:7 89:6,17	173:6,10,13	96:20,21,23,23	157:17,22,23
89:18 91:23	177:13,16,18	99:6,15,16,18	158:6,7 159:1
104:12,13	177:19	99:20,25 100:1	159:2,2,4,23,24
105:5,6,7,10	lidars 123:6	100:5,24,24,24	160:3,7,7,12,14
109:13,14,16	light 10:13,25	101:3,8,15	160:19,21
109:17,19	11:4 13:2,3	102:5,6 103:16	161:2,5,8
110:2 121:3	17:3,3 18:2	103:24 104:18	162:1,6,9,15,16
132:23 141:22	20:17 22:8,10	106:3,12,15,18	162:17,22,24
145:23,25	22:15 25:22	106:19 107:2	163:23 166:14
167:24 169:16	28:2,6,24 29:8	110:11 116:9	166:14,15,16

[light - look]

167:4,5,6,7,8 167:21,22,22 168:9,15,16,17 168:18 169:5 169:25 170:1 171:5,6,13,17 171:18,21,23 171:25 172:8,9 172:15 173:3,3 173:5 174:1,1 174:10,12 175:15,16 177:12 178:23 179:8,11,12,15 179:22,24,25 180:2 lighting 51:2,5 lights 41:7 44:18 48:25 52:15 55:21 106:24 limitation 67:18,18,23 68:12,24 80:14 81:10 82:6 85:3 92:16,16 93:1,10 94:20 95:10 96:6,17 99:9,11 100:13 100:14 102:2 103:10 117:5 117:10 119:4 120:6,7	limitations 82:8,19 91:12 91:14 92:22 95:21 96:4,13 128:14 145:18 165:10,20 178:10,12,18 limited 59:24 97:10 98:4 line 16:14,15 31:25 46:6 49:5 50:9 51:22,25 52:1 53:19 54:8 55:11,12,14 58:7 61:13 65:6,8 66:3 77:23 114:19 172:22 176:9 177:2 linear 96:23 97:9 138:24 lines 10:19 59:21 65:2 66:8 84:11 119:11 lining 162:16 list 95:16 lists 32:23 lit 51:3 little 22:22,24 27:17 33:17 36:24 59:1 60:9 61:5	62:21,25 154:7 154:7 155:3 169:7 llp 2:5 localization 129:6 localizing 107:17 located 6:13,15 39:8 70:12 124:14 125:4 131:14 136:14 150:24 151:8 154:19 location 18:8,9 23:20 26:12 37:4 53:23 69:12 70:1,5 70:22,23 71:1 75:1,3,4,16,21 76:1,3,4 77:5 78:6,7,10,15,16 78:18,24,25 79:2,3,4,7 87:25 106:21 108:9,9 109:25 125:2 126:13 129:5 131:12 136:9,20 138:4 139:11 142:4 142:12,16,20 142:21 144:15 144:18,19,22 145:2 148:15	149:21,23,24 150:11 152:2,4 152:5,23,25 153:1,3,13 156:8,17,20,21 158:1 163:5,7 164:3,9 166:7 167:2,16,20 179:2 180:2 locations 26:13 81:24 157:16 172:13 174:4 180:1 logical 15:15 long 51:19 106:8 124:1 141:6 152:11 153:22,22,24 155:23 longer 45:18 146:20 look 8:20 11:22 13:18 16:1 19:1 23:16,17 24:9 33:19 36:12 37:18 41:25 43:3,12 43:17 50:15,16 50:17 53:3 59:9,12 62:6 71:11,15 78:1 81:2 83:5 87:17 94:24 96:14 103:5
---	--	--	--

[look - markers]

112:18,19 119:5 123:1 128:3 131:3 139:25 140:12 143:17 144:1 145:14 146:8 147:8 149:18 157:14 168:7,8 175:6,7,7 178:14 looked 175:5 looking 15:22 15:23,25 24:7 24:16 29:2 32:23 35:25 36:1 37:5,6 38:13 39:19,21 41:4 42:16,16 43:15,15,23 44:17,18,18,21 47:21,21,22,22 49:2 50:14,14 51:2 52:6,17 52:21 57:13 58:4 59:18 71:9 74:4 80:2 80:9,10 83:11 83:12 89:16 91:9 106:5,21 108:25 118:24 120:20 122:2 124:4 125:20 131:22 132:5 150:8,9 151:18	151:19 162:2 162:21 164:11 164:13,14 168:24 169:6 172:24,25 lost 36:19 lot 44:1 71:7 106:16 123:11 151:24 161:22 169:10 lots 28:2 60:23 60:24 110:23 115:17 117:22 143:21 low 20:16 84:4 87:5 110:1 148:3 lower 55:24 58:12,18 61:7 115:12 150:9 luminance 48:20 luminous 146:4 lumped 68:20 lunch 78:3 lux 145:24	main 128:22 maintain 83:22 130:1 make 40:18 112:23 155:17 163:17 168:16 175:13 makes 71:6 158:14 174:6 making 126:8 154:24,25 manual 143:17 map 57:23,24 mapped 91:14 153:2 178:10 mapping 54:10 155:19 marked 3:9 121:14 147:5 marker 11:16 12:23 13:12 14:13,24 15:5 17:5,7,12,19,22 17:25 18:12,13 18:20,24 19:25 20:3,9,11,20,25 21:2,11,18,20 22:21 23:1,5 23:11,13,20,22 23:24 24:15,20 24:21,25 25:2 25:8,16,17 26:3,6,13,16,19 26:20,21,24	27:15 35:15 36:5 52:12 65:25 66:3 69:3 70:1,5,6 75:2,17 78:15 78:25 79:3 81:15,19,22 82:3,5,23 88:9 89:7 90:4 91:24 92:2,7 108:13 118:20 132:5,7,13 136:9,20 138:5 141:23 142:3,4 142:16,17,17 142:18 144:18 144:19,22 145:3,10,23,25 146:4,14 149:22 152:2 156:8 158:6,9 167:17,20 169:16 171:15 171:21 172:1 179:23 180:2 markers 10:14 10:18,20 11:21 13:20 14:3 17:23 18:22 20:16 21:7,16 22:2,14 23:11 23:12,15 24:10 24:12,13,15 26:8,12,15
	m		
	m 2:1 6:3 178:6 madam 180:14 made 47:12 73:15 145:20 magnitude 123:18		

[markers - mentions]

29:11,17 30:18 35:20,23 37:1 37:10,16 42:1 42:13,20 43:4 43:9,12 46:7 51:24 52:3,5 52:10,21,22,24 59:19,22,25 60:6 65:1,4 67:6 69:14 81:8 83:8,17 84:4 87:6 94:18 98:5 108:14 112:7 118:25 119:8 120:5 121:4 131:6,8 151:4 152:19 154:22 156:11,12 158:2 161:4 167:3 168:10 168:11 179:2 marking 10:24 11:10 12:3 16:20 20:15 65:14 83:9 84:3 89:5 markings 10:9 10:14,18 11:25 43:9,10,18 59:19 60:2 65:1 82:1 84:19 98:8 119:10 166:7	martial 130:22 masking 54:12 massachusetts 1:18 match 106:23 matching 152:1 math 33:6 49:15 130:4 131:15 133:7 matter 4:13 144:7 167:10 maximum 140:7 mean 22:8 55:4 57:1 83:12 110:16 114:22 121:22 124:21 128:7 137:2,3 143:19 144:18 145:17 163:22 meaning 34:18 34:21 75:16 137:12 means 13:10 15:1 17:11 24:20 29:23 30:23 34:23 35:4 40:6 42:24 56:2 76:3,4 83:20 86:8 89:20 113:13 122:18 150:15 153:5 157:17 161:3	162:6 165:9 meant 48:6 measure 60:2 98:7 100:5 116:24 119:9 122:11 123:25 124:1 126:6,12 measured 121:4 163:12 measurement 19:9 28:9 126:20 127:8 133:15 135:4 136:6 138:12 172:6 measurements 19:10 76:24 83:24 122:21 129:25 137:25 measures 28:5 68:13 95:25 99:15 100:1 102:5 104:24 111:19 113:21 116:12 174:5 measuring 10:7 10:12 98:19 104:9,24 105:18 111:15 112:15 113:20 114:6 116:7 126:24 153:3 156:23 164:2	measurment 111:18 112:5 mechanism 66:1 media 4:11 181:5 meet 24:17,22 24:25 meets 12:3 16:20 mellon 130:20 130:23 memory 64:16 64:19 mention 30:4 60:13 72:9 89:12 90:6,9 93:7 128:16,21 134:1 135:3,10 139:19 mentioned 25:18 48:2 64:9 91:16 130:12 164:23 mentioning 30:9 mentions 12:12 14:6 21:11,15 27:18 28:11,25 29:1 30:14 32:10 38:12 39:23 40:2 50:3 62:7 140:5
--	--	--	--

