

Software

Sensor Reliability Tests



STEMD trials:

- Laboratory - Italy
- Soil - Mozambique
- Large SH - Laos
- Reliability – Croatia
- Test data and their evaluation Italy (2004 – 2006)

Dieter Guelle

(Consultant BWB)

Other test: Colombia,
Afghanistan, Croatia,
Egypt,
Germany DS (2009)





Software Detection Reliability Test

- Developed by BAM (Federal Institute for Materials Research and Testing) and BWB (Federal Office of Defence Technology and Procurement) based on experience from
 - ITEP projects looking into the design of detector reliability trials (CEN WA)
 - STEMMD metal detector trials in Laos, Mozambique and Croatia
 - Dual sensor tests in Croatia and Germany 2007 & 2009
- The software helps to establish a test lay-out to obtain statistically valid detector performance results
 - The test layout: for a given number of detector types, test lanes, test targets and an optimum of operators the software will indicate the minimum number of test runs and by the operators with the optimal number of operators which will allow statistically valid performance data



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BAM-Working group
"Reliability of non-destructive diagnostic systems"



Experimental Design and the analysis of results
— WELCOME —

Logout
user:

- Home
- Login
- Your data area
- Guestbook
- Contact
- Impressum

- 1. Allocation of the test objects to the test lanes**
 - Dimensions of the test lanes
 - Number and types of the test objects
 - Position plan for all test objects in the test lanes
 - Download data and graphics for this position plan
- 2. Design of the experiment**
 - Specification of the statistical basis
 - Desired design
- 3. Protocols and measuring data**
 - Print out of protocols
 - Input measuring data from all detections
- 4. Identification of detections and false alarms**
 - Run the calculation program
- 5. Statistical analysis of the results**
 - Results for your selection

User data:

title:

name: !

first name:

PIN: !

repeat PIN: !

company:

address:

phone:

email: !

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The Way in!
(will be later given)

For registered user:

login is your email:

PIN:

- Allocation of the test objects to the test lanes
[\(Overview\)](#)
- Design of experiment
[\(Overview\)](#)
- Protocols and measured data
[\(Overview\)](#)
- Identification of detections and false alarms
[\(Overview\)](#)
- Statistical analysis of the results
[\(Overview\)](#)

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Software

Input

Output

Preparation

Testarea
Test Objects

Testlanes layout (measurments)
Targets & Clutter (distribution)

Design of experiment

Number of sensors
Operators

Employment (randomised)
Employment (randomised)
Forms for data collection
Test execution order (randomised)

Collected data

Coordinates of markers
What answers I am looking for?

Hits & Misses, false alarms
POD, data distribution,
influence of different factors as
soil, operators, sensors etc.



Detection Reliability Test Software

<i>What does the trial manager have to know prior to the trial?</i>	<i>What does the software do?</i>	<i>How can the trial manager use the software (output)?</i>
<ul style="list-style-type: none"> ● The number of test lanes available and their dimensions ● The types and number of test targets available, their HALO and the envisaged target depth range 	<ul style="list-style-type: none"> ● Random distribution of objects for each test lane, position plan (x, y and z coordinates) + target position map 	<ul style="list-style-type: none"> ● Bury test targets in test lanes ● Correct the proposed coordinates to the real field coordinates
<ul style="list-style-type: none"> ● The number of sensor types to be tested and the number of available specimen per detector type ● The number of available operators 	<ul style="list-style-type: none"> ● Calculates the design of the experiment giving a list of runs (combination of test lane, operator, detector type and detector type specimen) ● Produce data entry sheets 	<ul style="list-style-type: none"> ● Start the trial and record coordinates of detections on data entry sheets or electronically for direct input
<p style="text-align: center;">How to evaluate statistical results!!!</p>	<ul style="list-style-type: none"> ● Compares the original with the detected target positions and produces a map indicating the detections and false alarms ● Calculates probability of Detection (POD), False Alarm Rates (FAR) and POD versus target depth graphs, ROCs, boxplots etc. ● i.e. 3 x DS, 9 x operators, 6 x test lanes = about 60 graphs, curves (depictions) 	<ul style="list-style-type: none"> ● Enter recorded detection positions (x,y) ● Evaluation of the output (test results)

Preparation

Testarea

Test Objects

Testlanes layout (measurments)

Targets & Clutter (distribution)

List of basic data, targets coordinates (tabular position plan – planned)

Your data

ID	name of test	no. of lanes	lane	width for x-axis [m]	length for y-axis [m]	max. no. of mines	min. mine distance [m]	size of the area for all lanes [m]	date	Show all records
77	TestJuly	6	1	1.1	29.6	98	0.5	1: 1	2009-08-18 09:34:20 ^	delete select this design
			2	1.1	29.6	98		2: 1		
			3	0.85	19.6	50		3: 0.5		
			4	0.85	19.6	50				
			5	0.85	19.6	50				
			6	0.85	19.6	50				

Your data

ID	lane	test object type	target class	HALO diameter [m]	number	smallest depth [m]	largest depth [m]	date	
787	1	PMN	M	0.212	8	0.02	0.15	2009-07-05 20:49:54 ^	delete + change are not possible
787	1	C3	C	0.16	5	0.02	0.15	2009-07-05 20:49:54 ^	delete + change are not possible
781	1	C2	C	0.14	20	0.02	0.15	2009-07-05 20:49:54 ^	delete + change are not possible
775	1	C1	C	0.12	20	0.02	0.15	2009-07-05 20:49:54 ^	delete + change are not possible
789	1	CaT	M	0.16	19	0.02	0.15	2009-07-05 20:49:54 ^	delete + change are not possible
783	1	PPM2	M	0.224	18	0.02	0.15	2009-07-05 20:49:54 ^	delete + change are not possible

Name of test:

Number of test lanes: (HELP) 😊 OK

Rectangular test lane:

lane	width for x-axis	length for y-axis
------	------------------	-------------------

Minimum distance between test objects: [m]

Size of areas without test objects: (in length for the y-axis)

1: [m]

2: [m]

3: [m]

Name of test: **TestJuly** with

Input the test object parameters:

test object type:

HALO diameter: [m]

Lane:	1	2	3	4	5	6
maximum number of mines:	98	98	50	50	50	50
still possible:	8	8	0	0	0	0
number:	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

(not input for number then number = 0)

smallest depth: [m]

largest depth: [m]

target class:

or

Load an ASCII-file: (HELP) 😊



OK

Map of test lanes with planned/real target positions – overview + detail

Name of design: **TestJuly**

Input the Position Plan Parameter: **8524**

test object type:

target class:


HALO diameter: [m]

real x-position: → [m]

real y-position: → [m]

depth: → [m]

or

Load an ASCII-File with the corrected positions: 

Your data

ID	test lane	test object type	target class	HALO diameter [m]	x-position [m]		y-position [m]		depth [m]		date	
					planned	real	planned	real	planned	real		
8524	1	C3	C	0.16	0.87	1	0.12	0.04	0.15	0.15	2009-09-07 16:57:33	change
8525	1	PMN	M	0.212	0.14	0.16	0.15	0.12	0.13	0.13	2009-09-07 16:57:33	change
8526	1	CaT	M	0.16	0.57	0.61	0.61	0.56	0.08	0.08	2009-09-07 16:57:33	change
8527	1	C2	C	0.14	0.08	0.1	0.85	0.84	0.13	0.13	2009-09-07 16:57:33	change
8528	1	PMN	M	0.212	0.84	0.89	1.25	1.21	0.02	0.02	2009-09-07 16:57:33	change
8529	1	C1	C	0.12	0.37	0.4	1.56	1.52	0.07	0.07	2009-09-07 16:57:33	change

number	ypos	xpos	type	targetclass	halodiam	depth	
1	1	0.04	1	C3	C	0.16	0.15
2	2	0.12	0.16	PMN	M	0.212	0.13
3	3	0.56	0.61	CaT	M	0.16	0.08
4	4	0.84	0.1	C2	C	0.14	0.13
5	5	1.21	0.89	PMN	M	0.212	0.02
6	6	1.52	0.4	C1	C	0.12	0.07
7	7	1.68	1.08	C1	C	0.12	0.09
8	8	2.23	0.29	C2	C	0.14	0.13
9	9	2.62	0.99	CaT	M	0.16	0.08
10	10	3	0.33	CaT	M	0.16	0.08

width of lane: a = 1.1
length of lane: b = 29.6
area of lane: a*b = 32.56
total area of halo: 2.01 (= 6.17 %)
total area, not contaminated: 30.55 (= 93.83 %)

