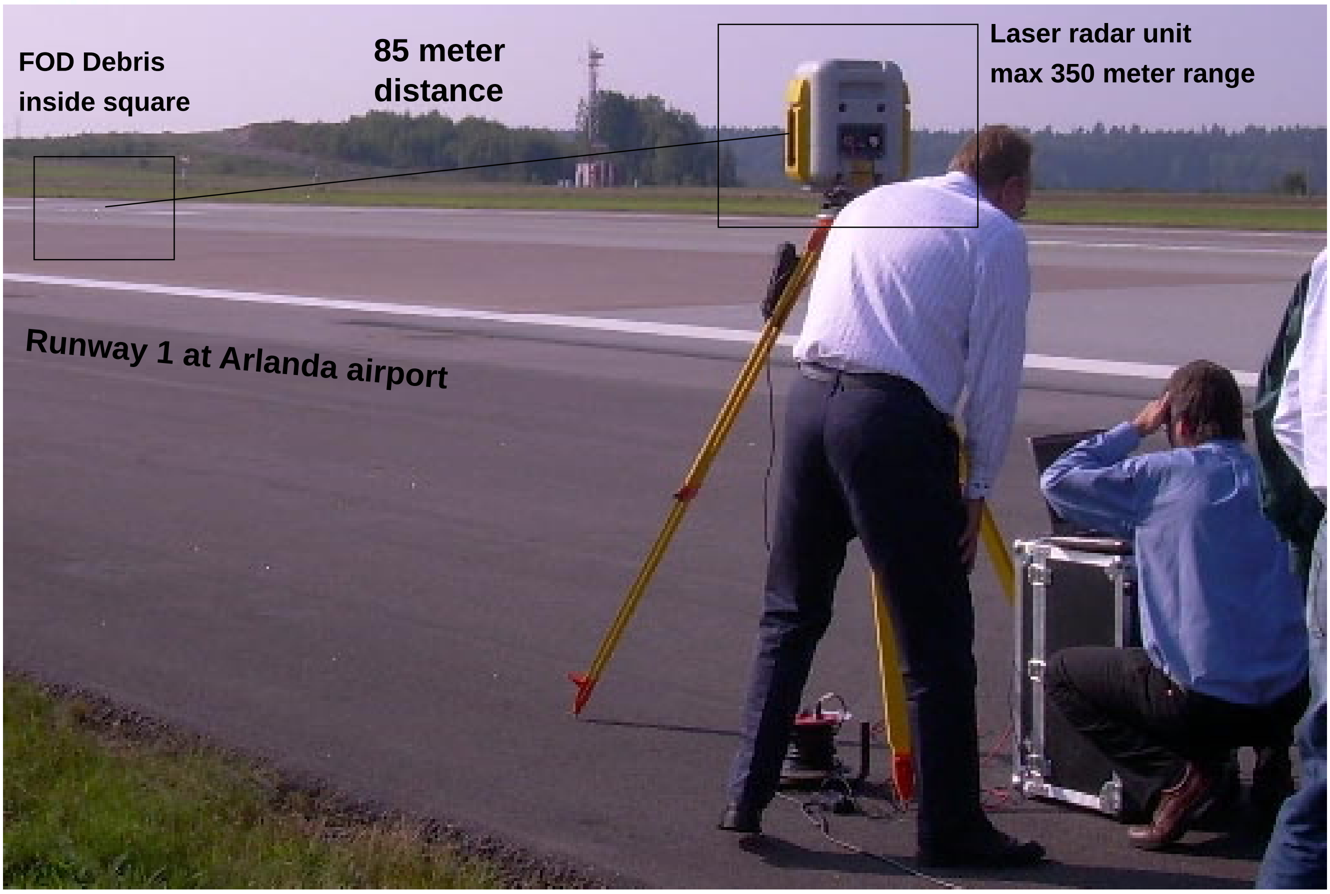