[merely - navigation]

merely 72:4 meter 38:14,25 39:9,9 158:4,5 meters 26:17 26:18 33:6,7,9 33:9 37:18,21 38:14,15 39:1 39:7 158:3,3,3 158:4 168:24 168:25,25 169:7 method 10:7 13:22 42:3 43:8 171:4,6,7 171:8,8 methods 147:19 170:2 michael 2:11 5:5 183:4 middle 127:18 164:1 millicandela 145:24 millimeters 33:10,12 mind 170:25 minimum 23:25 24:3,16 24:18 121:2 141:22 145:25 146:3 minute 177:23 minutes 33:4	mirror 122:18 123:12 mirrors 123:12 123:13 177:6 mischaracteri... 129:1 missing 26:12 27:15 157:12 misspoke 103:20 mobileye 1:4 4:13 182:3 mode 123:24 173:25 modern 123:6 modifying 110:4,7 149:15 modulate 123:1 modulated 123:2 127:3 129:15 modulation 177:8 module 46:25 47:3,4 68:25 76:22 93:14,19 94:24 95:7 99:4,25 102:9 103:17,24 104:18,19,25 105:17 107:2,3 107:4 110:13 111:14,20 112:2,14 113:1	113:22 134:18 molding 108:25 morning 4:2 6:5,6 mos 74:2 motion 16:17 107:18 motivated 93:23 103:15 103:23 111:25 127:2 128:24 129:2 170:10 171:22 179:17 motivation 133:19,25 135:7 140:19 142:11 144:23 mounted 39:14 99:4 125:1,8 161:3 176:18 mounting 38:23 move 55:20 117:5 121:11 122:18 moves 19:19 33:12 69:23 moving 10:13 33:3,5,7 34:23 37:21 132:12 132:25 133:4 179:3 msaunders 2:14	multiple 11:4 15:20,25 16:1 16:3 18:21 19:10 34:12 47:23 56:22 64:1 65:18 66:12,17 67:9 69:20,21 71:4 82:24 83:1 85:17,17 92:7 100:4 101:25 107:21 108:16 109:6 111:4 134:6 151:4 152:18 156:25 175:24 180:1 multiplying 12:1 19:13
			n
			n 2:1 3:1 4:1 6:3,3 178:6,6 name 4:18 6:7 115:14 130:13 named 1:17 nanosecond 122:14,15,16 nanoseconds 122:12,17,19 123:9 narrower 31:1 navigation 130:19

[navlab - objection]

navlab 130:20 near 56:4,6 124:15 147:22 148:9 150:13 150:14 151:15 154:25 155:7,8 175:14 necessarily 101:19 131:24 162:14 necessary 133:16 165:4 need 7:10,11 31:6 57:21 58:1 73:10 74:8,16 87:17 133:22 146:8,9 146:21 148:5 158:21 165:10 171:1 174:18 180:9,12,19,21 needed 11:8 138:7 needs 7:1 15:17 32:19 33:13 57:7 159:10,11 161:17 163:6 174:10 negative 23:23 neither 183:6 net 74:3 never 175:1 night 50:23	nodding 7:2 noise 19:4,6,9 33:20 non 17:5 18:12 18:13,24 19:25 20:3,9,11,15,20 20:25 21:11,20 54:10,15 82:3 83:9 84:3 88:9 89:4,7 118:20 155:5 nonreflective 93:5 nonresponsive 97:15 normal 141:3 174:12 note 4:4 73:5 notice 5:17 noticing 5:4 notion 13:6 64:20,21 number 8:23 12:19,20,23 14:22 17:10,11 17:18,20 23:2 23:4 24:10 26:18 28:9,24 29:1 31:3 38:16 57:22,24 58:13,18 63:23 64:11 74:10,18 74:21 80:1 150:23 151:7	154:19 181:4 numbered 8:10 numbers 13:1 74:23 85:21 116:17 118:13 nuts 170:13 nw 2:6	137:7 140:3,9 143:9 147:19 149:24 150:11 150:13 151:15 151:16 152:5 153:14 155:6 156:20,22 158:1 163:11 163:18 164:10 169:1 176:11 objection 9:25 11:18 13:15 14:18 17:13 21:3 22:6 25:11 27:1 29:13 35:17 42:2 44:7,15 45:4 46:4 51:12 56:11 57:18 60:22 61:3 62:5 65:17,19 66:5 69:19 71:21 72:20 75:18 76:10 77:19 78:22 80:7 81:16 82:9,20 87:12 88:13,21 88:22 89:22 90:19 91:2,21 94:9 96:8 97:3 98:16 99:2,14 99:23 100:10 102:14 103:18
		o	
		o 2:1 4:1 6:3 178:6 oath 6:23 object 33:14 57:25 58:14,15 60:14,17,20,23 61:2,8,21 62:19,22 64:15 65:12 70:11,25 76:14 81:12,20 82:11,22 85:20 86:1,4 91:24 97:15 107:8,12 108:5,17 109:13,14,15 109:17 110:3 111:2 117:8,17 118:11,22 119:3,20,25 122:17 123:5 124:8,11 126:15 129:4 130:3,4 131:11 131:12,14,24 133:1 134:4	

[objection - okay]

104:1,7,15,22 105:11 106:1 107:6,25 108:15 110:6 112:16 113:10 114:9 119:24 121:1,21 125:6 127:12 129:1 136:4 137:19 142:13 152:24 153:10 154:10 156:4 157:7,13 158:18,25 159:8 160:9,18 161:1 163:3,18 163:25 165:3 166:12 167:18 168:22 169:12 169:23 170:18 171:3,11 172:11 173:12 173:23 174:14 174:24 175:9 177:14 178:21 objections 4:24 objects 41:17 48:19,24 58:3 64:2,23 66:13 79:23 80:18 81:1,4 82:10 83:11,13 85:11 94:12 105:1 108:2 111:21 111:23 113:23	114:2 115:1 124:13 133:6 141:4,13,16 147:22 148:2 148:15 150:9 150:24 151:7 152:14,15 154:19 157:17 157:19 161:11 168:20,24 169:4 175:13 175:14 observation 127:7 130:6 131:16,20 132:14 133:1 133:11,12 134:5,8,9,12,19 135:11,15,17 138:10 141:1,9 141:23 142:2,9 142:21 143:2 143:23 144:10 146:1,5 161:23 162:3 observations 108:16 observe 126:10 observed 48:14 48:14 observer 94:24 obtain 83:23 134:19 173:10	obtained 14:12 17:6 81:17 90:3 91:22 obtaining 17:2 obvious 29:6 43:21,24 69:11 70:10 77:12 79:1 93:18 100:25 102:4 105:4,16 111:13 112:23 127:20 129:11 129:14 149:2 164:25 178:18 179:10 obviously 151:24 occasionally 13:20 occupy 55:19 occur 16:11 48:22 occurred 85:12 85:20 occurring 27:4 46:9 120:16 occurs 119:21 120:2 octagons 45:12 odd 132:5 odometry 76:16 88:3 offer 103:22	offered 129:10 offers 35:6 office 1:1 4:15 182:1 offices 6:16 officials 40:17 offset 15:13 offsets 19:22 oh 32:25 63:22 127:24 130:17 136:12 okay 5:21 8:3 9:11,17 19:23 20:6 22:20 23:2,3,8 26:4 27:24 38:2,5 39:23 40:8 46:24 59:11,15 60:8 67:15 69:9 75:14 78:6 79:12,15 80:12 81:2 84:24 91:11 93:16 112:10 114:20 115:21 117:23 118:9 118:17 119:17 121:19 125:20 127:17 128:2,6 135:10 140:18 144:5 146:23 147:25 149:8 149:10,15 154:6 156:8
--	---	---	--

[okay - pair]

165:13 170:15 178:1,8 180:7 180:10,20,25 181:1 old 64:21 109:1 once 131:10 134:12 138:19 151:4 152:19 164:7 177:10 oncoming 48:12 49:2,9 53:24 ones 15:11 16:3 24:8 82:4 89:17 127:24 128:1 ooo 181:9 open 74:12 opens 120:3 operably 80:16 operate 85:8 operating 132:7 operator 13:6 13:10 16:5,11 62:9 83:21,21 84:7 86:9,11 87:1 89:21 opine 102:16 opined 95:9 119:22 171:9 opining 101:2,8 117:15 119:2 158:16 163:15	opinion 75:15 90:24 91:9,18 103:22 119:18 128:23 129:10 165:15 166:5 166:22 opinions 81:9 91:14 97:17,20 103:5 133:25 163:4 165:14 opposed 25:8 35:15 37:10 63:15 135:16 167:15 optical 47:5 optics 147:20 151:23 order 33:13 41:6 46:7 47:15 58:3 89:18 156:21 172:5 175:15 orders 180:15 ordinarily 50:23 ordinary 29:6 43:21 74:12 77:12 100:3 105:4 107:15 112:17,22 organization 45:11 orient 75:9	orientation 150:23 151:7 154:19 oriented 75:12 outcome 4:23 183:12 output 11:11 11:13,16 12:12 14:23 15:11,16 15:17 17:17 23:3 31:2,5,8 46:18 65:13,20 65:22 85:15 110:18,21 118:10 outputs 22:3,10 65:18 127:3 overall 45:21 overhead 51:1 overwhelm 151:15 174:19 own 50:24 51:4 51:10 129:3,8 owner 1:8,19 2:10 4:13 5:6 74:25 78:23 182:7	181:3,8 page 3:2,10 13:19 19:2,15 23:16 47:4 59:3 67:14,24 68:2,8,9 80:15 81:11 92:13 95:18 99:3 100:16 114:22 116:5 119:5 120:19 124:7 127:16,19 128:3,15 129:13 138:6 139:23 143:25 145:6 147:10 147:16,17 148:19,21,22 148:23,24,25 149:3,5,5,8 151:1 154:11 154:15 155:4 162:21 168:8 178:15 pages 10:21 paint 22:2 painted 10:19 13:21,23 59:21 65:2 66:3,8 83:14,17 84:11 119:11 pair 48:25 52:15 123:13
		p	
		p 2:1,1 4:1 p.m. 1:16 79:13 79:16 115:22 115:25 146:24 147:2 178:2,5	

