

# TESTING OF GPS CONTROLLED SALT SPREADING AND DATA COLLECTION

## TEST METHOD DESCRIPTION

Version 0.9: April 2012 – Draft version

## INTRODUCTION

This document describes the process of testing and evaluating GPS controlled spreading and optionally also data collection to Vinterman, the Danish winter administration system. The test is designed to be carried out at Research Centre Bygholm within 2-3 hours in the end of a day with indoor spreader tests. The purpose of the test is to answer the questions:

- How well does the GPS controlling system works?
- How well does automatic data collection works?

The reason for establishing this test has been problems at the Danish marked with products who didn't work properly regarding GPS controlled spreading as well as data collection. In the same way it has been an important issue that the cost for running the tests should be low.

The test program is handled by Research Centre Bygholm, the Danish Spreader Development Group and the Vinterman group.

Tests ordered by manufactory companies will only be published if the company allows it. Test ordered by the Danish Road Directorate or other spreader customers will be published including comments from the manufactory company. The companies will have two weeks for preparing these comments.

In future it is a goal to present a standardized test method offered by Research Centre Bygholm similar to the indoor spreader tests.

## TEST PROGRAM

For each spreader this test is expected to last 2-3 hours. It will normally take place before or right after the indoor test. The test program is:

1. Salt loading and installation of video camera on a bar on top of the spreader
2. Evaluation of online data connection to Vinterman – only if this should be tested
3. Recording of the spreading route. This can be done with the spreader and truck or by a simulator in another car
4. Preparation of the route for replay – optionally by a separate tool
5. Replay of the route four times. Two times at 30 km/h and two times at 50 km/h
6. During the last replay an undefined detour during transport will be added in order to test the possibilities for the algorithm to hit the track again
7. At last the recorded video material is evaluated at the office by the test staff together with the tested company

If online data collection is present during the test, this will be evaluated by the Danish Road Directorate afterwards.



## TEST FIELD

The present test field is placed on a closed airfield just a few hundred meters away from Research Centre Bygholm. This gives a test field with no ordinary traffic where we can have permanent markings on the road for test purposes. All road markings are made according to a reference system with measurements starting at the inner tip of the O1 traffic circle.