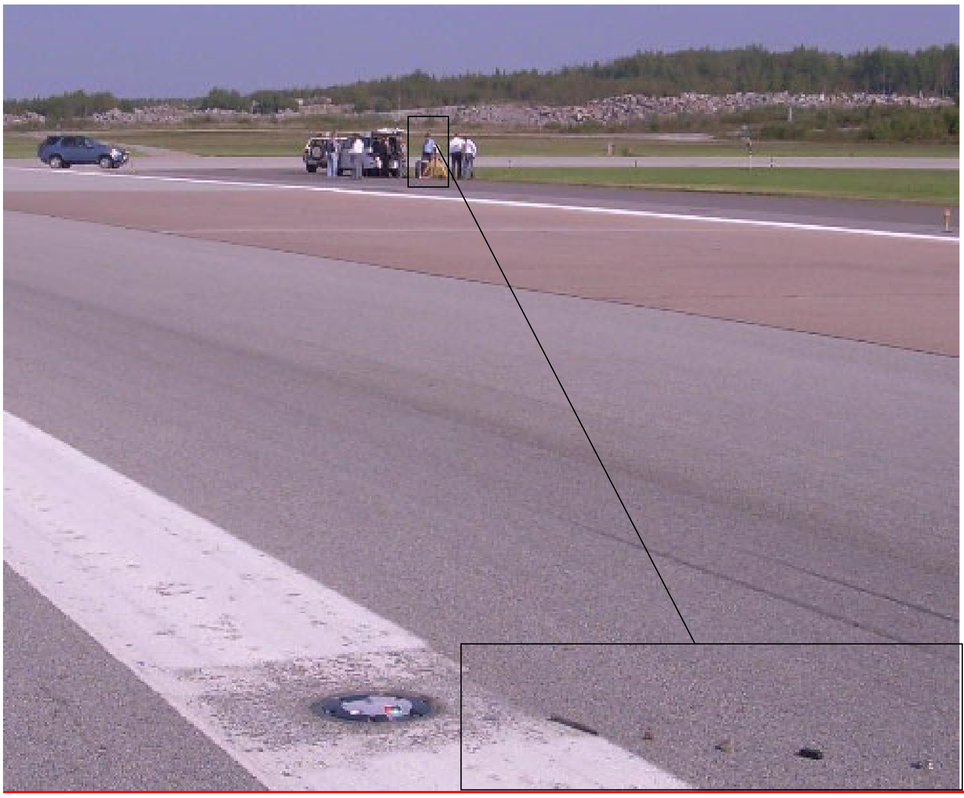
FOD Tests at Arlanda Sep 2006