[pairs - pass]

pairs 48:22 71:13 paper 9:13,14 40:20 147:8 papers 7:22 60:23,24 paragraph 12:11,25 13:5 13:9 14:1,6,10 14:15,17,25 15:8 16:10,18 16:19 19:2,3 20:13 21:6,10 21:14,15 23:7 23:19 24:19 26:10 27:13,20 27:21,22 28:11 28:15,23 29:19 30:20,22 32:6 32:25 33:16,16 34:5 35:22 37:19 38:13,13 39:11,24 40:1 41:19 42:21 43:6 45:5 46:5 49:18 50:4 59:2,3,5,7,16 59:17 60:10,12 62:7 67:14,15 67:24 68:19 69:4,5 72:1,3,7 72:12 73:4 74:24 75:9,13 77:1,6,7,25	78:1,2,12,19 79:20 80:15 81:3,5,10 82:7 82:8,16,16,18 83:5,18 84:14 85:4,14,19,22 85:25 86:3,7 86:23 89:3,5 90:1 91:16 92:3,12,14 93:9,9,15,17 94:10,16,23 95:2,17,20 96:2 97:4 98:13,21 99:20 99:24 100:15 100:22 102:2,4 102:7 103:6 104:2,8,16,23 106:7 112:9 114:22 116:5 117:6,7 118:1 118:3,15,18,24 119:15,23 120:7,11,13,16 121:2 124:6,16 125:17 127:1 128:17 129:19 129:24 134:4 134:16,22 135:3,6 137:21 137:23 139:12 139:19 141:20 141:21 145:21	150:20 151:2 153:11 154:3 155:21 164:2 164:20,21 171:12 178:15 178:16 paragraphs 11:23 12:6 15:12 16:4 19:1 20:1,2 28:21 82:25 93:1 117:19 137:18 164:16 164:24 178:20 parallel 89:8 104:4 113:15 parameters 132:23 part 13:11 49:21 53:25 54:18,18 59:3 73:18 90:6 92:15 98:22 113:17 128:13 133:7 135:7 136:8,18,19 138:3 139:14 140:19,22 142:3,11 158:16,22 174:3 partes 1:5 182:4	participants 4:7 particular 10:3 10:4 12:9 17:18 19:20 25:14 38:19 39:16 44:13,20 45:10 46:12 47:17,18 48:7 52:7 53:21 57:11,12 60:5 67:1 70:11 74:18,21 79:20 83:15 84:18 93:13 98:9 108:8 113:3 140:1 170:8 171:25 particularly 43:7 59:2,22 65:3 68:21 80:3,13 parties 4:10 182:23 183:8 parts 24:7 54:22 84:13 91:13 117:22 155:19,22 partway 119:6 party 4:22 183:1 pass 107:24 177:21 180:5
--	--	---	---

[passed - physical]

passed 26:23 27:6 passes 108:5 134:25 164:5 179:6 passing 107:13 past 19:19 patch 22:18 patent 1:1,2,6,8 1:19 2:10 3:11 3:14,16,17,20 4:13,15 5:6 8:5 8:6,7,13,14,18 8:22,23 9:3 10:6 11:22 21:24 30:6,10 30:13,16 45:17 67:19 74:25 78:23 164:15 167:14 168:7,8 182:1,2,5,7 patents 7:24 path 22:1 pattern 26:16 48:5,13,17,18 52:16,19 57:5 57:15 72:13,21 72:22 94:11,13 104:17 106:11 111:17,22 112:20 113:25 114:6,23,25 115:9,14 174:7 174:11 175:2	175:11 patterns 26:13 47:23 52:13 53:2 64:5 174:4 paved 135:5 pavement 10:20 13:20 22:13 36:21,22 41:25 42:13,20 43:4,12,18 59:22,24 60:6 65:4 66:3 84:11 98:4 119:8 120:5 peak 15:15 16:16 17:23 18:7 21:16 27:5,8,10 36:16,17 37:2 37:4 67:1,4,5 69:18 87:16 120:21,21 164:3 peaks 18:9 35:10,11 37:10 37:11 69:21 pedagogical 169:1 pencil 40:21 perfectly 133:4 perform 118:11 performed 88:12 112:2	performing 104:16 performs 85:23 period 45:16 periphery 54:13 55:25 permit 157:17 perpendicular 141:5,6,13 176:18 177:2 person 29:6 43:21 74:12 77:12 100:3 105:4 107:15 112:17,22 personal 129:9 perspective 138:17,18 176:13 petitioner 1:5 2:3 5:8 182:4 ph.d. 1:11 3:4 3:13 4:12 6:1 181:4 182:11 182:16 photo 126:5 photodetectors 15:10 16:2 106:20 123:7,9 photodiode 12:19 27:24 28:5,21 31:12 31:14 38:17 39:3 61:23	70:6 72:18 96:7,10,12,18 97:25 126:5 128:17 161:14 photodiodes 22:3,22 27:18 27:23 28:3 29:9,12,17 30:3 31:15,18 31:22,23 33:22 35:16 62:4 64:11 70:17 73:7,11 74:2,6 74:7,18 97:2,9 97:14 98:10,12 99:4,13 100:9 100:12 116:16 172:10,12,18 172:22 photon 47:6 photosensing 73:7,21,23 74:1 photosensitive 128:19 photosensor 47:12 phrase 78:10 89:4 99:6 109:2 137:12 156:5,6 physical 7:22 170:6
---	---	---	---

[physically - possible]

physically 6:13 6:15 physics 172:4 pick 41:16 picked 36:2 picking 13:23 18:22,23 70:6 picture 31:19 53:11,12 55:9 80:8 139:22 pictures 40:21 piece 27:25 40:20 ping 123:25 pixel 48:7,9 49:16 51:15,20 54:15 57:1 58:10 63:23 64:17 75:25 109:25 pixels 31:10 47:11 48:9 54:20 57:22,24 58:13,18 62:4 63:23,25 64:9 64:10 place 4:9 30:14 39:19 54:20 67:22 72:9 125:15 131:2 places 24:5 43:6 89:8 plane 77:24	platform 8:4 37:18 39:7 play 144:14 150:16 playing 143:13 147:20 150:11 plays 168:17 please 4:4,24 5:12 59:13 147:7 pleased 30:11 pllc 2:11 plural 157:17 157:24 plurality 29:4 29:19 42:22,24 47:8,15 68:13 73:15 99:15 100:1,5 150:3 152:9 159:3,7 159:22 160:3,5 166:16 167:7 173:4 174:2 175:16 179:11 point 15:2 36:22 49:10,13 51:10 52:7,14 53:20 72:1 75:25 78:2 85:21 95:16 97:24 98:2,14 98:25 106:22 113:7 114:17 131:10 134:25	137:17 138:21 139:6 142:7 146:17 165:5 166:2 pointed 16:19 33:16 35:16 51:23 56:3,5 106:20 107:4 157:25 pointing 56:24 76:13,20 96:2 98:22 106:19 140:3 172:12 177:6 points 50:22 131:9 134:6 158:10 poorly 132:6,6 pop 56:13 popovich 147:7 148:11,12,13 148:20 149:1,7 149:9,17 150:10 153:4 153:25 154:1,9 155:3,4,17,22 155:25 156:10 156:14 157:5 160:20,23 161:18,20,21 161:24 162:22 163:1,5,20 164:12,18 165:1,21,23	166:9,24 167:10,15 168:2 169:21 171:4,7,19 178:17 179:1,4 179:14,18,20 popovich's 164:13 portion 67:16 68:15 92:5 99:17 portions 54:12 54:13 posita 69:10 99:24 105:16 111:13,17 112:13 113:19 127:1 129:13 138:7 153:12 164:8 171:22 179:9 position 77:2 83:19,22 136:7 155:2 162:8,9 179:22 positioning 81:6 possibilities 46:14 98:23 possibility 99:7 possible 90:13 90:15 122:23 172:6,7
---	--	---	--

[posts - programmed]

posts 10:19 59:20 65:2 125:2 potential 40:11 107:8 114:11 114:12,13 potentially 74:1 powered 148:3 powerful 112:3 practically 146:9 practice 161:19 precise 37:3 138:2 precisely 41:14 99:4 precision 132:23 135:2 135:15 136:12 predetermined 12:2,3 16:21 16:25 17:20 19:14,15 24:23 25:1,18 150:3 152:9 159:3,7 159:12,16,22 160:4,5 166:17 167:7,24 173:4 174:2 175:16 179:12 predominantly 49:16 52:7	preferably 26:10 41:3 161:3 preferred 42:6 42:8,11,12,15 43:14 59:23 76:17 84:15 85:2 96:10 97:8 98:3 presence 25:23 46:22 present 2:16 5:1 10:9 11:17 12:24 13:13 14:24 17:12 24:25 26:20,22 46:6 52:2 53:19 65:14 84:16 pretty 30:1 43:24 108:19 108:20 114:16 146:16 previous 20:4 previously 3:9 121:14 147:5 174:9 primary 44:24 45:22,23 principle 42:10 123:25 principles 170:6	prior 67:18 78:11,20 92:17 92:19 130:11 131:4 168:3 probabilities 115:17 probability 52:15 probably 108:22 136:12 139:3 problem 38:20 148:4 151:14 161:24 proceed 5:13 proceeding 4:24 183:9 process 13:22 17:21 24:19 26:10 32:9 63:5 64:18 71:2 77:22 83:7,18 84:15 85:8 87:15 90:2,9,10,11,11 90:12 119:7,9 135:2 142:22 162:20 processed 11:13 15:8 processing 15:21 29:23 30:23 44:9 47:20 49:22	50:12 52:19,20 54:7 61:6,6,11 61:12 64:1,2,3 64:4,8,20 65:7 65:8 70:18 71:3,3,8,11,24 72:17,19 80:16 94:3 101:22,24 103:1,2 104:3 105:20 108:19 110:18,21 112:2 122:24 131:13 138:8 148:14,15,17 149:20 156:7 164:4 178:22 produce 48:15 63:16 64:1 102:24 174:15 produces 28:1 61:15 producing 32:1 62:12 63:6,7,8 115:4 professor 123:23 145:15 173:25 profile 155:15 171:24 172:9 179:5 program 84:5 86:24 programmed 11:24
--	--	---	---