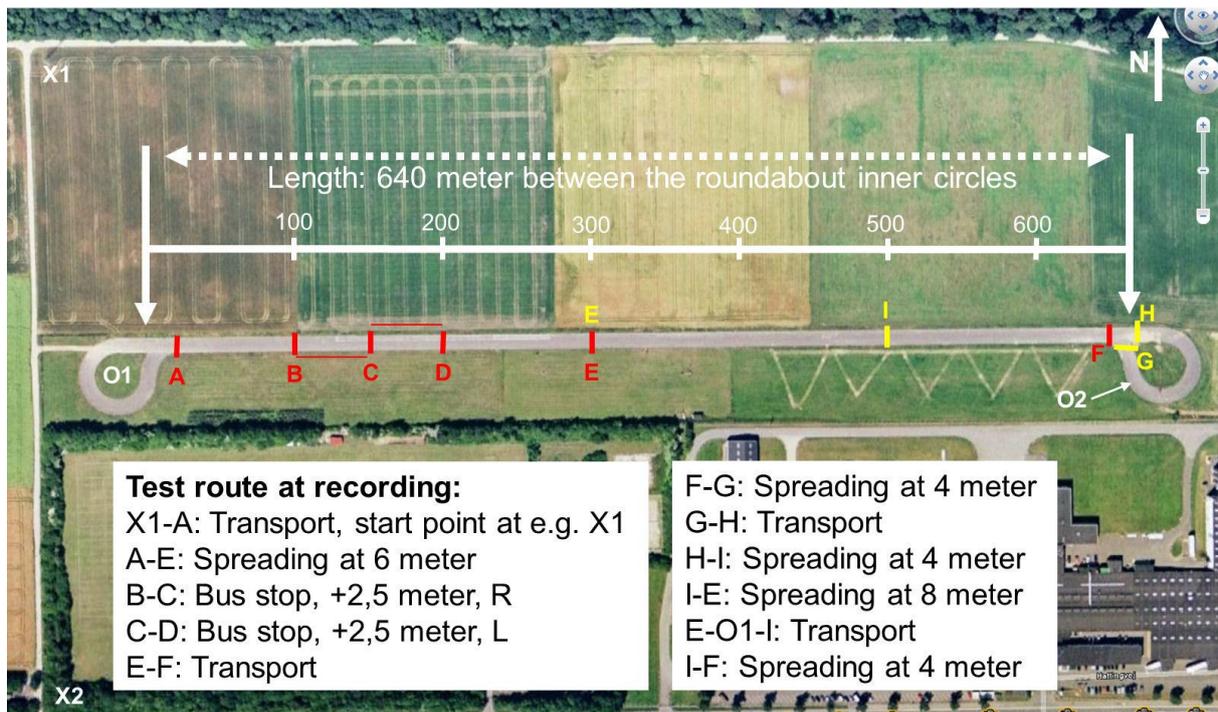


Figure: Test field with reference system starting at the inner tip in the traffic circle O1. All lines are marked as cross-lines on the road including a letter at the roadside

Detailed description of how a route should be driven during recording:

1. X1/X2-A: Transport, start point at X1 or X2 is chosen free
2. A: Spreading in 6 meter starts
3. B-C: Bus stop of 2.5 meters at the right side
4. C-D: Bus stop of 2.5 meters at the left side
5. E: Spreading stops
6. F: Spreading 4 meter starts just when entering traffic circle O2
7. G: Spreading stops after a little more than one round and there is transport during the last part of second round in O2
8. H: Spreading starts at 4 meters while leaving O2
9. I: Spreading width increased to 8 meters
10. J: Spread stopped and then transport down to and around in O1 and return to I
11. I: Spreading in 4 meters
12. F: Stop spreading and continue around in O2 for finishing the test

The test track length is 640 meters between the inner tips of the two traffic circles and has a road width of 9-10 meters. The reference system has zero at the inner tip of the traffic circle O1 to the left of the image (west). All points are localized in the reference system:

- A: 20 meters
- B: 100 meters
- C: 150 meters
- D: 200 meters
- E: 300 meters
- F: 620 meters - should be measured as 20 meters before the tip on the inner circle of O2
- G: Line parallel to the right side of the road
- H: 640 meters - or exactly at the tip inner circle of O2

Both bus stops are quite large and in total 50 meters long and simulates 2.5 meter extra road in each side. The size is chosen to improve the possibilities to identify all changes in width and symmetry.



*Figure: Traffic circle O2 during test in September 2010 – 43 metres in diameter when driving in the right side*

Traffic circle O1 and O2 are generally quite large with a length of approx. 135 meters when driving in the right side. During testing the traffic circles are assumed to have a width 4 meters located on the right side corresponding to the outer edge of the traffic circle. This will be marked on the road with buckets.

During testing O2 is traversed almost twice in a row:

- At the first time with salting at 4 meters for a little more than one full round from F to G

- Right after the beginning of the second round salting must stop at G and there is transport to H where salting is started again when leaving the traffic circle

The total salted area is 5090 m<sup>2</sup> divided as described in the table below.

Section	Length m	Spreading width m	Total area m <sup>2</sup>
A-B	80	6	480
B-C	50	8,5	425
C-D	50	8,5	425
D-E	100	6	600
F-G	160	4	640
H-I	125	4	500
I-E	200	8	1600
I-F	105	4	420
<b>Total</b>	<b>870</b>	<b>5,9</b>	<b>5090</b>

Figure: Length and area of each section of the test field

The actual test is about 2240 meters long measured from the start point A and until end point F. In the last test the transport length G-F grows due to a detour.

The above given length is mainly made to ensure correct markings on the road. When the companies do the recording before the test, the actual marking on the road must be followed even if it varies a little from the figures described in this document.

## DRIVING ON THE TEST FIELD

### PAINTED LINES AND DOTS ON THE TRACK

When possible the reference points are marked on the road as horizontal lines with some distance indicator markings showing the distance to each reference point.