Summary of results and related comments



Set up of test unit at runway nr 1 at Arlanda Airport Stockholm Sweden
Runway is 45 meter in width . It is very fine weather and sunny.



View the opposite way.

On right side of the FOD we have the central runway lamp down in the asphalt.
The height of the scanner was 1,5 meter and 1,1 meter over the runway edge.
Differences was not large and we do only show readings form 1,1 meter as this is closer to what real installations will have.
The width of debris in total is about 60-70 cm.

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Runway lamp white light in runway centre

Bolt with M 10 thread length about 200 mm Hexagonal head with 15 mm dimension.

Stone of gray granite from runway ballast. Dimensions about 15x15x20 mm.

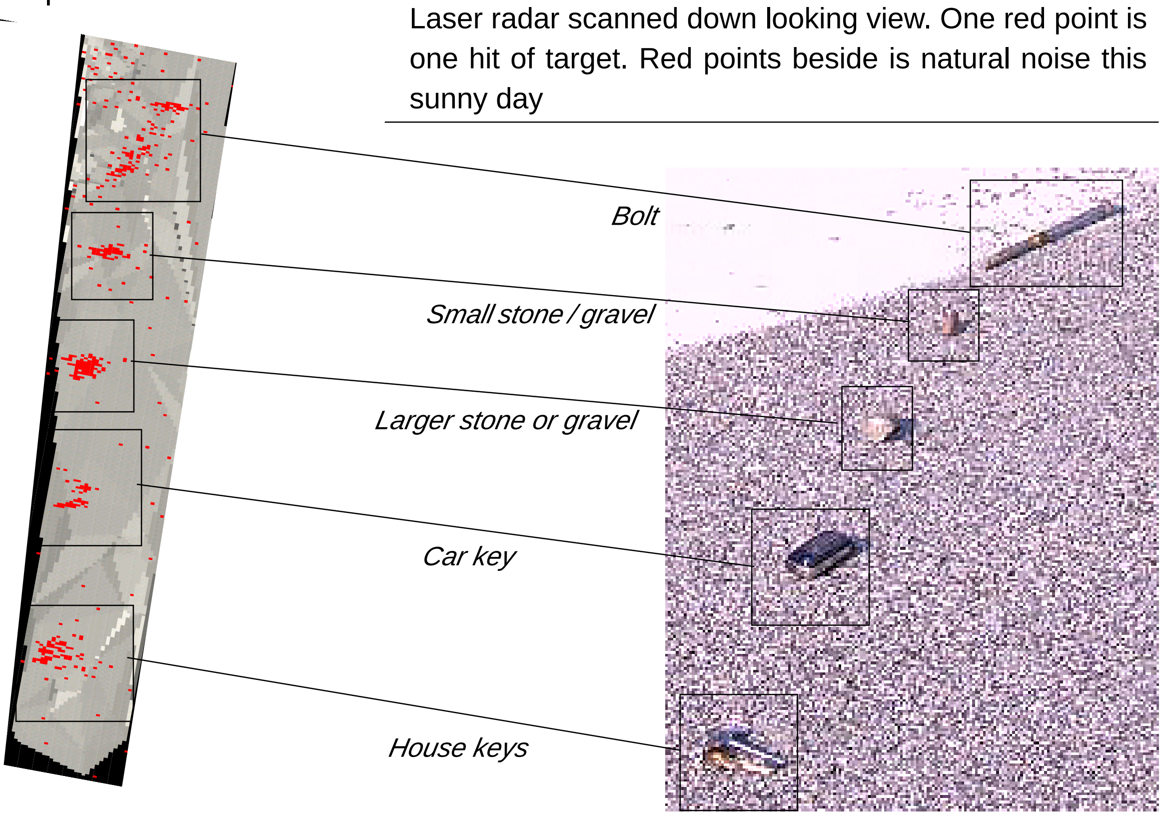
Stone of granite but larger. About 25x30x35 mm in dimensions

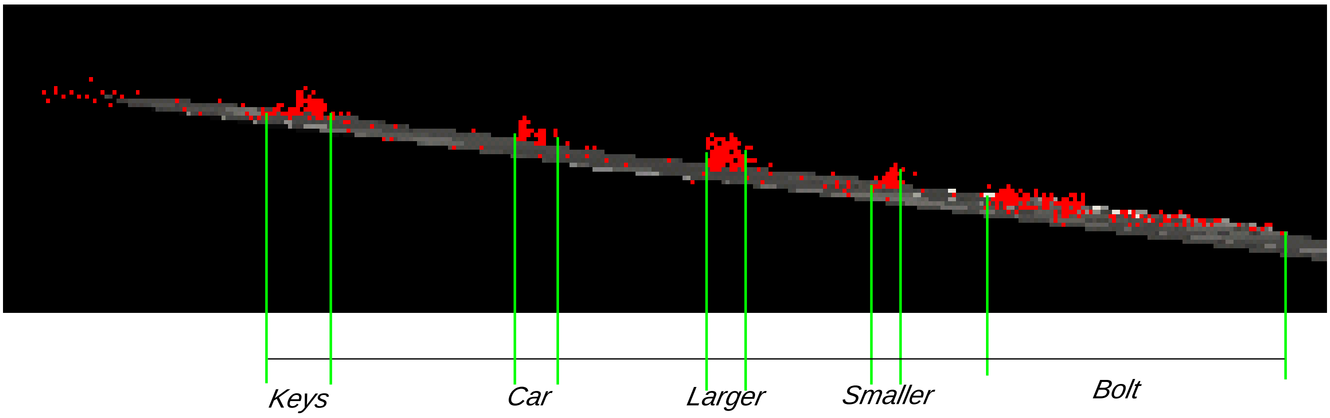
Keys from a WW Golf car. Dimensions of the face to scanner is 14 mm kin height and 64 mm in length
Partially chrome e plated surface like a mirror.

Key set with 3 keys and a bottle open er. Surface to scanner is about 20 mm in height and 50 mm in width. The keys are not solid and a broken up surface.