[progressively - range]

progressively 168:15 project 109:24 131:2 174:3 projected 39:7 projecting 139:6 projection 163:10,11 projective 139:2 proper 83:22 properly 39:15 62:10 66:9 99:5 132:4 proportional 28:1 38:23 162:18 proposed 74:19 101:7 109:9 114:7 140:22 143:14 145:17 159:21 160:22 161:19 163:22 169:20 170:7 173:9,22 proposing 100:18 101:14 110:25 113:4,8 114:5 125:22 173:22 provide 7:14,15 46:8,15 84:7 87:1 93:17	112:12 164:17 174:11 provided 26:14 29:20 73:15 87:7 128:12 135:16,17 143:6 174:21 provides 86:10 providing 13:10 15:1 29:23 54:15 83:20 86:8 135:11 166:25 provisions 1:22 publication 3:14,22 8:7 pulse 122:12,13 122:16 123:8 127:3 129:15 pulsed 129:17 pulses 138:13 pulsing 123:13 purchase 180:17 purely 168:23 173:14 purpose 9:23 44:5,24 45:22 45:24 121:19 121:22 147:12 148:12 169:19 purposes 42:5 46:10	pursuant 1:21 push 16:15 18:1 32:3 43:22 61:13,25 63:25 97:13 102:23 132:11 put 115:11 123:7 143:19 puts 151:12 157:22 putting 70:13 168:15	101:12,13 108:3 116:4 136:25 170:25 questions 7:1,5 9:12 14:21 58:25 91:16 114:18 116:3 145:13,16 175:19 178:8 quick 8:19 79:25 175:18 quickly 53:1 141:8 quite 30:24 33:19
		q	
		qualifications 130:18 qualifying 48:23 quality 4:5,6 23:11 64:3 65:6 144:11 quantitative 80:11 question 10:1 12:16 13:17,25 19:24 20:4 21:5,9 22:7 25:12 31:21 35:18 36:18 43:20 51:13 56:18 59:6 62:25 63:19 75:8 79:21 82:14 97:22	
			r
			r 2:1,1 4:1 radar 61:15 121:17 122:3,4 173:6 176:6 raised 10:20 13:20 59:22,24 60:6 65:3 84:11 98:4 119:7 120:5 135:5 random 175:18 range 51:19 74:13 79:23 83:3 98:23 122:20 123:17 124:3 126:20 127:8 130:15

[range - refer]

130:21,25 131:2 132:2,25 138:19 142:18 155:9 168:10 169:4 rangefinder 108:24 129:24 173:20 rangefinders 61:14 109:21 ranges 123:15 169:17 rapidly 134:12 rate 32:23,24 rather 7:1 63:7 107:3 135:21 ratio 57:22 rationale 179:19 rationales 164:17 raw 109:19 116:15 ray 75:24 164:4 164:7 179:5 rdr 1:20 182:15 183:19 read 5:16 30:10 30:16 55:7 87:3 112:9 144:17 153:24 161:2 162:18 165:14	reading 19:8 20:17,18 30:6 30:13 47:3 83:10 84:6,7 86:12,12,25,25 87:9 89:13 134:22 ready 181:1 real 51:17 57:20 62:9 really 49:19 50:21 118:7 130:2,2,4 141:11,12 146:7 148:5,13 161:16 realm 61:20 62:19 rear 23:23 24:10 reask 88:24 reason 7:13,15 41:14 90:11 115:16 reasonable 179:21 reasons 93:17 165:18 recall 30:8,14 30:17 119:5 131:18 178:9 received 15:10 28:6 84:1 123:10 138:13	171:15,25 receiver 126:4 receives 47:2 receiving 154:21 161:2,4 recently 91:11 receptive 38:18 receptivity 39:2 receptors 38:17 recess 38:4 79:14 115:23 146:25 178:3 recited 119:4 156:3 158:16 166:17 recites 16:19 142:1 160:2,13 recog 61:21 recognition 48:5,17,18 52:16,19 57:5 57:15 60:14,17 60:21,24 61:2 61:9,22 62:20 62:22 64:15 65:12 72:13,21 72:22 94:12,13 104:17 106:11 110:14 111:17 111:22 112:21 113:25 114:7 114:23,25 115:9,15 124:8	124:11 recognize 161:9 recognized 60:18 166:23 recognizing 26:12 64:23 recollection 30:13 record 1:22 4:3 4:10 5:3 6:8 7:19,21 37:25 38:3,6 79:10 79:13,16 115:19,22,25 146:22,24 147:2 178:2,5 180:8,15 181:2 182:19 183:10 recorded 4:8 4:11 recording 4:5,9 109:23 123:10 168:10 red 45:12 48:11 48:16 50:14,15 50:16,17 56:15 57:8 67:5 146:4 redirect 178:8 refer 8:22 9:14 35:2 75:20 82:24 96:19
--	--	---	---

[reference - regions]

reference 9:5,6 9:8,10,18,24 10:2 28:15,17 38:10,11 44:2 44:6,8,25 45:24 53:21 55:6 63:20 67:23 80:22 92:24 116:6 121:4,15,20 130:7,18 136:7 139:16 143:25 147:6,7,11,13 148:12 160:17 175:20 referenced 7:25 references 9:18 147:9 152:22 153:6 159:6,14 166:19,25 170:11,23 referred 88:10 122:5 168:4 referring 8:23 72:15,16 73:12 78:11,13,19 84:9 100:23 106:6,10 116:9 116:11 138:14 139:17 176:5 refers 47:24 58:9 72:22 75:2 78:25 79:6 125:7	179:17 refine 131:15 reflectance 11:25 12:4 13:4,5 14:8,12 15:4 16:21,25 17:4,5,6,22 18:11,12,14,16 18:19,25 19:25 20:3,5,10,12,14 20:15,18,20,23 20:24 21:1,7 21:11,20 22:25 23:22,23,25 24:3,17,18,23 25:1,19 32:11 34:2 35:15 77:7 82:2,3 83:10 84:1,3,7 86:12,13,25 87:4,5,9 88:8,9 89:4,6,7,13,17 89:18 90:4 91:23 118:19 118:21 121:3,8 121:9 124:3 131:9,18 132:1 132:3 141:22 142:17 144:24 145:23,25 155:1 169:15 171:14 reflected 11:4 17:3 29:22	39:15 64:4 69:2 99:5 154:21 158:7 161:4 176:5 reflecting 123:19 132:6 144:2 reflection 92:6 155:10,13 157:20 reflective 10:14 10:19 13:20 17:7,24 21:17 22:2,14 35:20 36:5 43:2 59:19,20 60:2 64:25 65:2 66:3,8 69:2 77:3 81:14,18 81:18,21 82:13 82:23 91:23 92:1 93:4 98:7 98:18 117:8,17 118:12,23 119:3,10,10,21 120:1,16,24 123:16 131:14 134:11 145:9 149:23 151:4 152:3,19 156:11,14,15 reflectivity 10:6,12 24:22 29:24 48:20	59:18 64:25 83:23 92:5 98:19 104:23 104:24 105:18 111:15,18,19 112:5,15 113:20,21 114:6 116:7,13 116:24 117:1 141:8 142:22 144:12 145:20 145:22 146:13 reflector 27:12 66:10 67:4,5 81:7 86:15,22 114:11,12,13 114:15 146:10 176:18 177:2 179:7 reflectors 13:23 15:20,23 15:25 18:2 19:19 20:5,7 35:25 64:6 66:21 67:8 71:12,13,14 84:11 150:18 regarding 8:17 133:25 regards 93:8 135:15 165:2 region 160:10 regions 47:16 73:17,19
---	---	--	--

[regular - results]

regular 125:9 131:13 180:22 relate 25:20 140:10 related 4:21 48:9 121:9 183:7 relates 20:2 43:8 158:23 relating 8:14 relation 15:3 51:23 117:24 relationship 71:11 relationships 53:21 71:10 relative 70:23 136:7 138:21 138:23 153:20 155:25 179:9 179:24 183:9 relatively 11:5 20:16 35:9 39:6 76:7 84:5 87:6 175:7,8 175:10 relevant 167:11 168:12 reliable 33:25 relied 128:8 157:5 rely 93:10 relying 28:20 68:1,11,23	82:7,15,18 92:22,23 93:2 96:6,9,17 99:12 100:8,11 102:3,8 117:10 120:8 128:11 136:23 153:6 157:8 160:25 161:20 163:2 165:17 166:25 remember 65:16,18 70:3 80:23 82:24 102:10 131:1 170:12 remote 1:10 182:10 remotely 4:17 5:2 6:10 render 75:15 127:20 129:8 149:1 178:17 rendered 90:24 91:9 100:25 119:18 128:23 165:15 repeatedly 105:2 rephrase 35:18 report 60:10 96:16 97:17,23 98:14,21 99:1 99:3,9,10 100:16 102:16	115:4 119:18 120:8 129:10 131:11 147:10 report's 100:7 105:8 reporter 4:20 5:11,14 6:25 15:24 110:20 180:14,16,21 180:25 reporter's 3:7 182:9 reports 97:20 representing 4:18 29:24 reproduced 154:15 reproduction 155:4 require 15:21 15:22 38:21,22 38:22 56:9,19 57:5,20 88:11 110:4,7,13 135:4,14 177:4 required 56:14 72:4 135:23 158:8 requires 20:7 56:21 57:8 65:6 139:3 142:18,19 177:5,6,7	resolution 31:9 55:20,25 58:5 58:12,17,21 74:16 respect 71:20 171:17 responds 47:14 response 18:4,6 19:20,21,24 45:2 120:21,22 127:13 responses 17:23 21:16 35:24 57:9 66:18,20 responsible 150:1 152:7 153:8,15,21 159:1 167:5,22 rest 49:21 123:23 144:20 restate 10:1 11:19 13:16 14:19 17:14 21:4 22:7 25:12 27:2 29:14 result 34:1 73:10 74:8 156:2 results 62:8 84:20 94:25 104:11,12,13 113:16
---	---	--	--