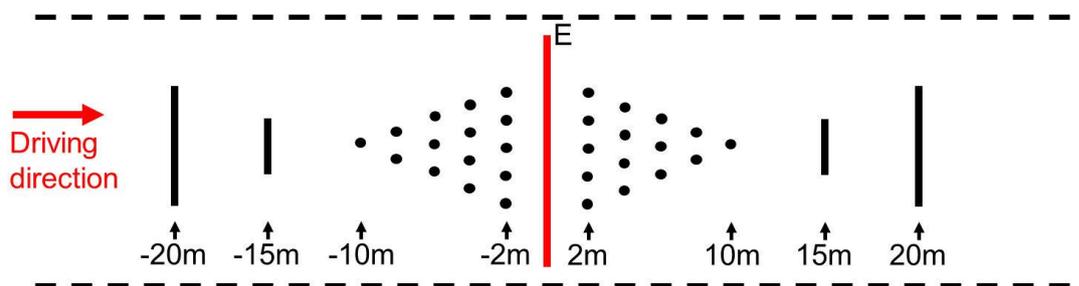


Figure: Reference point E and distance indicators marked on the road



Figure: Video from the top of the spreader showing reference point A and some of the distance markings

The distance indicators are only marked on the road where there is room enough for it. There are e.g. fewer markings in O2.

## DRIVING INSTRUCTIONS

Generally, the route must be driven in the right side of the road. There will be a few buckets on the centreline to indicate it, although it is not marked at the road. At the straight part these buckets will be placed exactly at the reference lines to ensure that they are easy to identify from the truck. Inside O2 there will be more buckets to ensure that the right side of the road is used.

During testing, the following spreading widths are used:

- 4 meters corresponding to salting in the lane as the truck itself is driving in
- 6 meters, equivalent to driving at a normal two-lane road where salting is handled from the right side in a single pass
- 8 meters, equivalent to driving at a wider two-lane road which still is handled from the right side in a single pass.
- 8.5 meters when the two bus stops are passed on the 6 meter road.

Traffic circles are usually one-way and must be taken in the right side while left side on the test field is assumed not to be paved. Therefore, salting width is only 4 meters in the traffic circle and the centreline of O2 will be marked with buckets.

If the spreader can't be set to the exactly spreading width or symmetry, it must be set as close as possible – just like what's going on in the real world.

During recording of the trip one person from the test team will participate in the truck or car with a control box simulator car. During the four replays one person from the test team must also be present in the truck.

When online data collection to Vinterman is tested, the data collection must be stopped and started between each trip.

### **DOSAGE, SPEED ETC.**

After recording of the route it is replayed four times:

- Two trips at 30 km/h on the straight part of the route
- Two trips at 50 km/h on the straight part of the route

The speed in the traffic circles is expected to be around 20 km/h during all four trips, which is normal for a truck.

During recording it is accepted that the speed is slower close to the reference points to improve the recording quality.

If everything seems to work during the first tests, the last test will have a detour to simulate road work during the transport section before the last salting section. The detour will start at O1 and leave the track to e.g. X1 or X2 without salting. The purpose is to see if the GPS controlled spreading algorithm can find back on the track again before salting the final section I-F.

To ensure the easiest way of evaluating the video film, the dosage setting must be:

- Spreading liquid using nozzles: At least 30 ml/m<sup>2</sup> but 40 ml/m<sup>2</sup> are preferred if possible
- Spreading dry salt using a disc: At least 20 g/m<sup>2</sup> dry salt

When tests are carried out with liquid, it is recommended to use natural water instead of brine with salt.

## **PREPARATION BEFORE THE TEST DAY**

In the two weeks just before a test the company is welcome to reserve time at the outdoor test field. In the same period the company is welcome to test the data collection connection to Vinterman if data collection is covered by the test.

When data collection is tested, the logging distance must be as low as possible. It is preferred with logs for every 20-40 meter and of course when a setting is changed.



Contact about booking of the test field:

- Krister Persson, Krister.Persson@agrsci.dk, +45 2068 4175

Contact about Vinterman:

- Bo Sommer, bs1@vd.dk, +45 7244 3433

## VIDEO EVALUATION

Just after the test all video material is evaluated by the test staff together with the company who has ordered the test.