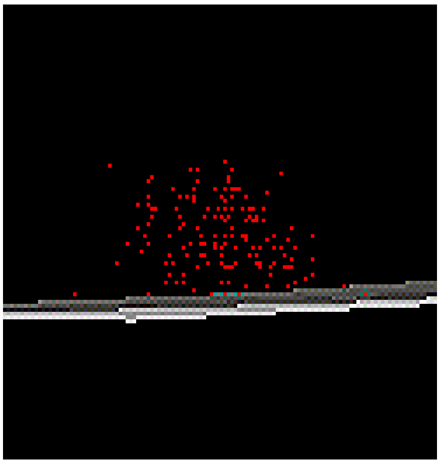
Asphalt surface under strong sun shine. No clouds.
This area is scanned by a grid of 2x5 mm from 85 meter distance and height is about 1,1 meter. This will give a beam close to parallel to the surface.

Laser radar scanned down looking view. One red point is one hit of target. Red points beside is natural noise this sunny day

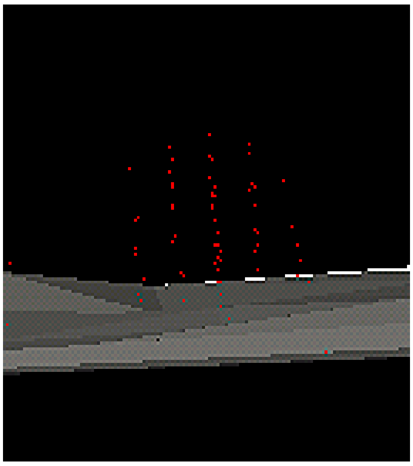




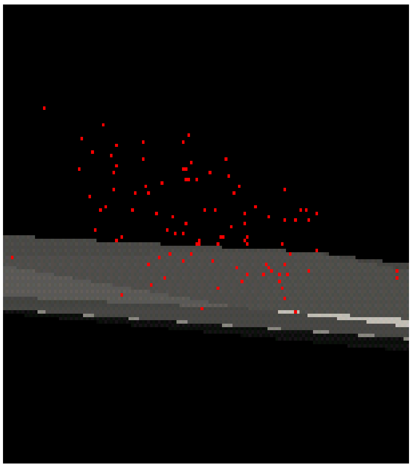
Close to horizontal view of debris laying on the runway. Gray is the surface skin of asphalt When the debris was added the changes are coloured in red. In this view the contrast between surface and debris is extremely clear and easy to see and calculate.



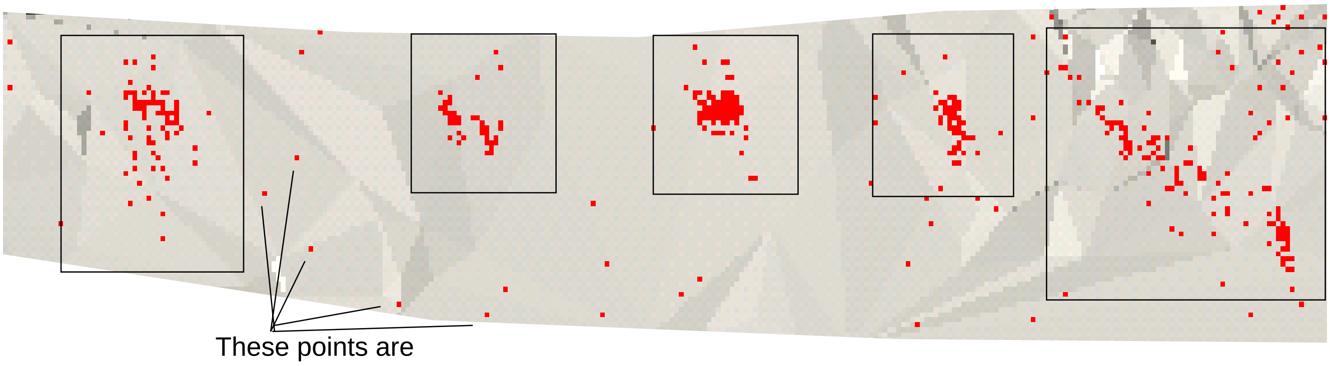
Front view of large stone cloud of points. This is between 120 and 150 hits on the stone surface.