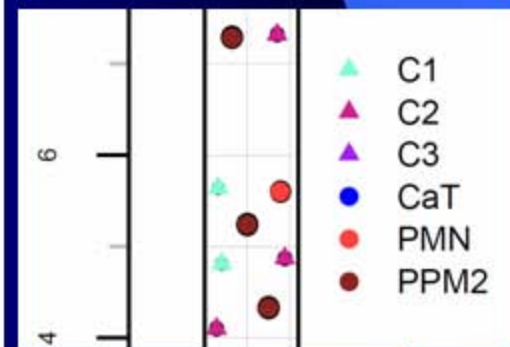
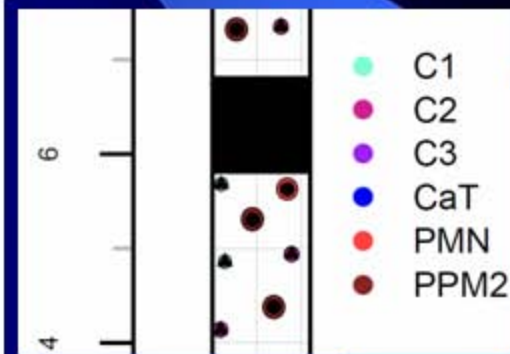
The following targets have minimum distances smaller than the minimum distance 0.5 :

number1	ypos1	xpos1	number2	ypos2	xpos2	distance	
1	24	8.51	0.26	26	8.91	0.54	0.49
2	29	9.87	0.65	30	10.14	0.24	0.48
3	33	11.10	0.29	35	11.59	0.21	0.50
4	50	17.42	0.20	52	17.25	0.17	0.41
5	51	17.58	1.00	53	18.04	0.83	0.49
6	71	23.87	0.82	73	24.36	0.75	0.49
7	77	25.49	0.91	78	25.96	0.80	0.48
8	80	26.68	0.49	82	27.12	0.26	0.50
9	82	27.12	0.26	84	27.61	0.17	0.50
10	85	27.74	0.94	86	28.06	0.56	0.50

All targets are inside the lane

The following targets have distances from the margins of the lane that are smaller than one half of their halo diameters:

number	ypos	xpos	
1	1	0.04	1.00
2	7	1.68	1.08
3	11	3.60	1.07
4	22	7.90	1.06
5	25	8.65	1.02
6	45	15.61	0.06
7	67	22.69	1.04
8	87	28.55	0.09



Design of experiment

Number of sensors

Operators

Employment (randomised)

Employment (randomised)

Forms for data collection

Test execution order

Allocation of deminers and detectors to the test runs

Before the input:

Design of experiment
— Specification of the statistical basis —

Logout
user 2

Test: please choose metal detector test dual sensor test

Test specification: ID:

Parameters:

no. of detector types: [HELP!](#)

no. of detector types for which only one specimen is available: [HELP!](#)

no. of all operators: [HELP!](#)

no. of test lanes:

OK

Your Data

ID	name of test	test specification	metal detector or dual sensor test (no. of detector types for which only one specimen is available)	(serial numbers of each dual sensors types available)	no. of detectors	no. of operators	no. of test lanes	date	Show all records
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Numbers of available specimens of each detector type:

- for metal detector test:
How many detectors of the above number are only one time available.
- for dual sensor test:
This number concerns all detectors (e.g. 1 or 2 times available).

After the input:

Test: TestJuly metal detector test dual sensor test

Test specification: ID:

Parameters:

no. of detector types: [HELP!](#)

no. of detector types for which only one specimen is available: [HELP!](#)

no. of all operators: [HELP!](#)

no. of test lanes:

OK

126	TestJuly	DSMD1	dual sensor test (1)		2	4	6	2010-02-08 08:25:48 ^	delete go to this design
134	TestJuly	MD&GPR	dual sensor test (1)		2	4	6	2010-02-08 09:03:31 ^	delete go to this design
169	TestJuly	Test4DS	dual sensor test (2)		3	6	6	2010-02-07 22:41:45 ^	delete go to this design
173	TestJuly	Test2MD	metal detector test (0)		6	18	6	2010-02-10 13:00:13 ^	delete go to this design
181	TestJuly	Test4DS	dual sensor test (2)		3	6	6	2010-02-08 18:38:50 ^	delete go to this design

Number of operators for metal detector test:

- If the number of the detector types is an odd number, the number of operators should be the number of detectors or a multiple of the number of detectors.
- If the number of detector types is an even number, the number of operators should be number of detectors or a multiple of the number of detector/2.

Examples:
For 5 detector types, the number of operators should be 5, 10, 15, 20,
For 6 detector types, the number of operators should be 6, 9, 12, 15, 18,

Number of operators for dual sensor test:

- The number of the operators can only be a multiple number of the detectors.

Test sheet print -out

Your data

Test: **TestJuly** Test number: 77

Specification: **DSMD1** Specification number: 126

dual sensor test

no. of detectors: 2

serial numbers of each dual
sensors types available (1 or 2): 1

no. of operators: 4

no. of test lanes: 6

The last actualisation

Date: 2010-02-08 08:25:48

IP: 217.83.95.214

Input parameters

number of device types: d = 2
number of operators: o = 4
number of lanes: l = 6
number of starts: s = 12

One specimen is available for each device type

Number of the versions: 1

Downloads

Result from calculation program

Design of experiment

Data: overview: [test77-specification126_plan8a.txt](#)

selected plan: [test77-specification126_plan9a.txt](#)

One specimen is available for each device type

In each cell of the following table two abbreviations are supplied:

operator A1 , A2 , B1 , B2 ,

detector a , b ,

separated by : .

start

	start	lane 1	lane 2	lane 3	lane 4	lane 5	lane 6
1	1	B2:b					A2:a
2	2			A1:a	B1:b		
3	3			A1:a	B1:b		
4	4	A1:a	B1:b				
5	5	B2:b					A2:a
6	6				A1:a	B1:b	
7	7				A1:a	B1:b	
8	8		A2:a	B2:b			
9	9				A2:a	B2:b	
10	10	A1:a	B1:b				
11	11				A2:a	B2:b	
12	12		A2:a	B2:b			

Each row of the following table should be used as the heading of a table in which the positions x and y of the signals have to be written down.

	start	run	lane	operator	device	specimen
24	1	1	1	B2	b	1
23	1	2	6	A2	a	1
17	2	3	3	A1	a	1
18	2	4	4	B1	b	1
5	3	5	3	A1	a	1
6	3	6	4	B1	b	1
1	4	7	1	A1	a	1
2	4	8	2	B1	b	1
12	5	9	1	B2	b	1
11	5	10	6	A2	a	1
9	6	11	5	A1	a	1
10	6	12	6	B1	b	1
21	7	13	5	A1	a	1
22	7	14	6	B1	b	1
3	8	15	2	A2	a	1
4	8	16	3	B2	b	1
7	9	17	4	A2	a	1
8	9	18	5	B2	b	1
13	10	19	1	A1	a	1
14	10	20	2	B1	b	1
19	11	21	4	A2	a	1
20	11	22	5	B2	b	1
15	12	23	2	A2	a	1
16	12	24	3	B2	b	1

continued

Input of results

Used names on graphs

Test: **TestJuly** Test number: 77
Specification: **DSMD1** Specification number: 126
dual sensor test

If you wanted, here you can put down the precise names.
Then these also appear on the graphics.
Maximum 8 signs (only letters without umlauts and numbers) are permitted.

name of detector	name of operator	name of lane (e.g. cell)
b ETrac	B2 B2	1 1
a 422GC	A2 A2	6 6
	A1 A1	3 3
	B1 B1	4 4
		2 2
		5 5

OK

dual sensor test

Test: **TestJuly** | Specification: **DSMD1**

Size of the area in which no test objects should be: 1 — 1 — 0.5

Minimum distance between test objects: 0.5

Number of test lanes: 6

Number of the:

- detectors: 2
- specimens: 1
- operators: 4

Input of results


- by run by run
- as collected data by ID

Your data

ID	run	start	test lane	operator	detector type	specimen	file input with measured data measured data remarks
4033	1	1	1	B2 B2	b ETrac	1	test77-specification126-design4033_res.txt

print protocol ^
input measured data

save

Load an ASCII-file to input measured data for ALL starts: 

Output

[test77-specification126_all_xypos_measuring.txt](#)


Durchsuchen...