*Figure: Evaluation of the spreading actions just after the outdoor test*

The video for each test run is evaluated and it is detected when each change actually occur. This is filled into the scheme shown at next page. After the evaluation the company will receive a copy of the result-scheme.

During the evaluation the following principles are followed for dry salt:

- Salting starts when the first salt is seen at the road
- Symmetry settings is seen when the disc is moved, a mechanical move of the spreader system or when salt is placed elsewhere on the road
- Salting stops when the salt amount is significant lower

When evaluating liquid spreading with nozzles:

- Salting starts when the first water is seen at the road
- Symmetry settings is seen when there is power on all extra nozzles (growing width) or when the power of the extra nozzles has disappeared
- Salting stops when the power of the nozzles has disappeared

Ref. point	Action	1: 30 km	2: 30 km	3: 50 km	4: 50 km
A	Start, 6 m	2	-4	5	4
B	Bus stop right, 6+2,5	0	2	3	-5
C	Bus stop left, 6+2,5	-2	-4	0	8
D	End of bus stop, 6 m	3	0	-4	7
E	Salting stops	0	-3	22	-7
F	Start at O2, 4 m.	-6	-4	7	0
G	Salting stops	0	0	0	0
H	Salting starts leaving O2, 4 m.	-4	-4	-5	-5
I	Change 4->8 m	-7	-4	-1	-4
E	Salting stops	-10	-11	-4	-4
O1	Transport				Detour: Yes
I	Salting starts, 4 m	-4	-9	0	4
F	Salting stops	10	-10	4	-3

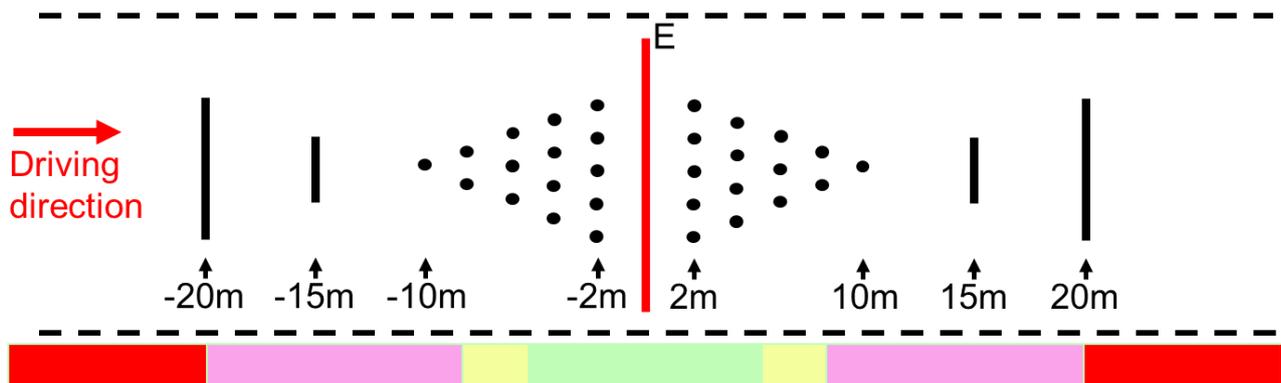
Figure: Example of test result scheme (random test result) filled in during the video evaluation

In generally negative values are used if a change is seen before the reference line, positive values are used if the change is seen after the reference line.



## TEST REPORT: GPS CONTROLLED SPREADING

The test results will be part of the test report in a version, where all cells gets a colour according to the precision given below.



Color	Definition
Fine	A fine start or stop is when the change occurs within 5 meters from the specified reference point. 5 meters are equal to 0,3 second driving at 60 km/h
Acceptable	A just acceptable result will be when a change occur with a precision of 8 meters from the specified point equal to 0,5 second at 60 km/h
Unacceptable	An unacceptable result is a precision of 8-20 meters corresponding to 0,5-1,2 second at 60 km/h
Missed change	A missed change is when it takes place more than 20 meter away form the reference point or does not take place at all

Figure: Categories for the accuracy of a change in a reference point

The entire test result scheme will be coloured based on the criteria shown above. A fifth column is defined as the maximum deviance in the four measurements at each reference point. This column is also coloured, but here is given an extra 5 meters in acceptance criteria (green within 10 meter, yellow within 13 meter, pink within 25 meter).