Front view of small stone cloud of points. When calculated we get 61 hits on the stone surface



Front view of house keys cloud of points.Here the tartget was splt up a lot but we still get far over 100 hits



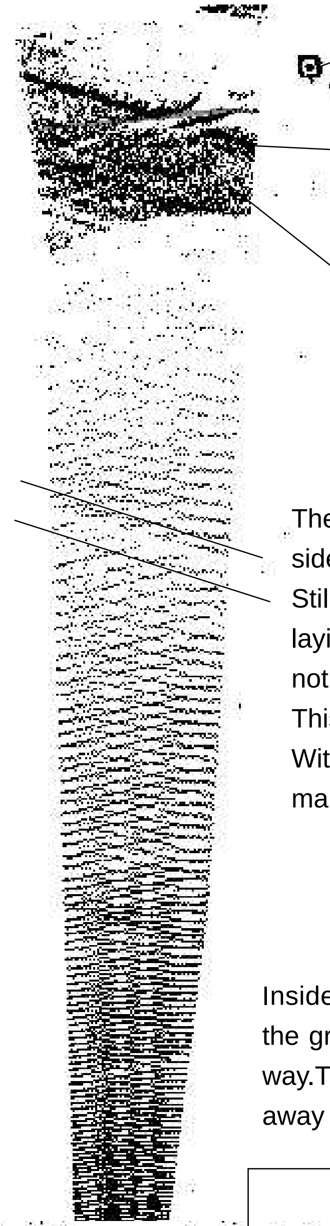
The house keys gives a splitted surface as they are so. There is no solid front surface but the system can anyway see this FOD in a reliable way

Point density of cloud is many times higher here than the normal surface induced noise.

Car key with partially mirror surface make some drop outs and reflexes. It is still there.

The 2 stones are dense in cloud corresponding to the surface of the granite. They appear a bit larger as partial hits can be detected as hits. Here the 5 mm beam diameter makes it larger.

Bott gives some reflexes making hits close to the bolt. The hexagonal head gives a more dense local cloud of points. If parts of beam hits asphalt and parts the bolt the sum distance can be somewhere in the area and is hard to predict. Some of the close points are possible made this way.



Prism on runway just beside debris

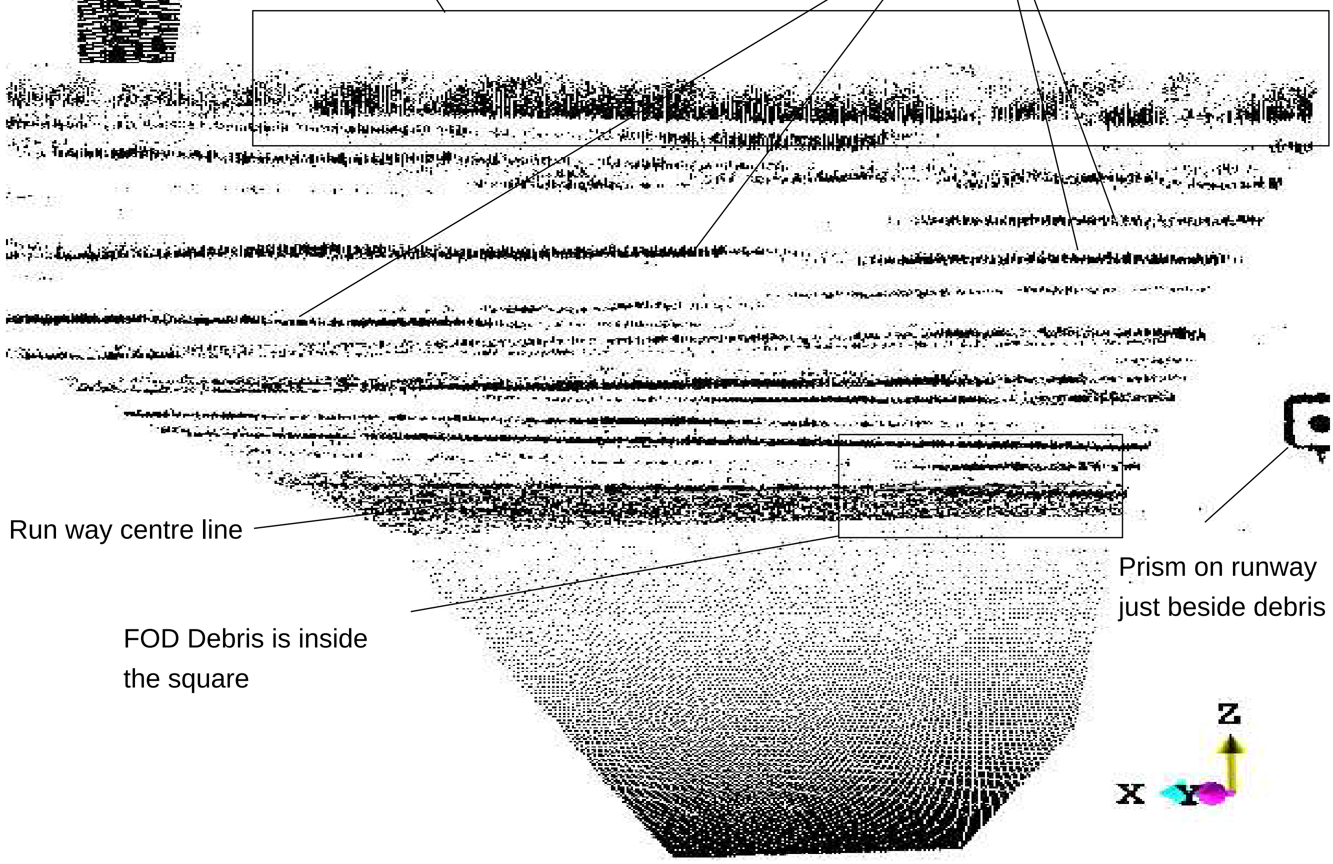
Darker area is run way centre where surface is deviated and there is a white reflectoive surface