- input measured data for all starts
- create for separately run through a file with all detections

OK

If you have data-import with false data  then do you could delete all measured data for all runs.

delete

 Your data area
—— Identification for detections and false alarms ——

The output can later be used as input for other specifications

Output of the computed data

dual sensor test

Test: Specification:

Size of the area in which no test objects should be: 1 — 1 — 0.5

Minimum distance between test objects: 0.5

Number of test lanes: 6

Number of the:

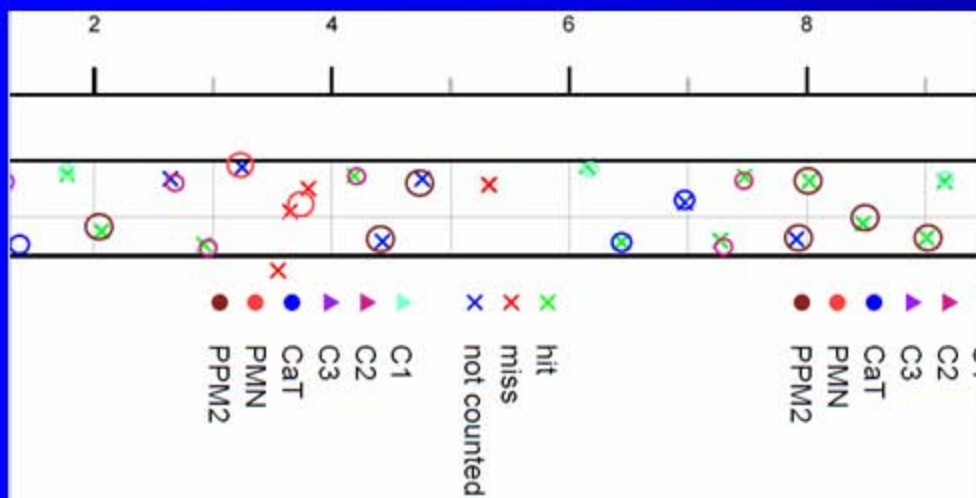
- detectors: 2
- specimens: 1
- operators: 4

Your data

ID	measuring data signals d-file signals s-file signals pdf-file	date
4033	test77-specification126-design4033_res.txt test77-specification126-design4033_D.txt test77-specification126-design4033_S.txt test77-specification126-design4033_DS.pdf	2010-04-14 14:18:21 ^
4034	test77-specification126-design4034_res.txt test77-specification126-design4034_D.txt test77-specification126-design4034_S.txt test77-specification126-design4034_DS.pdf	2010-04-14 14:18:21 ^

run	start	lane	lanearea	haloarea	operator	device	specimen	number	ypos	xpos	type	targetclass	halodiam	depth	detect	add
1	1	1	32.56	2.01	B2	ETrac	1	1	0.04	1.00	C3	C	0.160	0.15	0	NA
2	1	1	32.56	2.01	B2	ETrac	1	2	0.12	0.16	PMN	M	0.212	0.13	0	NA
3	1	1	32.56	2.01	B2	ETrac	1	3	0.56	0.61	CaT	M	0.160	0.08	0	NA
4	1	1	32.56	2.01	B2	ETrac	1	4	0.84	0.10	C2	C	0.140	0.13	0	NA

run	start	lane	lanearea	haloarea	operator	device	specimen	numsig	y	x	add	detect	
1	2	1	6	16.66	1.22	A2	422GC	1	1	0.008	0.772	1	0
2	2	1	6	16.66	1.22	A2	422GC	1	2	0.199	0.139	0	0
3	2	1	6	16.66	1.22	A2	422GC	1	3	0.683	0.084	0	2
4	2	1	6	16.66	1.22	A2	422GC	1	4	0.688	0.709	1	3
5	2	1	6	16.66	1.22	A2	422GC	1	5	1.318	0.100	0	4
6	2	1	6	16.66	1.22	A2	422GC	1	6	1.859	0.089	1	6



Cumulative files for statistical analysis:

[test77-specification169_D.txt](#)

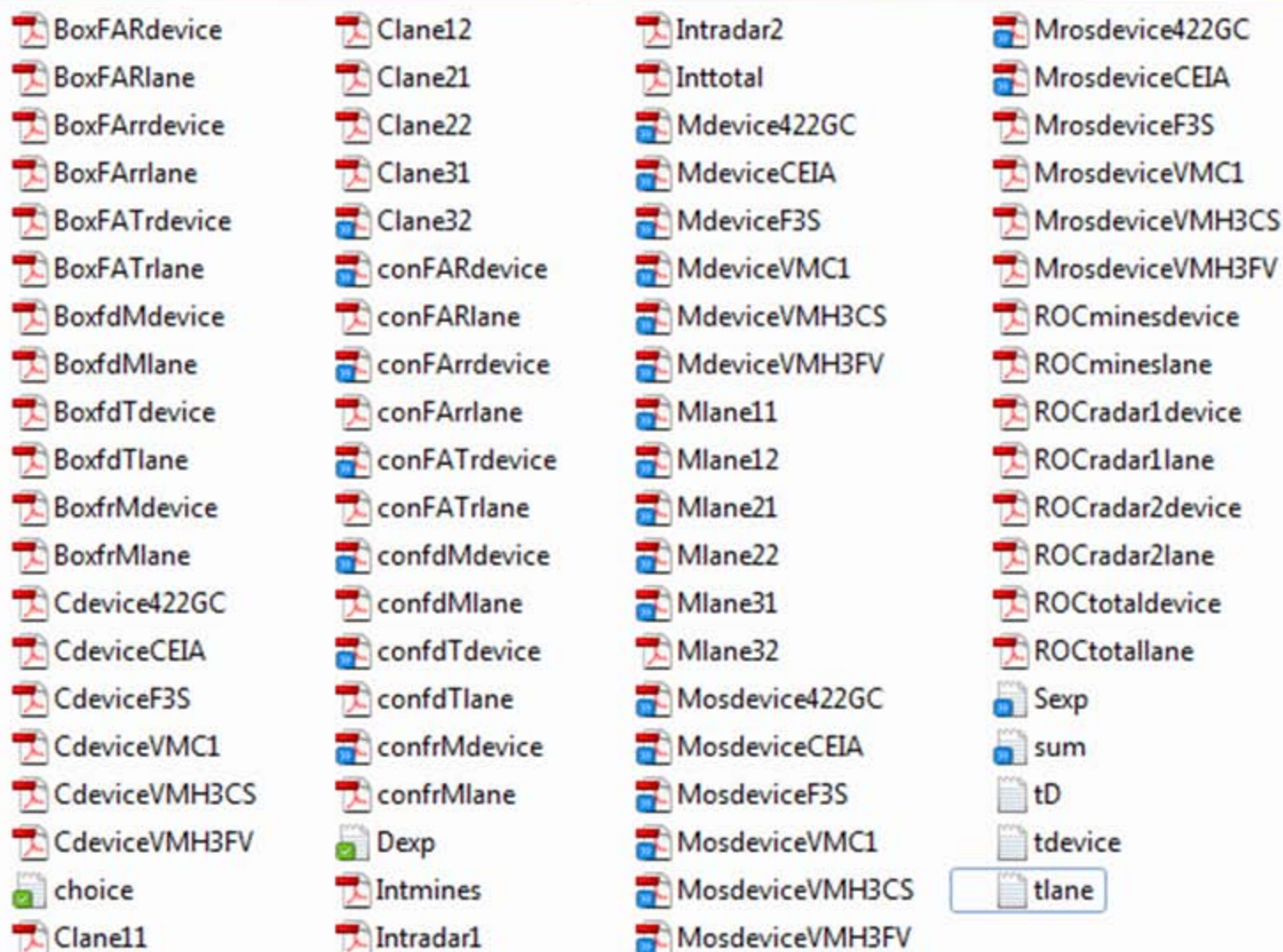
[test77-specification169_S.txt](#)