Ref. point	Action	1: 30 km	2: 30 km	3: 50 km	4: 50 km	Max-Min
A	Start, 6 m	2	11	5	4	9
B	Bus stop right, 6+2,5	0	2	3	-5	8
C	Bus stop left, 6+2,5	-2	-4	0	8	12
D	End of bus stop, 6 m	3	0	-7	7	14
E	Salting stops	0	-3	22	-7	29
F	Start at O2, 4 m.	..	..	..	..	..

Figure: Example of the evaluation colours at part of a test result (random data)

Having coloured all the cells, the number of cells with each colour is counted and made relative to the total number of cells. This final relative value for each colour is weighted with the points given in the first line of the table below. Based on this, the test result is converted into a single figure.

Test example (random figures)	Green	Yellow	Pink	Red	Total
Weight for each colour in the score	0	0,5	2	8	
Number of cells with each colour	48	6	5	1	60
Relative number of cells, %	80,0	10,0	8,3	1,7	100
Test result: Score	0,0	5,0	16,7	13,3	<b>35,0</b>

Figure: Translating coloured cells into a total score at 35 points

In the fictive example at the figure above, the GPS test gave a total of 35 points.

Other examples are:

- 0 points will be a perfect result with only green cells
- 25 points will be given for a result with half green and half yellow cells
- 800 points will be given for a not working system with just red cells

As mentioned earlier the test report will not decide whatever 15, 35 or 80 points is good or bad. Each customer has to decide where the minimum quality demand must be and how a low score could be weighted higher in his total evaluation of the spreader.

In the same way a customer must decide by himself whatever he will accept “red cells” which are missed changes or changes taken place with very low accuracy.

## TEST REPORT: DATA COLLECTION

The test report covering data collection to Vinterman will not end up in a single score as the GPS controlled spreading test. This report will contain a main table with key figures as shown in the example below.

Company, date: Key Figures	Reference	Recording	1: 30 km/h	2: 30 km/h	3: 50 km/h	4: 50 km/h
Vinterman database activity ID		3.939	3.943	3.947	3.954	3.957
Dosage setting, ex. liquid, ml/m <sup>2</sup>	40	40	40	40	40	40
Speed at straight forward sections, km/h	30/50		27-33	27-33	46-51	46-50
Number of identified reference points	12	12	12	12	12	12
Salting length, m	870	920	916	933	899	906
Salted area, m <sup>2</sup>	5.090	5.200	5.401	5.433	5.021	5.394
Brine consumption, l	204		207	208	194	190

Figure: Key figures from the data collection in Vinterman – random data



Within Vinterman the following figures is checked:

- Is the dosage setting as ordered?
- Is the speed at the straight sections as ordered?
- Can all reference points be identified in data?
- Salting length is calculated to identify the difference from specified route
- Salted area is calculated as spreading width multiplied by the length to identify the difference from the specified route
- Consumption of brine and/or dry salt is shown directly from the counters in the data collection
- Does any other data look strange?

In general it is expected, that all changes can be found in the data collection as specified. Length and area will normally not exactly as specified due to differences in spreading width settings and company specific algorithm settings, where a little bias might be added before start and after a stop command.

Salted length is compared section by section with the visual evaluation of the GPS Controlled spreading as shown in the example below.