Debris is in this area just in front of centre line

The surface on this side of centre line is having a a more angled laser beam than opposite side. This gives a far more dense pattern of readings.
Still there are some variations caused by the less flat surface of runway. The asphalt laying machines move along the runway and the tracks are caused by them. The eye can not see this defect but the mm resolution of the scanner will do.
This indicates that a snow surface can easily be measured as a layer on top the asphalt. With additional calculations the thickness of snow layer can be measured and a thickness map made by this.

Runway is not 100% flat. On raf side the centre line the angle of the laser beam is very flat and almost parallel to the surface.
Smallest deviations are then very visible and the parallel almost horizontal lines. The 3D gives a very extreme view and deviations of a few mm is very visible and enlarged.

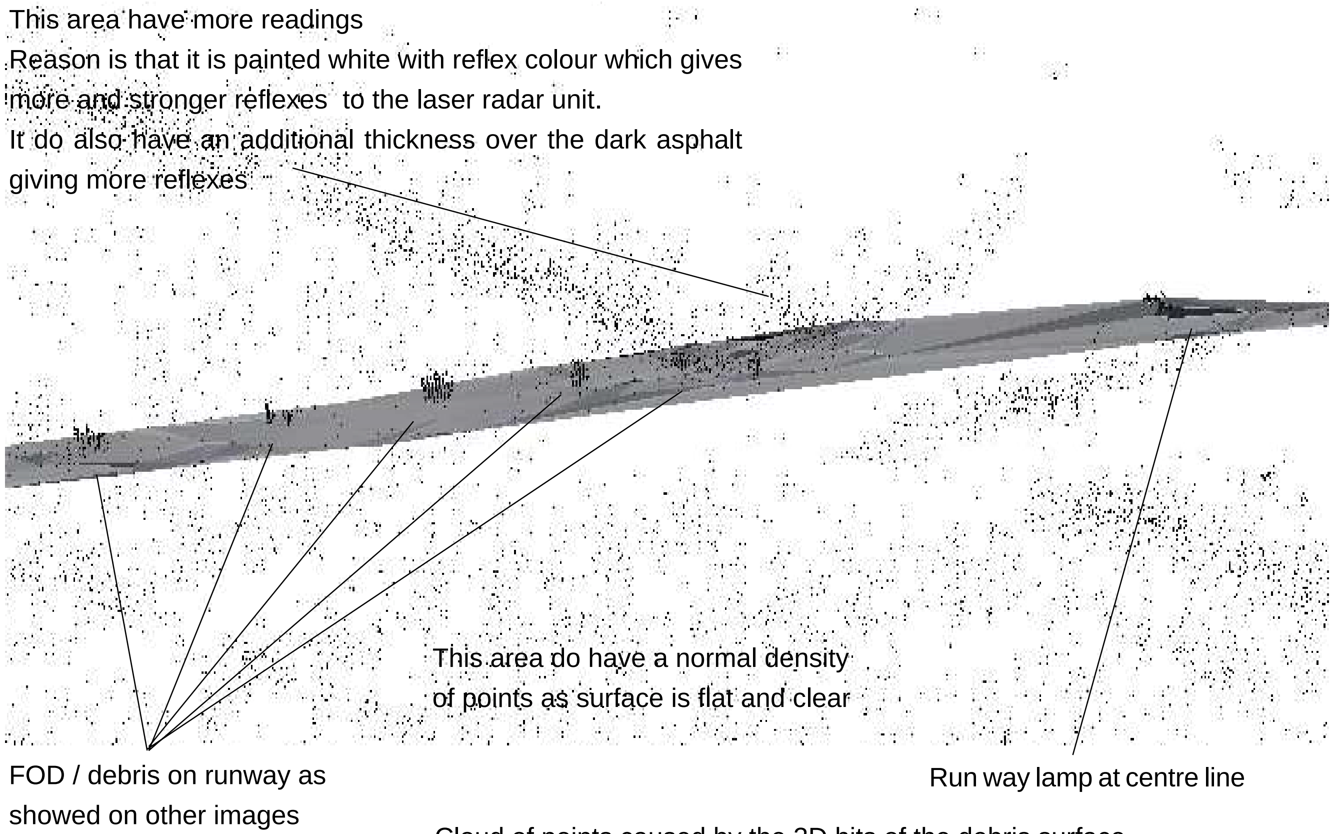
Inside the square there is the grass ar far side of run way.This is about 150 meter away