Your data area

— Statistical analysis of the results —

Statistical output: examples depictions



Test: TestJuly

Specification: Test4DS

Size of the area in which no test objects should be: 1 — 1 — 0.5

Minimum distance between test objects: 0.5

Number of test lanes: 6

Number of the:

detectors: 3

specimens: 2

operators: 6

stars: 24

Selection for calculation

detector	lane	starts	target types	depts [m]
<input checked="" type="checkbox"/> all	<input checked="" type="checkbox"/> all	<input checked="" type="checkbox"/> all	<input checked="" type="checkbox"/> all	min. 0.02
<input type="checkbox"/> VMR2FV	<input type="checkbox"/> 11	<input type="checkbox"/> 1	<input type="checkbox"/> PMN	max. 0.15
<input type="checkbox"/> ALIS	<input type="checkbox"/> 12	<input type="checkbox"/> 2	<input type="checkbox"/> C3	
<input type="checkbox"/> VMR2	<input type="checkbox"/> 21	<input type="checkbox"/> 3	<input type="checkbox"/> C2	
	<input type="checkbox"/> 22	<input type="checkbox"/> 4	<input type="checkbox"/> C1	
	<input type="checkbox"/> 31	<input type="checkbox"/> 5	<input type="checkbox"/> CaT	
	<input type="checkbox"/> 32	<input type="checkbox"/> 6	<input type="checkbox"/> PPM2	
		<input type="checkbox"/> 23		
		<input type="checkbox"/> 24		

runs // selection to not include for the calculation

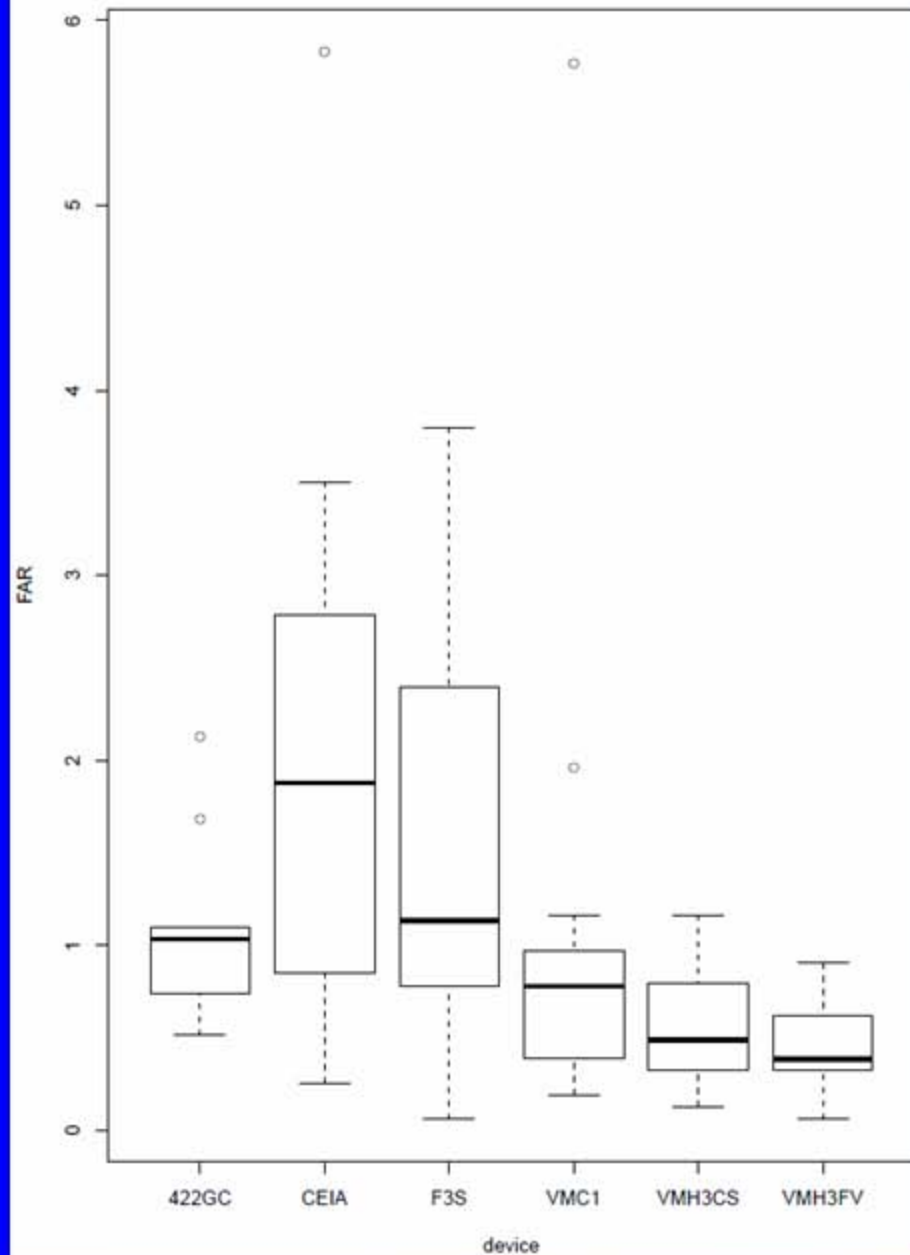
run	start	test lane	operator	detector type	specimen
<input checked="" type="checkbox"/> none					
<input type="checkbox"/> 1	1	1	C3	c	1
<input type="checkbox"/> 2	1	2	A4	a	2
<input type="checkbox"/> 3	1	3	B4	b	2
<input type="checkbox"/> 4	1	4	C4	c	2
<input type="checkbox"/> 5	1	5	A3	a	1
<input type="checkbox"/> 6	1	6	B3	b	1
<input checked="" type="checkbox"/> 143	24	5	C1	c	1
<input type="checkbox"/> 144	24	6	A2	a	2

Your choice!!