[retained - road]

retained 181:5	30:8 34:15	rise 66:9	60:3 61:25
retroreflective	37:15,22 38:8	road 10:9,14,16	64:25 65:1,1
134:13 135:5	38:9 41:12	10:17,18,18,23	65:14 67:6
141:4	42:1,25 43:5	11:10,16,21,25	69:13 70:1,5,6
retroreflectiv...	43:13,18,25	12:3,23 13:12	71:15 75:2,16
140:24	44:1 50:25	14:3,3,8,13,23	76:1 78:15,24
retroreflector	51:7 57:11	15:4 16:14,15	79:3 81:8,14
15:18 36:12,13	62:16 65:20	16:20 17:5,7	81:19,22,25
36:14 37:6	68:7 75:10,12	17:12,19,22,23	82:4,23 83:17
124:14 125:4,5	76:20 77:18	17:25 18:2,19	83:19,23 84:2
126:7,11 127:6	79:18 80:12	18:22 19:6	84:3,4,4,18,19
136:14 137:23	85:1,9,12,23	20:15,16 21:1	87:5 88:8 89:4
140:17 144:2,7	86:1,5,9 87:2	21:6,16,18	89:6 90:4
144:12,15	87:24 88:2,16	22:1,2,5,14,18	91:24 92:1,5,7
145:20 164:6	91:5 93:2,8,25	22:21 23:1,5	94:18,18 97:14
171:18 176:7,9	95:7,22 101:4	23:11,11,12,13	98:8 108:14
179:7	102:9,13	23:15,20 24:15	112:6,6 118:20
retroreflectors	103:10 110:5	24:20,21,25	118:24 119:10
36:19 50:22	111:6 116:2,20	25:2,8,9,15,17	124:15 126:17
119:13 124:20	118:1,16	25:21 26:6,8	131:6,7 132:9
124:24,25	121:13,25	26:12,13,15,16	132:12,17
125:7,8,11,12	124:9 126:15	26:19,20,21,24	133:5,12,18
141:5 143:23	126:25 127:11	27:12,15 29:11	134:1 135:3
150:7	132:10 133:3,9	29:16,22,25	136:9,20 137:8
return 26:2	135:8,12 140:6	30:18 32:4	138:4 141:6,13
returned 17:19	143:6 145:4,13	33:12,18 34:25	141:23 142:3,4
123:1 161:8	150:25 152:21	35:1,5,14,20	144:18,19,22
162:1	154:4 162:2,13	36:5,8 37:1,10	145:3,10,23,25
review 1:5	164:16 165:7	37:16 40:19	146:4 149:22
182:4	168:3 170:4,17	41:11,21,24	151:4 152:2,19
rgb 110:1	173:7 174:13	42:14,20 43:4	156:8,11
right 6:13 8:11	174:23 175:18	43:9,9,12 45:3	163:10 166:7
16:6 18:20	176:25 177:21	46:2 53:1	167:3,17,20
22:23 28:25		59:19,19,20	169:16 171:15

[road - schofield]

171:21 172:1 176:19,19 179:23 180:2 roads 40:4,6,9 40:15 75:23 roadway 10:10 32:1 34:9,15 37:21 40:12 41:18 42:17 98:19 102:19 102:23 107:5 125:1,8 132:25 169:8 robert 2:4 5:7 183:3 robert.high 2:8 robot 108:23 129:3 role 123:15 143:12 144:14 room 6:17 rough 19:5 180:19,23 roughly 56:5 122:13 row 31:15,23 32:2,2,3,3,3 58:10 62:1,1,1 62:1,2,18 64:18,20,21 69:22 70:7,17 75:20 97:12 rows 32:5 58:8 64:1 69:23	run 34:15 104:10 151:13 running 104:2 104:5 113:15 115:3,6 s s 2:1 4:1 sample 32:12 32:14,16 33:22 33:23 118:6 samples 33:15 sampling 32:22 32:25 33:1,8 samplings 33:11 satisfied 176:22 satisfies 157:6 170:8 satisfy 165:9,10 saturate 174:20 saunders 2:11 3:5 5:5,5,15,21 6:4 37:24 38:7 79:10,17 114:18 115:19 116:1 146:18 146:22 147:3 177:21,25 178:21 180:6 180:10,12,21 180:23 183:4 saw 117:25	saying 23:10 54:19 70:5 74:4 78:9 93:23 95:5 97:6 101:19 106:9 108:13 111:4,6 112:22 114:12 115:7 118:5 125:10 142:8,10 145:10 159:10 170:8,10 172:2 172:3 says 8:19 10:17 14:2,11 23:3,3 26:9 29:3 34:10,24 39:14 41:3 49:8 59:7 73:13 74:25 76:16 85:7,14 86:3,23 88:1 90:2 93:15 98:2 102:4 111:2 113:12 123:18 127:18 136:19 scale 38:20 scan 31:25 79:25 107:11 scanned 109:23 scanner 109:22 scanning 61:14 107:9 109:21 123:11,12,12	scattered 36:21 scenarios 163:14 scene 39:22 47:1,7 54:13 54:18,19 55:3 63:25 73:16 74:5 75:6,22 93:5 109:23 122:9 123:8 139:7 175:4 schofield 8:6 9:7,9 44:2,6,8 44:14,16,25 45:22,24 46:11 46:16 48:4 49:4,25 50:3,6 53:5,9,10,16 55:4 56:3,13 56:19 57:7 58:5 59:7 67:23 70:4,9 70:23 71:9,17 71:19,25 73:5 73:9,13 74:7 74:20,22 79:23 80:2 92:24 93:7,11,13 94:3,6,7,11,21 95:10 100:19 100:20 101:6 101:11,18 102:11,16,20 102:21 103:6
--	---	---	--

[schofield - sensitivity]

104:4 105:3,10 106:21 107:7 107:23 108:2,4 109:10 110:4 111:1,11,16 112:19 114:8 114:11 115:6 116:22 125:23 126:2 127:19 128:9,12,21,21 130:7,8 139:1 139:15 142:25 148:20 149:1,6 149:9,13 154:14 160:23 164:23 165:1,5 165:17,25 166:3,6 167:19 schofield's 46:19,21,24 52:4 56:9 57:4 57:15 61:14 62:24 69:11 70:15,17,21 71:2,3,7,8 72:5 72:12,17,19,22 93:19,24 94:1 94:2,17,23 95:7 101:3,22 101:24 102:8 103:16,23 104:16,19,25 105:17,24 106:3,10,13,17	106:22 107:3,4 108:12 110:17 111:14,19 112:1,6,13 113:1,21 126:14,24 127:10 128:19 129:20 151:10 151:12 school 130:23 science 130:23 scope 61:3 157:13 171:3 175:9 screen 4:8 search 20:21 second 26:22 27:6 33:2,7,8 79:21 121:12 122:23 131:10 141:1 seconds 33:5 secretly 7:18,21 section 12:9 83:25 93:8,22 99:10 125:21 149:6 sections 10:16 20:15 84:4 see 8:5,5,8 12:13 14:1,4,5 14:6,8,9,10,13 14:14 15:11,18 16:22,23 21:12	21:13,18,19 24:4,10 26:9 27:14,14 28:12 28:15,17 32:12 32:23 34:6 39:25 40:4,5 41:22,23 48:25 49:8,10,11 50:4,5 51:18 51:24 53:8,17 60:15,16 69:14 69:15 73:12,13 74:14,15,25 75:3,8 80:1 84:21 87:15 90:2 103:7,8 111:7 113:5 114:3 116:6 117:19 118:4 118:17 120:21 122:19 123:2 126:10 127:15 127:16,18,21 128:9 133:5 136:18 139:21 140:12 141:13 142:5,6 145:11 149:2 151:14 152:14 158:20 160:15 164:23 168:9 174:17 174:18 177:1 seeing 145:9	seen 4:7 26:18 53:20 70:25 111:17 113:20 115:5,7 129:7 146:14,15 176:10 sees 123:17 selecting 14:11 17:6,21 81:17 82:4 90:3 91:22 169:15 171:13 selects 15:4 sense 42:13 71:7 76:25 97:6 118:6 137:11 155:17 161:8 169:18 sensed 17:23 21:16 27:5 54:14 senses 16:14 46:25 sensing 13:8 16:13 18:7 29:8 30:21 35:23 47:11 97:13 114:14 118:8 130:25 162:8 171:7,8 171:8 sensitive 126:6 sensitivity 51:15
---	--	---	--