<b>Company, date</b>										
<b>Section</b>	<b>Length m</b>	<b>Recording length, m</b>	<b>1: 30 km/h</b>		<b>2: 30 km/h</b>		<b>3: 50 km/h</b>		<b>4: 50 km/h</b>	
			<b>Length, m</b>	<b>Length, m</b>	<b>Length, m</b>	<b>Length, m</b>	<b>Length, m</b>	<b>Length, m</b>		
			<b>Video</b>	<b>Data</b>	<b>Video</b>	<b>Data</b>	<b>Video</b>	<b>Data</b>	<b>Video</b>	<b>Data</b>
A-B	80	88	88	91	96	93	90	88	95	98
B-C	50	50	54	58	53	54	44	48	52	50
C-D	50	54	48	52	54	55	52	47	50	52
D-E	100	112	102	102	111	112	95	96	92	97
F-G	160	150	150	152	154	152	152	155	149	149
H-I	125	121	130	131	122	125	117	118	129	134
I-E	200	197	198	197	203	208	202	199	194	197
I-F	105	104	115	112	121	122	105	114	108	130
A-E	280	304	292	303	314	314	281	279	289	297
H-E	325	318	328	328	325	333	319	317	323	331
<b>Total</b>	<b>870</b>	<b>876</b>	<b>885</b>	<b>895</b>	<b>914</b>	<b>921</b>	<b>857</b>	<b>865</b>	<b>869</b>	<b>907</b>

Figure: Section lengths based on the registrations on video and data collection – random data

This table compares the length from the data collection with the length seen at the video during the action. A-E and H-E is calculated as two extra sections defined as information between clear “Start” and “Stop” of salting.

The purpose of this last table is to visualize the accuracy of the data collection compared to the visual registration.



The last figure in the report is typically a map showing parts of the driven trip. This map gives an idea about the accuracy of the GPS itself and will be used to evaluate the precision of the connection between the GPS position and the data.

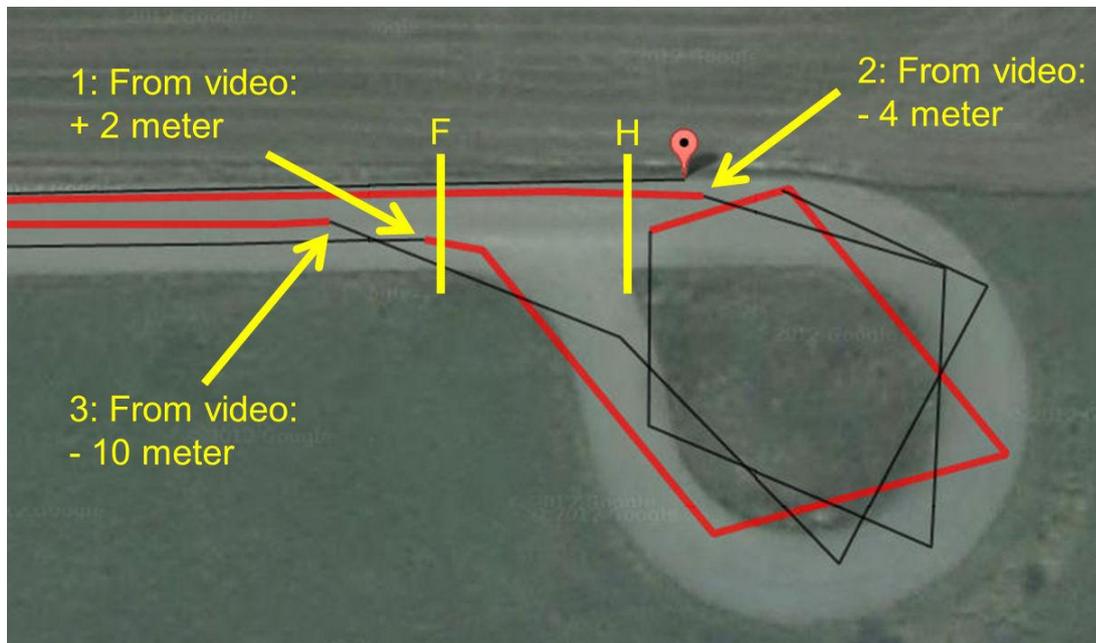


Figure: Example of data collection from O2 with red lines connecting data points during salting and black lines connecting points during transport

In the example above it is easy to identify each road side during the trip and tree positions have been evaluated:

1. At the video salting starts two meters after F, but the coordinates says app. one meter before
2. At the video salting starts four meters before H which are equal to what is seen at the coordinates
3. At the video salting stops 10 meters before F which are equal to what is seen at the coordinates

In this example there is a fine connection between coordinates, data collection and what is seen at the video. The GPS quality is also fine and right and left side of the road easily is identified.

When the company gets the report for comments, all data from the data collection will be forwarded in Excel format.