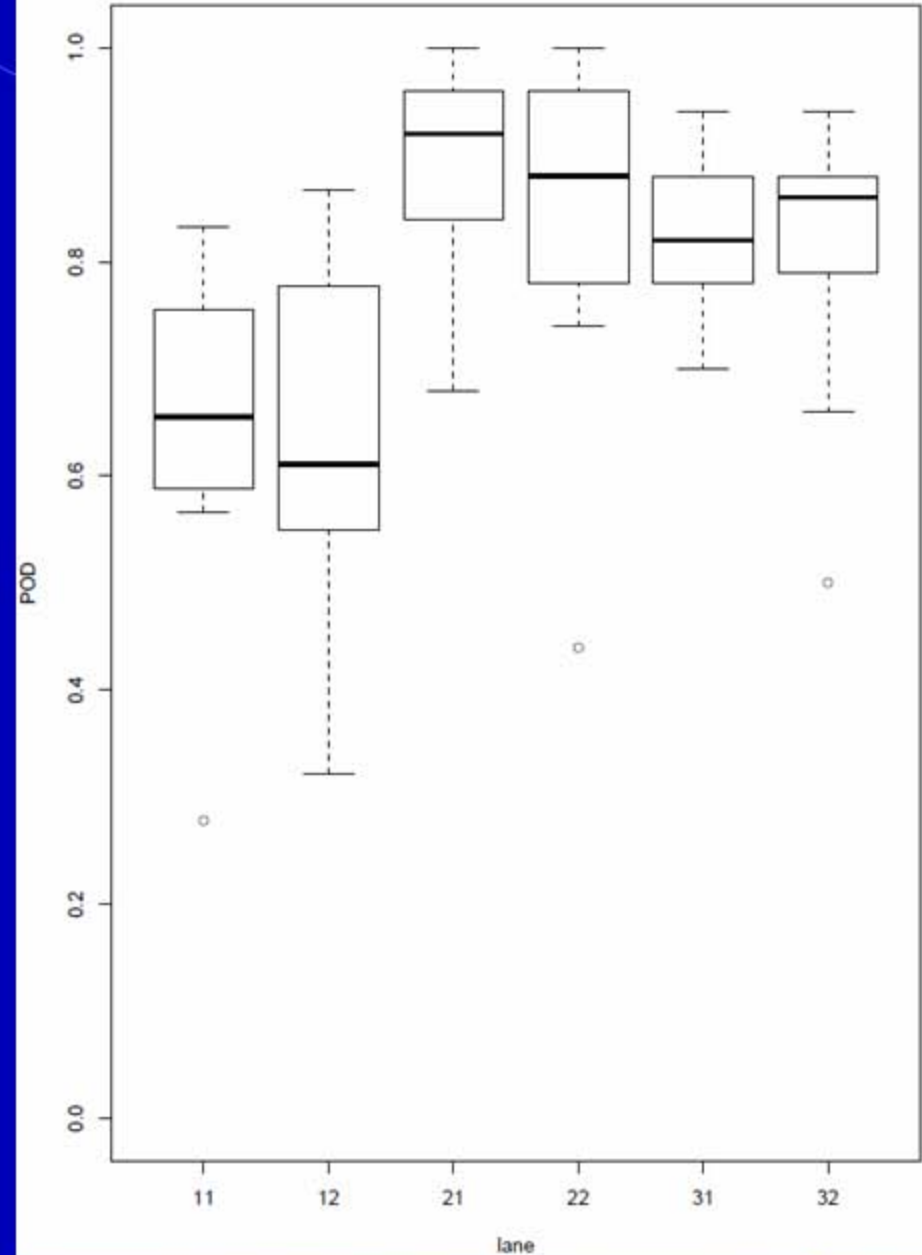
OK

Statistical output: examples Boxplots

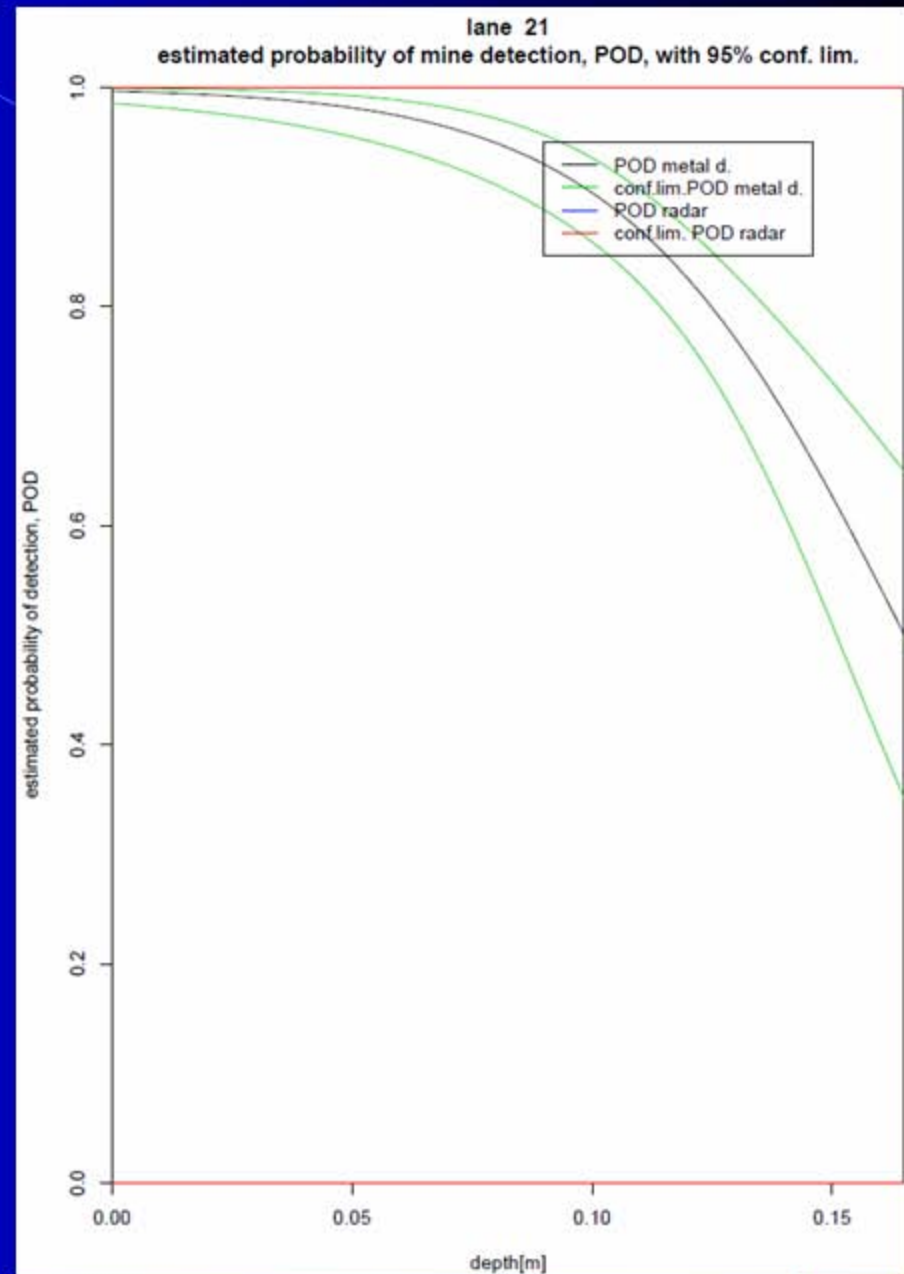
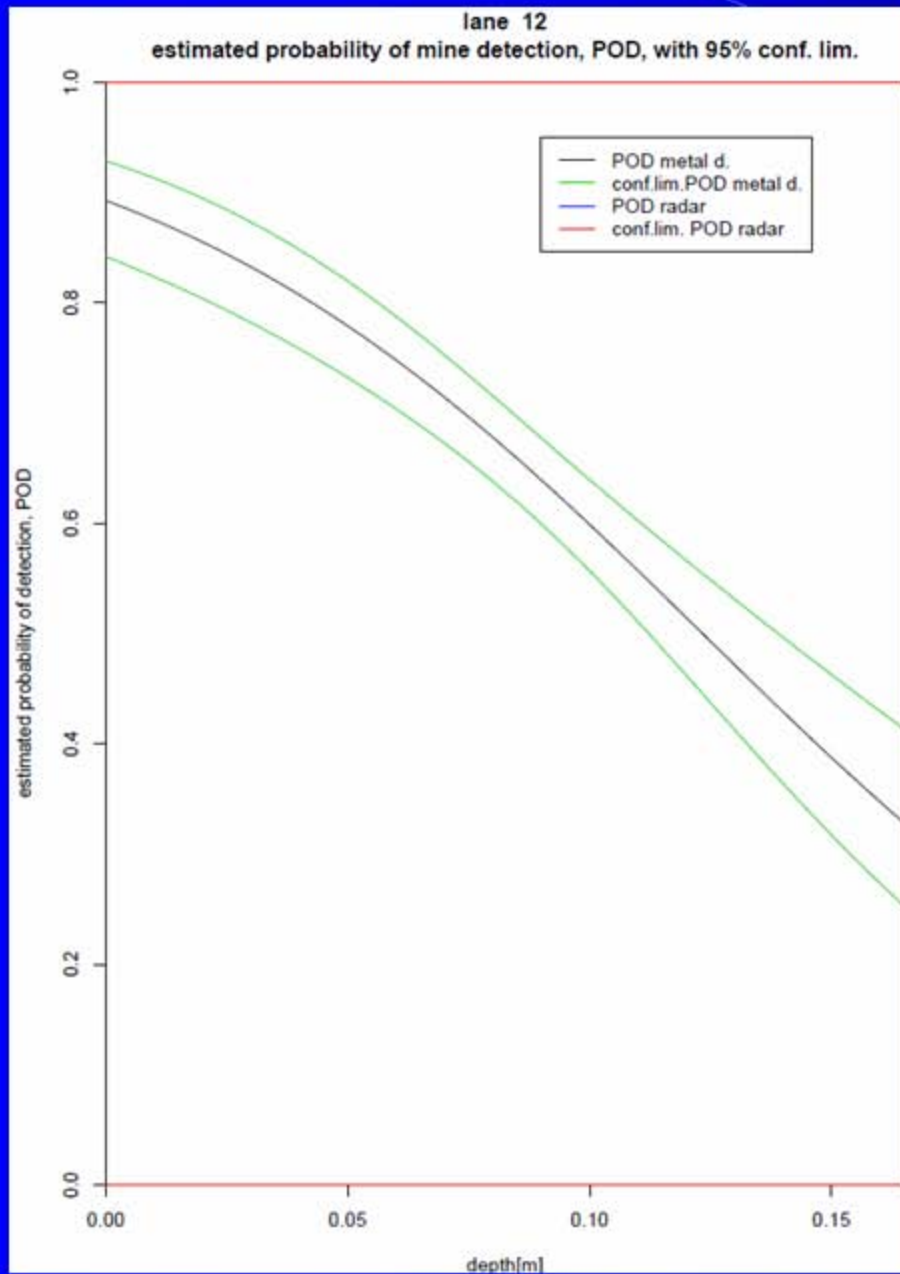
Boxplot of false alarm rate of the metal detector, by device