[sensor - shapes]

sensor 13:19 15:16 17:3 18:3,5 19:19 19:21,22 20:17 22:8 29:3,21 30:23 36:1 40:12 42:25 46:25 47:2,3,4 50:13 54:11,20 58:17 68:12,25 70:16,21 71:8 71:23 73:1 75:5 76:4,21 77:15 78:8 79:5 80:17 84:1,6 86:11 86:25 87:19 88:2 93:14,19 94:24 95:7,23 95:24 99:15,25 100:19,20,24 100:25 101:3,9 101:15,23,24 102:3,5,9,22,23 103:24 104:3,4 104:18,19,25 105:5,10,17,19 105:24 106:3,4 106:12,13,15 106:18 107:2,3 107:4,14 108:8 109:2,5,11,12 109:14,16,17 109:18,19	110:1,3,11,17 111:2,14,20 112:1,6,14 113:1,22 116:10,14 122:2 132:13 132:19,21 133:10 134:15 134:18 136:16 137:2,6,8 138:20,20,22 143:10 149:24 152:5,23,25 153:1,13,18 156:18,19 158:12 160:11 161:18 162:1,2 162:5 164:3,9 169:5 171:9 172:10 174:20 sensors 11:4,7 11:7,8,9,12,13 11:16 13:2,3 18:1,21,22 22:9 27:17 28:12,16,21,24 28:25 29:1,2,4 29:20 30:2,25 33:18 35:23 38:16,22 39:3 39:13,16,24 42:22,24 47:6 47:15 61:12,13 62:23,23,24	66:17,19 67:10 68:23 69:1,16 69:17,20,25 71:24 73:9,15 74:4,10 76:13 77:11 83:24 85:16,18 96:11 96:20,22,24 98:11 99:3,7 99:20 101:20 103:16,25 107:24 108:1,6 108:11,17 109:7 115:11 133:2 153:2 160:24 164:13 169:15,22 170:3,6,9,24 171:1 sentence 49:8 60:13 78:1,10 78:19,21 103:9 103:11 106:6,9 106:9 112:8 113:13 114:21 116:5 120:3 152:11 153:22 153:23,24 155:22 sentences 78:11 separate 58:19 101:15 separated 73:17	separating 47:7 157:17,24 separation 55:15,17 sequence 64:5 89:11 series 32:4 65:9 84:17 108:21 set 32:12 37:17 40:16,18 50:13 50:15 121:23 131:21 157:19 177:10 182:17 setting 16:24 44:10 56:16 66:16 settings 56:14 settles 161:24 setup 70:24 163:20 seven 127:25 several 33:15 70:14 shakey 108:22 shape 36:14,24 36:25 37:4 48:20 50:9 57:19,20 58:14 58:15 113:23 161:10 shaped 36:17 shapes 57:17 58:3 109:24
---	--	--	--

[share - source]

share 8:4 9:2 121:14 shelton 1:20 4:20 182:14 183:19 shifted 123:3,4 shining 36:7 39:19 46:3 show 27:20 57:25 169:1 showing 84:1 87:3 120:19 150:10 168:14 shown 23:25 27:11 84:10 164:15 shows 122:25 133:21 sic 50:9 68:2 81:18 side 15:20,20 16:1,1 87:18 87:18 108:25 128:20 155:13 sight 162:3 sign 50:11,23 51:4,18 signal 14:16 15:9 29:23 61:6,6 116:15 122:24 123:1,2 176:6 signals 35:9 38:18	signature 45:10 47:18,24 50:8 182:21 183:19 significant 173:1,2 174:3 signs 10:19 41:24 42:14,20 43:4,12,15,17 44:18 45:10,13 45:13,16,17 50:4,7,10,14,18 50:21 51:1,2,9 59:20 65:2 94:18 112:6 141:4 silicon 170:14 similar 72:6 103:9 177:3 similarly 118:14 simple 77:10 138:9,15 143:5 simpler 154:7 simplicity 59:23 98:3 119:6 120:3 simplify 133:7 simply 26:7 simultaneously 157:18 single 15:22 16:13 31:14,15 31:23,25 51:20 102:21 103:25	122:8 123:12 164:12 sits 110:14 sitting 30:8 situation 25:5 25:20 26:4 36:9 172:16 six 181:5 size 47:22 48:2 48:4 51:14 54:16 57:23 133:9 skill 29:7 43:21 52:5 63:19 74:13 77:12 93:23 100:3 103:14,22 105:4 107:15 112:17,22 128:24 166:23 167:13 skilled 56:17 60:1 98:6 161:8 skip 12:5 slices 65:8,9 slide 46:5 slightly 134:7 small 11:5 18:4 131:22 smaller 63:24 141:15 smooth 33:24	smoothed 34:1 smoothing 35:8 solid 73:14 solutions 4:19 4:21 181:6 183:20 somewhat 103:1 132:18 soon 146:17 sophisticated 47:20 122:24 150:15 sorry 5:17 12:15 20:10 38:8 48:3 69:5 79:20 82:16 83:3 84:22 102:7 105:15 118:2 122:2 sort 128:20 source 10:25 18:2 36:2,5,11 37:6 38:21 39:5,5,11 41:10 46:22 48:8 58:20,23 68:16 95:23 96:23 99:18 100:24 106:19 117:3 126:3 127:4 129:15 129:16,18 131:20 136:15 140:25 141:2
--	--	--	---

[source - starting]

150:1,4,12,14 150:15 152:7 152:10 153:8 153:15,20,20 159:1,4,24 160:8,14,19,21 166:15 167:5,8 167:22 168:9 168:18 170:1 171:17,18 172:9 173:5 174:10,12 175:17 177:12 178:23 179:9 179:12 source's 69:12 179:22,24 sources 35:21 37:11 46:16 48:11 49:10,13 49:19,20 51:10 52:7,14 53:20 53:22 55:14,16 58:20,22 71:5 73:17 173:15 space 26:7 75:3 76:4,5,15 77:5 77:23 78:7 79:1,4,7 123:22 126:13 126:15 129:5 139:9,10 163:6 164:14	spaced 52:22 52:23 71:15 spacing 26:14 52:24 spatial 48:6 53:23 54:9,14 55:4,9,19 71:9 71:11 73:19 spatially 47:16 73:17 speak 96:21 speaks 137:20 specific 15:14 21:22,24 28:14 31:1 50:19 80:1 92:9 96:21 98:13 99:8 119:12 165:20 specifically 39:18 57:4 63:1 97:1,16 103:4 116:22 133:24 166:24 specification 53:8 specificity 167:25 specifics 28:4 specified 37:2 specifies 53:6 specify 39:16 spectral 35:24 36:15 45:10	47:8,18,24 48:20 50:8 52:8,9,10,18 66:17,20 113:24 spectrum 36:14 speculate 89:23 161:15 speculating 135:21 speculation 169:13 174:25 177:15 speed 153:17 speeds 32:24 spell 113:7 spelled 89:24 113:5 spend 46:11 spends 44:21 split 148:6,7 splitter 161:25 splitting 154:17 spot 16:17 31:14 70:7 126:18 137:5 145:9 162:10 174:16,16 spots 123:19 spreading 150:7 154:23 158:20,23 square 57:24 57:25 158:7,7	158:8 squished 57:25 stand 178:19 178:24 179:7 179:16 180:4 standard 11:1 41:15 97:12 115:9,14 125:8 135:6,10,13,14 140:19,22 180:19 standards 3:19 40:14 52:25 135:4 start 5:16 12:11 18:3 41:10 42:11 68:18 81:10 85:5 87:18 112:8 117:25 118:2 128:15 147:9,11,14 155:6 started 64:14 starting 9:17 49:5 54:8 67:14,24 68:2 80:14 84:22,25 85:7 92:12,12 92:25 93:16 118:7 119:5 120:7 125:16 125:19 138:6 148:19,21,22
---	--	---	--

[starting - supposed]

148:23 149:5 149:11 178:15 starts 55:11 65:10,11 67:7 84:15 113:18 117:5 state 1:20 4:24 5:2 6:7 40:16 73:14 stated 1:22 statement 75:20 99:12 states 1:1 182:1 static 34:10,12 34:19,22,23 35:12 steep 40:11,22 41:5 steer 13:6 86:19,20 steered 122:8 steering 35:9 46:8 65:21 119:16 122:4 step 12:25 14:7 14:11,12,15 15:1,3,3,7,8 16:4,8,10 17:21 21:10,14 21:21,21 24:19 26:11 32:9,15 32:17,18 80:22 80:22,25 81:4 81:7 82:15,18	82:21 83:18 85:14,22,25 86:3,7,18 87:10,24 88:5 88:10,11,11,19 88:20,23 89:1 89:2,3,3,12,14 89:16,20 90:1 90:2,3,6,7,9,10 90:11,11,12,14 90:14,15,17,18 90:25 91:1,19 91:20 92:3 117:14,14,25 118:3,15,18 119:19,23 120:2 steps 11:24 80:21 81:11 83:15 84:17,25 86:17,21 87:11 89:11 90:21,23 92:8,9 117:14 117:15,24,25 119:14 stop 45:12 50:14,17 51:18 store 64:16 stored 65:22 storing 69:21 84:19 straight 55:24 172:25 176:10 176:19	straightforward 70:24 71:17 97:11 137:16 138:22 169:3 street 2:6,12 22:16,18,23 183:21 streetlight 25:10 48:14 streetlights 25:23 stretch 14:3 22:13 strike 107:19 stripe 81:6 86:15 87:14,14 stripes 13:21 13:23 83:14,17 strong 26:1 35:15,21 36:5 89:10 stronger 38:21 158:10 student 145:15 stuff 144:20 157:2 subfield 150:24 151:8 154:18 154:20 159:16 159:18,20,23 160:6,10 161:9 168:20 subfields 150:21 151:5	154:17,22 157:18,20,25 159:15 161:4 168:5 169:10 subject 76:6 167:10 submitted 8:12 8:17 111:8,9 subphrase 167:9 subsample 54:21 subsection 68:6 subsequent 86:17,20 87:11 subsequently 87:16 success 179:21 sufficient 130:1 suggesting 94:21 suite 2:6,12 183:22 summarizing 143:21 summary 30:24 35:7 supply 10:15 supported 112:4 supposed 26:17 33:19 54:24 71:12,14
---	--	--	---