Run way centre line

Prism on runway just beside debris

FOD Debris is inside the square



Cloud of points caused by the 3D hits of the debris surface.

*　1

In this perspective we can clearly see a far larger density of points. This is one way they are confirmed as a problem.

*2

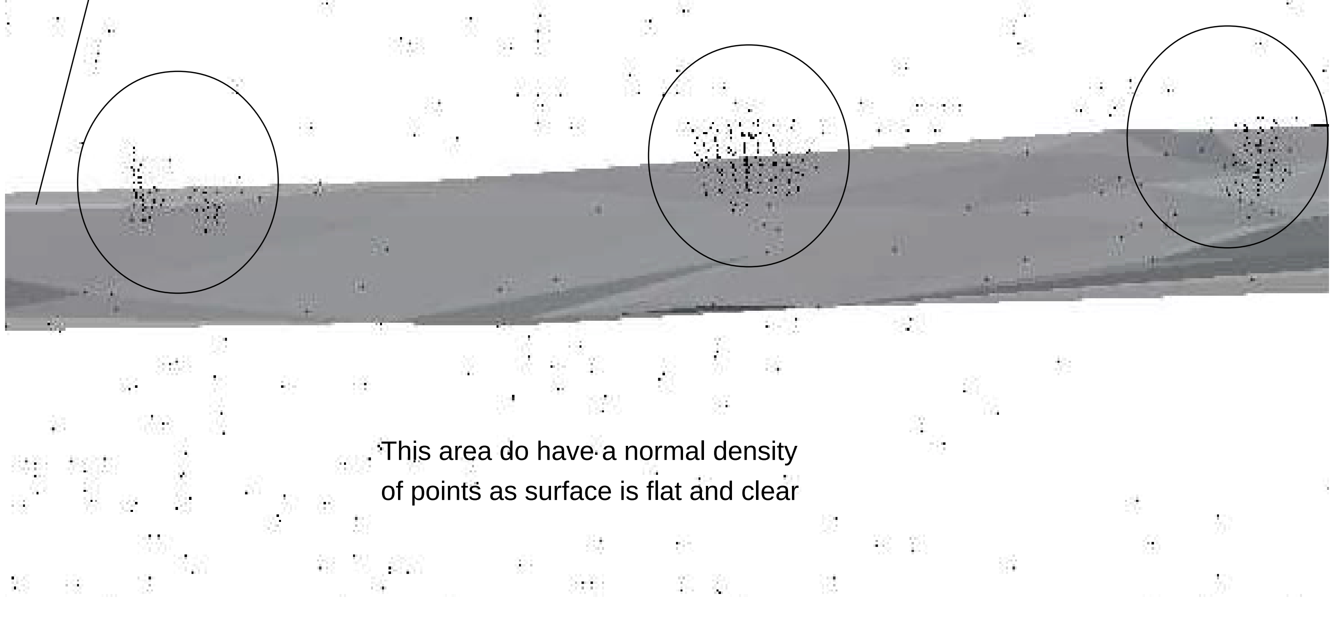
As we can se they are over the surface and we can say how much. This is also one way to see the debris

*3

If we compare the master surface with this last add on surface with debris we can subtract the two surfaces. The remaining differences is a highly cleaned out surface with a very dense point of clouds for debris only.