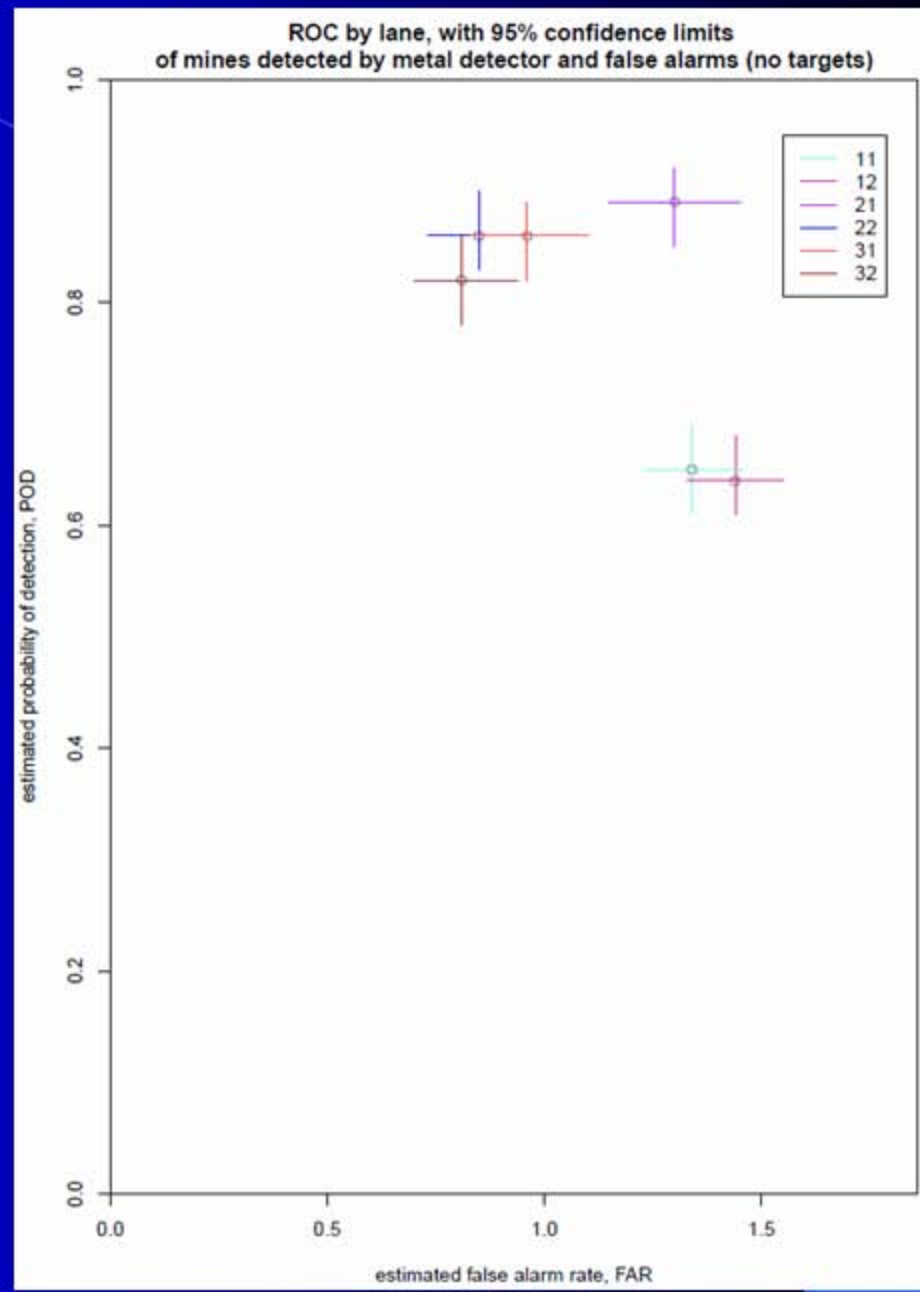
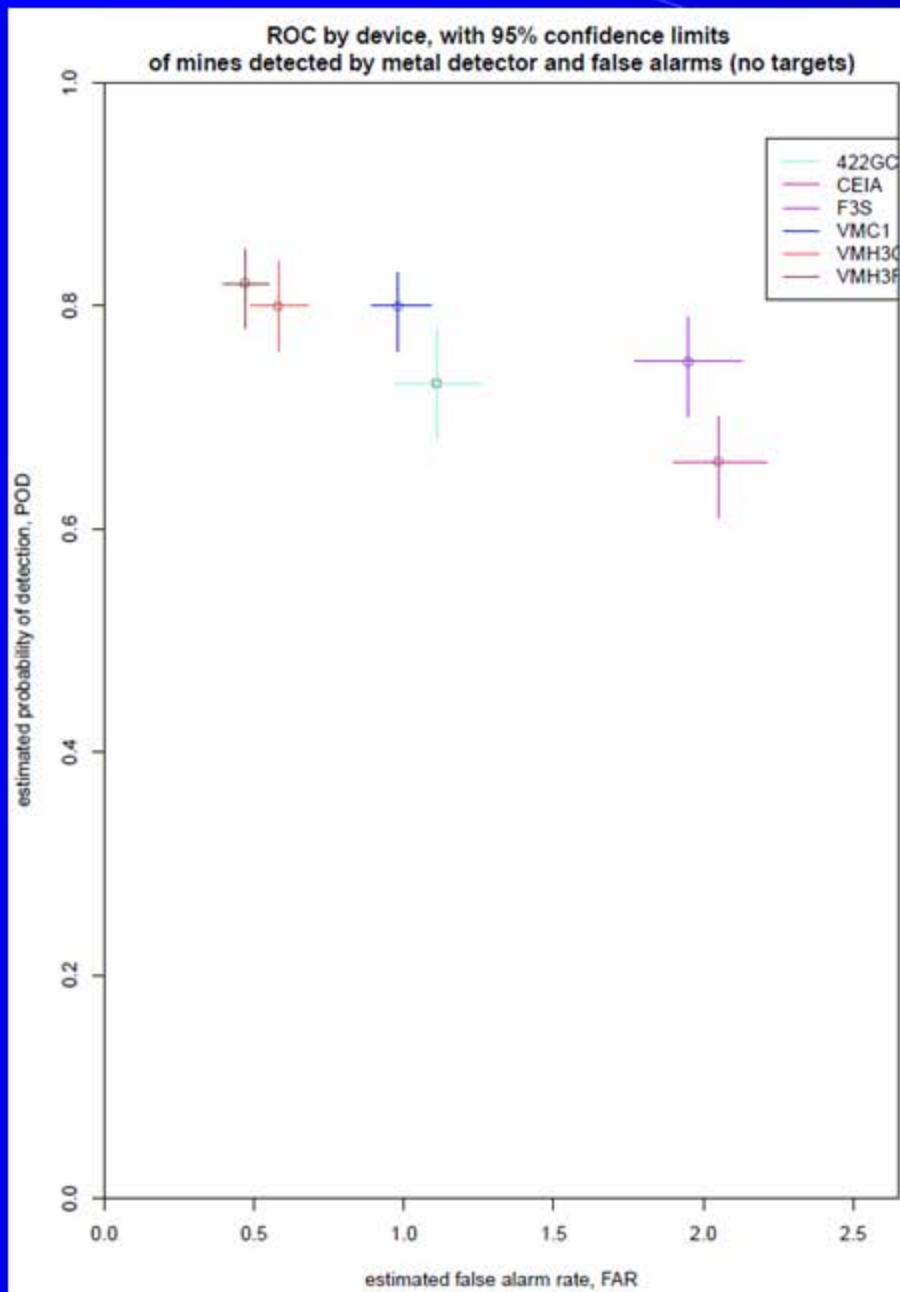
Boxplot of fractions of targets detected by the metal detector, by lane