[sure - talking]

sure 37:13 39:4 40:18 53:6 66:6 110:7 163:17 177:25 surface 17:7 36:8 69:2 76:1 81:14,19,22 82:13,23 91:23 92:1 117:8,17 118:12,23 119:3,21 120:1 120:16 124:15 131:19 134:11 134:13 141:3 149:23 152:4 156:14,16 surfaces 17:24 21:17 22:15 43:2 89:5 93:4 93:5 98:18 119:11 120:4 123:16 surrounded 48:16 susceptible 41:17 103:2 swapping 71:23 swear 5:12 sweep 140:5,7 140:8,15 sweaped 132:9 sweeping 169:6	sworn 5:14 6:2 182:18 symmetrical 54:10 179:5 synced 106:18 synthetic 61:15 system 10:3,4,5 10:8 28:18 36:3,23,25 37:18 44:5,17 46:14,24 48:14 56:9,21 66:16 80:16 81:1,12 85:10 93:3,24 94:2,2,3,17 98:17 101:1,7 102:13,18 103:15,25 105:7 116:11 116:12 121:18 121:20 122:3 126:23 128:25 129:3,12 130:12,14,16 131:21 132:9 132:24 147:12 148:12 149:16 149:20,21 156:2,7 157:15 164:4 165:1,24 168:12,16 169:8 170:9,9 170:24 171:1 176:25 177:4,5	177:8,9 178:23 systems 60:25 101:20 104:20 110:22,23 111:21 112:20 113:15,24 114:24 129:3 133:17 147:18 154:12 156:1 170:13,14 172:5 t t 2:1 6:3 178:6 table 143:25 tables 143:22 tag 14:2 24:20 26:19 tagged 27:11 27:16 tagging 24:20 66:1 taillights 44:22 44:25 45:25 46:13 48:13,22 48:24 49:20 50:17,20 53:24 55:18 56:15 71:10 take 4:9 8:19 12:18 25:5 59:9 63:16 86:14 96:14 97:11 114:19	120:18 129:25 137:25 146:19 149:19 156:5 157:14 177:23 180:15 taken 1:18 4:12 94:7 183:9 takes 33:14,17 33:23 110:14 122:19 talk 18:10 27:17 36:24 49:18 74:22 80:13 118:7 124:25 130:17 156:10 talked 32:7 37:20 95:12,12 95:13,14,15 112:24 132:8 142:25 143:1 158:24 161:22 166:4,5 167:17 talking 21:6 27:22 28:24 32:22 38:9 39:4,10 42:4,8 42:9 43:1,25 49:25 50:8 59:17 60:4 65:7 70:19 71:9 72:12 75:10 78:20 81:25 94:5
---	---	--	--

[talking - third]

95:2 101:25 133:24 147:9 147:15 148:4 156:11 164:20 164:22 168:19 168:21 179:13 talks 19:15 20:13 27:13 34:11 35:22 44:16 45:6 50:12 52:13 56:13 66:16 86:8 97:5 104:8 108:2,8 116:22 130:9 133:22 179:14 179:14 target 127:9 129:23 137:25 taught 77:21 163:19 teach 10:4 37:9 133:17 teaches 10:2 teaching 97:10 141:22 169:25 teachings 170:12,15,20 170:23 171:2 technique 60:6 72:5 73:6 166:10 167:1 172:19	techniques 44:10 50:16,20 72:17,19,23 101:17,18 103:1 115:9,15 115:18 129:22 137:24 138:8 147:21 148:16 148:17 160:24 161:20 163:19 165:23 166:24 167:15,16 173:21 179:1 technologies 74:1 103:3 technology 1:7 4:14,17 73:25 109:1 182:6 tedious 51:21 teeth 61:18 tell 36:20 43:3 44:12 52:4 66:2,25 67:3 69:17 74:7 86:20 125:5 126:14,16 133:15,16 137:4 155:6,14 162:15 175:20 telling 43:11 87:9 124:23 143:8 144:14 144:21	tells 45:16 88:18 89:1 123:4 ten 28:12,16,17 28:25 29:2 62:3,4 162:14 172:18 tend 61:4 75:23 term 49:12 60:25 terry 2:17 4:18 test 34:10,12,19 34:22 41:22,24 42:13,19 43:5 43:13 62:8 64:24 tested 11:10 14:3 84:19 testified 6:2 testimony 7:14 7:16 10:11 181:3 182:19 tests 10:17 34:12 62:9 texas 1:21 2:13 182:14 183:20 183:22 text 46:12 thank 5:21 9:16 thanks 163:18 theta 139:25 140:11,17 143:9 144:16 175:20,22	176:2,3,8,11,16 176:19,22 thing 76:19 77:21 153:4 156:12 things 19:4 20:23 41:16 42:16 44:19 45:6 55:22,23 56:4,6,7 61:4 61:20 71:8 74:14,15 83:1 94:5 95:14 97:5,7 106:25 108:10 113:23 118:6 129:6 131:15,19 152:20 175:6,7 think 5:16,17 14:21,24 15:6 24:8 32:7 41:1 43:24 55:7 75:7 79:6 91:15 103:19 115:5,7 117:21 117:23 127:24 145:6 146:16 146:20 148:24 155:17 165:4 168:4 180:12 180:18 third 71:6 113:13 158:9
---	--	--	---

[thorpe - turn]

thorpe 1:11 3:4 3:13 4:12 6:1,5 6:9 38:9 79:18 116:2 145:14 147:4 163:17 178:9 181:4 182:11,16 thought 62:13 thousand 33:10 three 71:16,22 72:2,10,14 169:2,24 172:3 172:5 180:24 180:24 threshold 17:9 23:24 24:5,11 26:2,5,19,21 27:5,8,10 35:12 65:15,24 66:9,10 67:4,5 120:25 121:2,5 121:6 thresholds 120:19,22 throckmorton 183:21 tie 15:14 time 4:25 16:2 38:3,6 41:25 43:18 44:21 45:18 51:17 56:16 62:9,18 64:18 69:18 71:4 79:13,16	89:9 115:22,25 125:24 138:12 138:14 146:24 147:2 163:18 167:13 178:2,5 180:13,22 182:23 183:1 times 33:1,8 122:23 158:10 169:2,2 title 10:6 121:25 147:18 titled 60:23,24 61:18 today 5:8 6:10 6:18 7:5,14 8:12,22 9:11 76:16 112:24 today's 181:3 together 68:20 70:13 101:21 111:23 112:21 114:1 115:1,11 156:2 169:24 170:21 top 45:8,21 48:18 49:24 50:2 61:8 70:21 110:14 113:18 114:21 129:13 148:25 170:25 176:12 total 181:4	toward 129:4 129:13 155:12 157:25 158:9 track 107:12,23 108:10 tracking 34:12 67:6 107:17 108:2,5 134:14 150:17 trademark 1:1 4:15 182:1 traffic 44:18 45:10 50:3,7,9 50:9,11,21,23 51:9 transcript 180:17 182:18 182:22 transition 41:14 transitioning 41:9 transmitted 138:13 157:25 transportation 40:17 travel 141:7 traveled 23:21 88:4 traveling 32:24 treated 102:24 trend 63:4 trial 1:2 8:13 182:2	triangles 45:13 45:15,18 177:3 triangulation 180:3 trickier 155:3 tried 15:2 trigger 65:25 trigonometry 138:9,15,16 143:5,13 trouble 36:8 truckload 36:19 true 58:3 130:5 182:18 truthful 7:14 7:16 try 136:1 trying 10:5 17:15 25:13,13 25:19 41:25 44:14 45:5 63:18 65:5 75:9 91:12,18 96:15 108:23 110:24 111:7 113:2 119:17 149:19 150:6 155:24 160:4 161:23 165:13 166:21 170:22 174:15 175:13 turn 12:19 23:19 28:8
--	---	--	---

[turn - uses]

34:5 44:1 45:1 48:5 63:5 84:13 95:17 100:14 116:16 132:4 139:12 turnaround 180:22 turned 31:3 turning 51:22 73:4 77:25 81:9 85:10 124:6 tweak 151:11 two 18:22 19:4 27:3 36:10 50:10 52:6 58:19,22 70:13 76:5,18 87:18 89:8,11 92:8 101:20,20 104:8 107:24 108:1,5 110:14 110:15,16,22 110:23 114:12 115:11 124:4 131:8 142:19 154:12 157:1 162:10,22,24 163:6,8,23 type 34:10 47:10 73:22 125:5 126:5 128:18 154:20 161:5 162:8	177:12 types 56:22 60:2 64:23 66:13 69:13 98:7,11 99:7 107:24 108:1 119:9 124:24 typically 125:9 typo 59:10	170:15 understanding 5:18,20 17:16 31:24 34:18,21 49:12 61:19 77:22 91:7 155:18 161:13 understood 99:25 153:12 164:8 undulating 40:4 uniform 54:15 151:12 155:5 unit 4:11 39:8 united 1:1 182:1 universities 61:1 university 130:24 unmarked 8:1 8:1 uploaded 8:16 9:1 121:13 use 11:2,7 12:22 14:22 18:24 19:25 20:9,11 36:25 48:4 60:5 70:15,17 71:7 71:10 72:5 88:15 95:5 96:11 100:19	101:22,24 103:23 113:4 114:6 132:4 142:11 146:10 151:22 162:5 162:12 167:14 167:19 169:9 170:20,23 173:10,13 179:22 used 9:18 10:12 10:15 11:9 13:11,14 14:2 21:21 27:18 29:5 35:24 37:3 42:4 46:6 47:10 48:23 50:17 52:2 57:11 69:25 73:22 87:10 90:14,15 102:10 106:2 119:9 130:12 140:16 150:22 151:6 154:18 154:21 160:24 161:10,19 181:5 183:1 useful 60:7 74:1 134:15 143:2 user 86:20 uses 11:6 13:5 17:9 20:19
---	--	---	---

[uses - vehicle]