The accuracy is about 3 mm in this case and all what is larger than this can be detected in some ways. At 100 meter distance this confirms we can see 3 times the accuracy equal to about 10 mm sized debris.

Gray skin added by the computer in the enlarged area of debris



FOD Tests at Arlanda Sep 2006

Summary of results and related comments

About noise and debris on runways

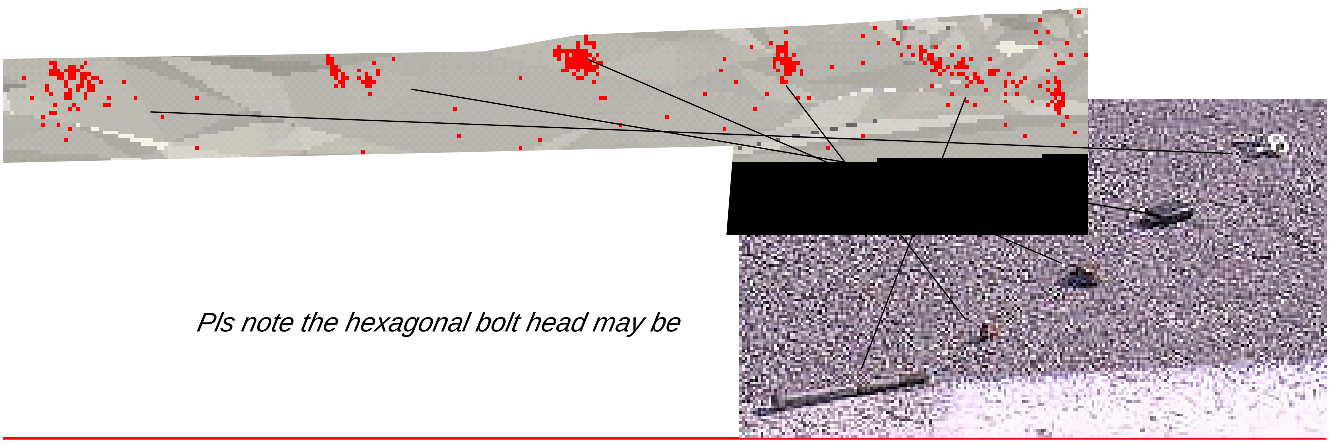
Range of scanner

As viewed in this paper the smallest debris we detect have a front surface of 15x20 mm and is granite gray. At 85 meter the beam is about 5 mm in diameter and it increase linear by range. At 300 meter the beam can be about 15 mm in diameter which still is a bit smaller than the stone. We know the scanner can do 350 meter in distance.
This indicates that we can see the stone as it is at 300 meter distance in a theoretical way. One reason for more hits is the angle to asphalt. We have some reflexes of asphalt in front of stone which get counts. We can see we have problems to see asphalt as angle is very flat. This helps to mirror away more hits of debris.

Stone got hit by 61 laser shots over a 15x20 mm surface. This tells we must have a lot of partial hits on the surface. Scanner stepped in a 2x5 mm matrix. The 300 square mm surface was hit by 30 shots theoretically. We got twice as many so partial hits at edges must have increased the number a lot. This indicates that we have good margins in the detection and sensitivity. Sunshine was strong and this is normally less favourable

Noise and natural disturbances.

All readings we look at tell the cloud density has increased a lot where there is debris. Still there are some noise outside the area here and there. These are almost alone points and no dense clouds.
The smallest stone get a density of about one hit per 5 square mm. 15x20 mm get over 60 hits. The noise factor appears very much lower and is hard to calculate and a bit differing over the surface. In average it can be about 1-2 hits per 100x100 mm and not more.
Signal to noise ration shall them be compared with 1-2 shots /5 square mm from debris and noise of 1-2 shoots per 10 000 square mm. Signal to noise is then about 33 to 1 on small gravel.
This is in vertical views only.
If we look at horizontal views and signal to noise level this can be higher. Pls. see image at previous page where this is viewed very clearly



Pls note the hexagonal bolt head may be

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