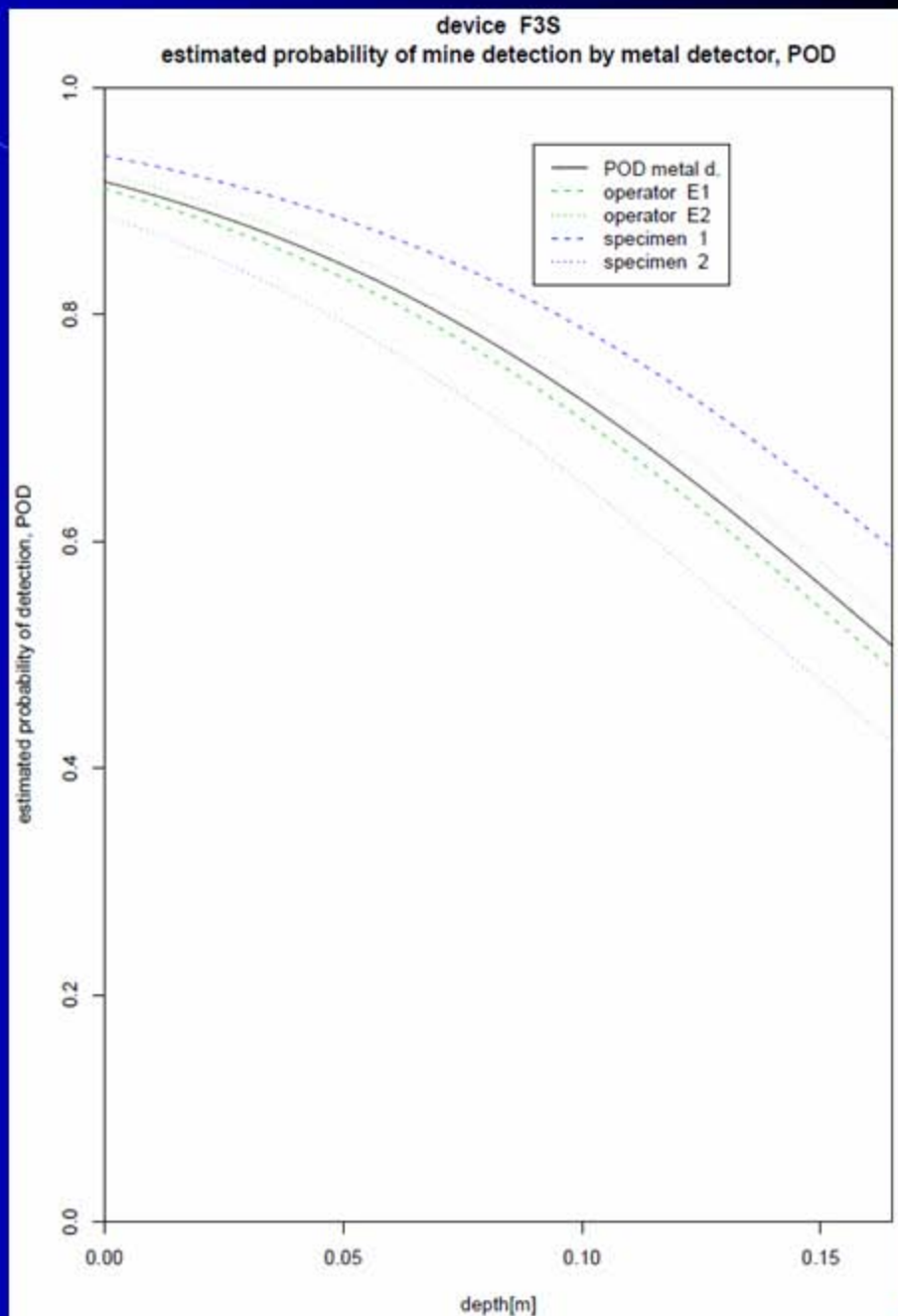
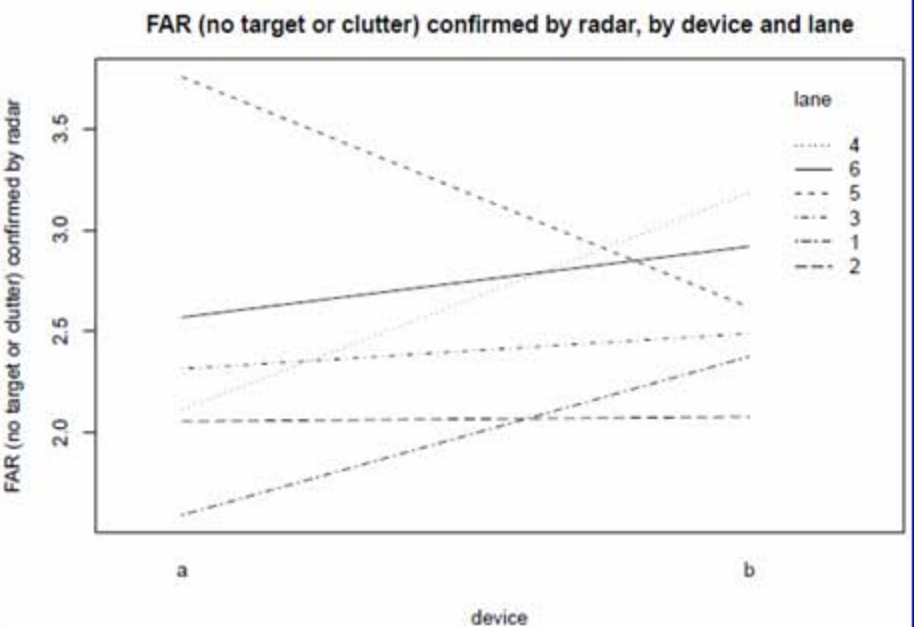
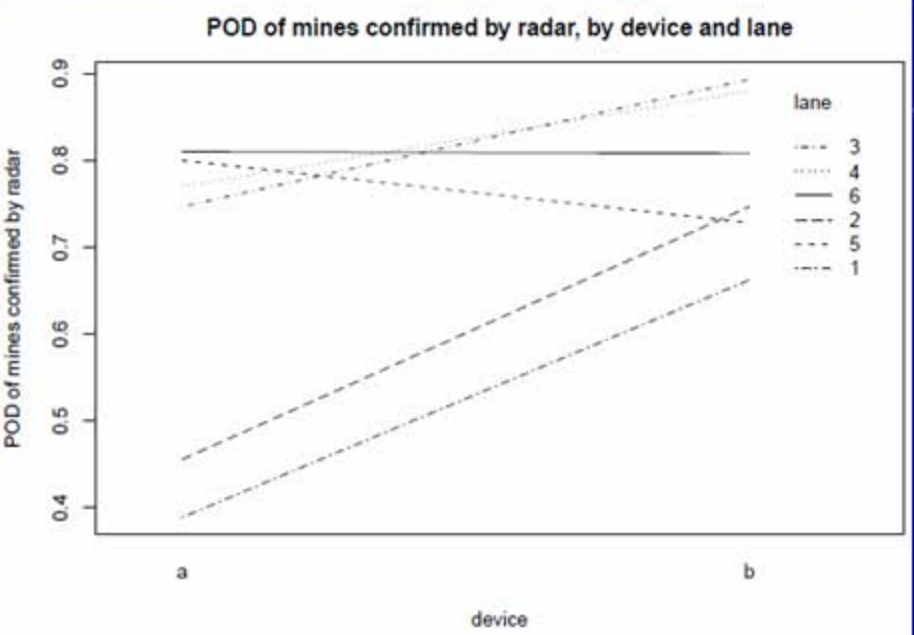
Statistical output: POD and target depth