50:16 85:1 89:3 96:10,22 173:6 178:23 using 4:17 13:1 14:16 15:12 28:9 29:11,17 30:18 33:21 47:13 48:17 71:24,24 72:16 72:18 73:6,10 88:19,23 89:1 89:12,20 90:17 90:21,22,25 91:20 94:18,23 95:2 96:20 98:19 101:10 104:17 105:19 105:24 106:11 106:12 108:24 111:2 112:7 114:13 115:9 116:13,25 117:1,1 127:10 128:17 129:3,4 129:23 130:9 138:12 140:15 140:22 147:19 148:3,16 149:22,23 152:3,4,23 153:13 155:2 156:13,15,17 163:19,20 164:8,12	165:21 166:14 168:9 169:9 170:5 171:2 172:19 173:13 173:15,19 175:11 179:4 180:2 usually 48:22 63:17 utilized 45:9 v valid 26:15 27:12 value 17:19 19:7,11 34:3 67:1 78:14 81:13,21 82:12 91:25 144:16 145:1,23 160:12 171:25 values 20:10 68:13 69:22 95:25 99:16 100:1,5 102:6 117:9,18 120:2 138:11 149:22 150:2 152:3,8 153:9,16,21 156:13,15,24 159:2 166:14 167:6,23 171:14,21 173:3 174:1	180:1,3 variations 25:8 varied 141:23 145:25 varies 158:6,7 179:9 variety 30:22 42:4 44:9,16 44:19 46:10 59:18 61:12 64:25 66:24 74:22 81:4,25 95:3 97:5 99:21 104:11 109:7 113:14 118:5 122:7,25 126:4 147:20 148:6,16,17 150:15 154:17 various 112:25 117:14 178:10 178:12 vary 22:15 132:18,20 varying 150:22 151:5 171:5,6 vector 149:25 150:2 152:6,8 152:16 153:7 153:15,19 156:23,25 159:3,17,20,23 160:3,7,11 164:5,7 166:15	166:16 167:4,7 167:21 168:18 169:25 171:23 172:8 173:4 174:1 179:6,11 179:15 vectors 150:3 152:9 156:25 159:4,7,13,19 159:22 160:4,6 166:17 167:8 167:24 173:4 174:2 175:15 175:16 179:12 vehicle 10:13 10:15 13:6,11 16:6,8,12,16 19:5 21:25 34:9,14,23 37:22 39:8 40:10 41:15 45:2,25 46:2,8 47:1,8,17 49:14 53:24 54:2 55:18 73:16 76:14,15 80:4 83:19,21 83:22 89:21 107:10,13,18 121:17 122:3,4 124:16 132:16 133:5,23 134:10,13 137:9,22
---	--	---	---

[vehicle - way]

138:23 148:3 161:3 174:22 175:2 176:7,9 178:24 179:3 vehicle's 45:1 50:24 vehicles 49:9 122:1 verbal 7:1 verify 95:14 veritext 4:19,21 181:6 183:20 versions 109:18 versus 4:14 25:17 37:6 56:15 58:22 92:23 177:13 vertical 31:9 39:2 40:14,22 41:5 vertically 57:24 132:17 video 4:9,11 30:3 47:10,13 63:14 73:22 97:12 108:24 129:3 162:7 180:8,9,11,13 videoconfere... 1:21 videographer 2:17 4:2,19 5:11 38:2,5 79:12,15	115:21,24 146:23 147:1 178:1,4 180:7 180:10,14 181:1 videotaped 1:10,16 182:10 view 13:7,19 15:3 18:3,5,7 29:21 38:11 39:11,12,17 40:11,25 42:23 47:16 51:14 53:4,10,13,15 54:4,25 56:1 56:25 68:14 69:12 70:2,11 74:14 75:2,5 75:17,19 77:20 78:8,16,17,25 79:5 80:3,5,19 81:15,22 85:5 97:10 99:16 102:19 132:13 132:19 133:2,9 134:15,25 136:8,10,21 137:1,2,6,13 138:5,17,25,25 142:5 145:3 147:21 148:1,5 150:21 151:3,5 152:13,18 160:11 176:12	179:4 viewed 62:8 65:23 viewing 11:5 views 134:6,7 viii.d.4. 179:17 179:19 virtual 4:17 virtually 4:5 visible 51:5 vision 56:21 61:5,7,10 62:14 63:1,2,5 63:13,17,21 130:19,24 139:5 visual 83:20 visualization 95:15 vital 10:15 voltage 28:1 31:3 voltages 31:6 162:17 vs 1:6 182:5	59:1 67:7 74:14,15 77:25 80:13 92:21 97:16 103:4 141:11,12 142:8 143:19 144:6,8 161:15 167:14 174:12 180:18 wanted 167:21 warning 46:8 watching 15:9 15:10 18:15 107:18 wavelength 36:6 wavelengths 123:3,4 wavy 40:9 way 12:16 13:25 16:14 20:19 21:9,23 30:20 31:21 34:11 40:15,15 45:15 54:6 63:19 70:15,18 70:20 71:6,18 72:6 86:10 90:17 91:19 101:23 106:24 122:11 124:23 126:17,18 131:8,10 151:17,19
		w	
		wait 122:2 waived 182:22 walk 84:12 walked 80:20 want 12:10 32:6 41:8 44:12 49:4	

[way - yellow]

157:10 167:12 169:14 170:17 170:20 ways 19:17 29:7 30:22 52:6 54:25 55:2 70:15 71:22 72:2,10 72:14 92:7 94:16 95:4,14 99:21 100:4 101:21,25 102:21 105:2 107:16,20,21 110:23 111:4 111:10 112:25 113:4,5,7,14 115:16 120:4 122:7,25 126:4 131:8 147:23 150:5,17,18,19 168:14 169:18 173:15 we've 8:16 26:23 27:4,6 37:24 43:25 70:18 101:16 101:16 114:10 149:14 154:13 154:14 161:22 166:2 167:17 174:9 welcome 38:8 79:18 147:4	west 2:12,17 4:18 white 48:11,16 48:25 52:15 56:14 57:8 67:4 wide 29:20 30:22 39:6 42:22 44:16 56:24 59:18 62:4 64:25 80:9 81:4,25 97:5 118:5 148:5 158:21 widening 147:19 wider 60:5 66:23 98:23 width 64:10 132:19 willing 145:16 window 130:1 138:1 windshield 57:13 wiring 170:14 wise 168:21 withdraw 12:16 16:9 20:10 35:3 48:3 79:22 82:17 88:17 102:15 103:19 120:11 124:18	135:5 140:20 witness 1:17 4:7 5:10,12,14 105:13 146:20 177:22 180:5 182:16,19,22 wo 3:22 wonderful 44:8 45:19 158:2 word 156:5,5 words 79:8 151:25 152:1 work 11:21 43:17 61:17 111:22 112:21 114:1,25 130:21 161:14 163:21 working 127:14 178:13 works 17:16 25:14 123:24 161:12 world 57:21 76:7 106:22 108:9,10 126:9 137:3 138:18 151:13 world's 109:20 worried 54:17 55:22,23 147:22 worry 127:23 128:1	worse 58:12,17 worth 183:22 wright 2:11 5:6 written 10:11 57:3 wrong 149:4 wyatt 2:4 5:8 wyatt.bazrod 2:8
			x
			x 3:1 6:3 23:20 77:9 162:19 178:6 xy 75:21 xyz 76:12 109:25
			y
			y 23:21,23 77:8 77:10 162:19 yaw 140:2 yeah 11:20 17:15 22:8 25:13 29:15 32:10 35:19 55:8,11 69:8 78:4 82:15 89:15 114:18 143:20 146:18 148:24 151:2 160:2 166:21 176:3 yellow 35:25 36:1 45:13,15

[yellow - zoom]

45:18
z
zero 146:9 162:4 zone 41:16 zoom 1:21 6:11 80:9

Federal Rules of Civil Procedure

Rule 30

(e) Review By the Witness; Changes.

(1) Review; Statement of Changes. On request by the deponent or a party before the deposition is completed, the deponent must be allowed 30 days after being notified by the officer that the transcript or recording is available in which:

(A) to review the transcript or recording; and

(B) if there are changes in form or substance, to sign a statement listing the changes and the reasons for making them.

(2) Changes Indicated in the Officer's Certificate. The officer must note in the certificate prescribed by Rule 30(f)(1) whether a review was requested and, if so, must attach any changes the deponent makes during the 30-day period.

DISCLAIMER: THE FOREGOING FEDERAL PROCEDURE RULES ARE PROVIDED FOR INFORMATIONAL PURPOSES ONLY.

THE ABOVE RULES ARE CURRENT AS OF APRIL 1, 2019. PLEASE REFER TO THE APPLICABLE FEDERAL RULES OF CIVIL PROCEDURE FOR UP-TO-DATE INFORMATION.

VERITEXT LEGAL SOLUTIONS

COMPANY CERTIFICATE AND DISCLOSURE STATEMENT

Veritext Legal Solutions represents that the foregoing transcript is a true, correct and complete transcript of the colloquies, questions and answers as submitted by the court reporter. Veritext Legal Solutions further represents that the attached exhibits, if any, are true, correct and complete documents as submitted by the court reporter and/or attorneys in relation to this deposition and that the documents were processed in accordance with our litigation support and production standards.

Veritext Legal Solutions is committed to maintaining the confidentiality of client and witness information, in accordance with the regulations promulgated under the Health Insurance Portability and Accountability Act (HIPAA), as amended with respect to protected health information and the Gramm-Leach-Bliley Act, as amended, with respect to Personally Identifiable Information (PII). Physical transcripts and exhibits are managed under strict facility and personnel access controls. Electronic files of documents are stored in encrypted form and are transmitted in an encrypted

fashion to authenticated parties who are permitted to access the material. Our data is hosted in a Tier 4 SSAE 16 certified facility.

Veritext Legal Solutions complies with all federal and State regulations with respect to the provision of court reporting services, and maintains its neutrality and independence regardless of relationship or the financial outcome of any litigation. Veritext requires adherence to the foregoing professional and ethical standards from all of its subcontractors in their independent contractor agreements.

Inquiries about Veritext Legal Solutions' confidentiality and security policies and practices should be directed to Veritext's Client Services Associates indicated on the cover of this document or at www.veritext.com.