Statistical output: examples ROC

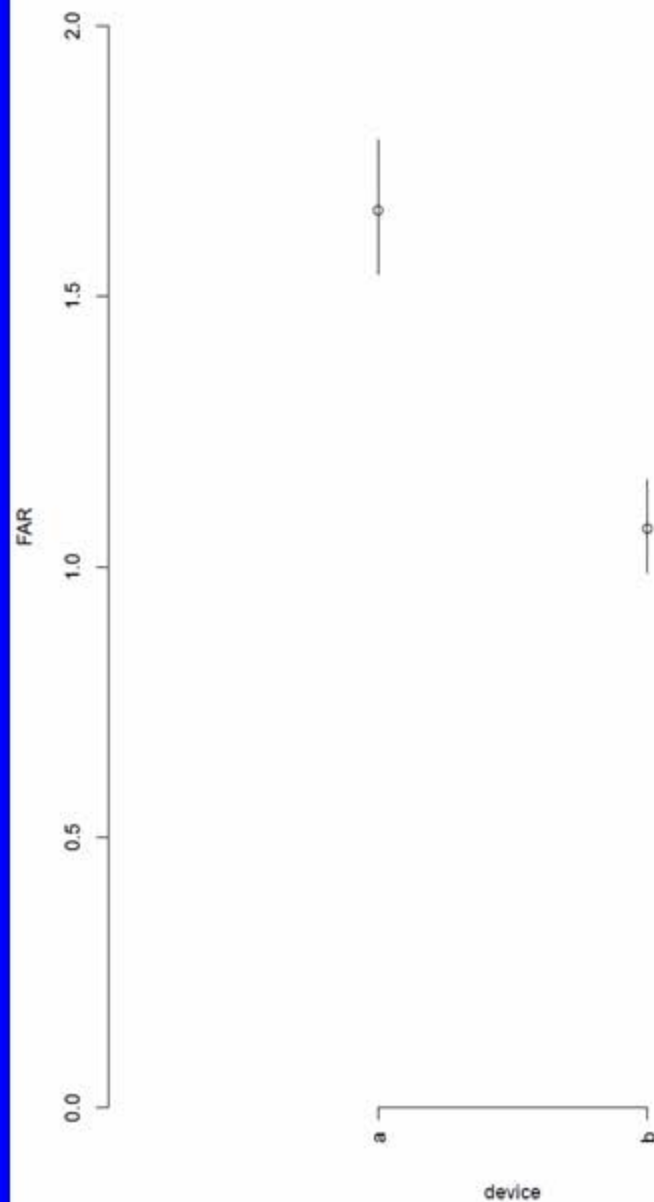


Statistical output: examples POD Mines, operators vs depth, Clutter GPR

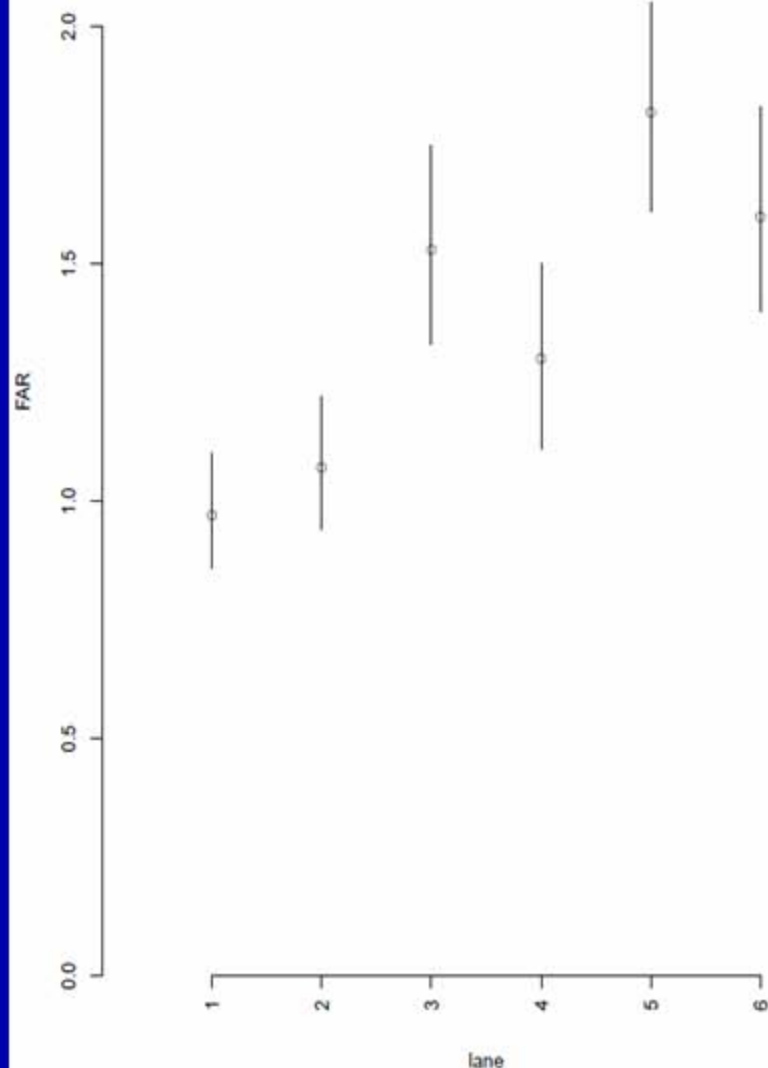


Statistical output: examples FAR no used test objects included

95% confidence intervals for the FAR (no target or clutter) confirmed by radar



95% confidence intervals for the FAR (no target or clutter) confirmed by radar



The following abbreviations are used in the tables (just samples out of 47):

nT number of targets

dT number of targets detected by the metal detector

fdT = dT/nT fraction of targets detected by the metal detector

fdTL, fdTU confidence limits (95% confidence level)

rT number of targets for which the detection is confirmed by radar

frT = rT/nT fraction of targets for which the detection is confirmed by radar

frTL, frTU confidence limits (95% confidence level)

nM number of mines

dM number of mines detected by the metal detector

summary results by runs

run	start	lane	lanearea	haloarea	operator	device	specimen	lanearea	haloarea	nT
1	1	1	32,33	2,01	B2	b	2	32,33	2,01	90
2	1	4	16,48	1,22	A1	a	1	16,48	1,22	50
3	1	5	16,50	1,22	B1	b	1	16,50	1,22	50
5	2	1	32,33	2,01	B3	b	1	32,33	2,01	90
7	2	3	16,49	1,22	B4	b	2	16,49	1,22	50
8	2	6	16,50	1,22	A3	a	1	16,50	1,22	50
10	3	4	16,48	1,22	A2	a	1	16,48	1,22	50
13	4	1	32,33	2,01	B4	b	1	32,33	2,01	90
16	4	6	16,50	1,22	A4	a	1	16,50	1,22	50

summary results by devices

type	la	ha	nT	dT	fdT	fdTL	fdTU	rT	frT	frTL	frTU	nM	dM	fdM
a	458,09	31,58	1340	849	0,63	0,61	0,66	848	0,63	0,61	0,66	670	425	0,63
b	670,19	45,72	1950	1499	0,77	0,75	0,79	1092	0,56	0,54	0,58	975	793	0,81

summary results by lanes

lane	la	ha	nT	dT	fdT	fdTL	fdTU	rT	frT	frTL	frTU	nM	dM	fdM	fdML
1	290,97	18,09	810	433	0,53	0,50	0,57	342	0,42	0,39	0,46	405	229	0,57	0,52
2	227,08	14,07	630	420	0,67	0,63	0,70	338	0,54	0,50	0,58	315	216	0,69	0,63
3	148,41	10,98	450	375	0,83	0,80	0,87	333	0,74	0,70	0,78	225	192	0,85	0,80
4	148,32	10,98	450	367	0,82	0,78	0,85	289	0,64	0,60	0,69	225	191	0,85	0,80



NO

Questions!