

Payment

Do you accept payment by credit card?

No.

The premise 'first pay, then deliver' is not acceptable to us. Is there a way out?

Certainly, please contact carpet@tno.nl.

Installation

How do I transfer CARPET to another PC?

1. E-mail carpet@tno.nl that CARPET needs to be transferred to another PC. You will receive download and install instructions.
2. Install CARPET on the 'new' PC.
3. Please de-install CARPET on the 'old' PC: Start - [Settings -] Control Panel - Add or Remove Programs.

Suppose my hard disk crashes. How do I get CARPET re-installed?

Inform carpet@tno.nl of the disk-problem. You will receive download and install instructions.

What is the latest release? And do I really need that release?

Check document 'About the CARPET versions' on the Internet (www.tno.nl/carpet) on information about the latest release. It is indeed advised to get hold of that latest release.

How do I get the latest release?

Ideally, you will be informed when a latest release is available and you will receive download instructions. If this hasn't been the case, do not hesitate to contact carpet@tno.nl.

Do I need to send you the license file after doing the CARPET update?

No. Just download the new release, unzip it, and place the resulting executable in the CARPET folder (typically C:\Program Files\carpet). The new version should communicate alright with the existing license file.

Technical

Compared to CARPET 1, what is actually new in CARPET 2?

1. Non-SI units (nm, ft, knots) are supported.
2. Antenna patterns can be imported.
3. Several 'patches' has been implemented, check page 'About the CARPET versions' on www.tno.nl/carpet.
4. Numerical values of diagrams can be exported.
5. The use of colour in the diagrams has been improved.
6. Minimum and maximum values of settings have been reconsidered.
7. CARPET 2 is a true Windows application, running on all versions since '95.
8. Contour plots can be made of the vertical coverage and blindzone diagrams.

With the new release of CARPET 2, if I switch off Pulse Compression, the detection capability worsens significantly. Do I have to switch it off? It is a maritime navigation radar.

Radar systems of this type are generally not equipped with analog or digital pulse compression, toggle Pulse Compression must therefore be switched off. A possible cause for the poor detection capability is that the receiver bandwidth, B , is excessive high, i.e., $B > 1/\tau$, with τ the duration of the (uncompressed) pulse. If so, the noise power is affected, resulting in a relatively high SNCR (signal-to-noise-plus-clutter ratio), which can cause a disappointingly low probability of detection.

If I broaden the bandwidth, the probability of detection gets better, not worse as expected. When I look at the received powers graph what is happening is that as the bandwidth increases the noise gets worse, exactly as you would expect. The clutter power remains the same, as you would expect. But the signal power increases. Why?

Note: this question was posed prior to version 2.11, which introduced the Pulse Compression toggle.

When you increase the bandwidth in a scenario without clutter both the noise power (kTB) and the target power (τB , being the pulse compression gain) increase, proportional to the bandwidth. Therefore, the SNR and thus the detection probability will stay the same. However, in a scenario with clutter, the situation changes. While both the noise power and the target power increase proportionally to the bandwidth, the clutter power stays the same because the increase in the pulse compression gain (τB) and the decrease in clutter area after pulse compression (inversely proportion to B) compensate each other. The net effect is that the signal-to-interference ratio in clutter increases when the bandwidth increases, which leads to an improved detection probability.

I don't see any effects of volume clutter (rain or chaff).

Put toggle Clutter - Rain or toggle Clutter - Chaff in the on position.

CARPET seems to indicate no effect of rain for targets beyond the rain. Wouldn't the rain attenuate the portion of the signal that goes through a rain band?

When the target is 'in' the column of rain, i.e., its range is between the minimum and maximum range of the precipitation, its echo has to compete with the return from rain drops within the range cell of the target. So you have signal (= target) against noise + volumeclutter + surfaceclutter. If the target is beyond (farther than) the maximum range of the column of rain, there is no competition, it is signal against noise + surfaceclutter. Indeed the column of rain absorbs some of the energy, but that effect is smaller than the effect of direct reflection against rain drops.

I have a small target in sea 5. Detection improves as the range reduces, which disagrees with the experience of a couple of our staff, who have much bridge experience. That is, they would expect the target to be more difficult to see as it approaches the vessel into the higher clutter returns.

The following two mechanisms might cause a discrepancy between CARPET results and experience from the bridge:

1. Target obscuration by sea waves. Especially when having high sea states and a physically small target this phenomenon can have significant impact. It is not modelled in CARPET 2 (and it is by no means straightforward to do that). Modelling the obscuration effect is on our wish-list for CARPET 3.
2. You use a short pulse length of 50 ns in your settings file. Sea spikes then get more pronounced which hinders detection of such a small target. This effect is also not covered in CARPET 2.

Please, clarify the expression of the cumulative probability as defined in the user's manual.

Citing from Skolnik's Radar Handbook, 2nd edition, Section 2.0, page 2.60:

'In principle, if the probability of detecting the target on a single scan at range R_i is P_i , on the assumption that the target fluctuation is independently random from scan to scan, the cumulative probability $P_c(R)$ that the approaching target will be detected at least once by the time it reaches range R is

$$P_c(R) = 1 - \prod_{i=1}^n (1 - P_i), \quad (1)$$

where the scans occurring prior to the target reaching range R are numbered 1, 2, 3, ... n .'

Thus, the cumulative probability of detection diagram shows the probability that the target is detected at least during one scan. Realise that the cumulative probability of detection depends on target speed and antenna rotation rate. In CARPET, the target travels inbound starting off at the maximum plot range. The user must set this maximum plot range such that the probability of detection at that range is zero.

Shouldn't the cumulative probability of detection plot be a monotonically increasing (as the target approaches the antenna) function? Some of my plots have various minima.

No, this would only be the case if the single scan detection probability is a monotonically increasing function. Due to aspects as multipath, eclipsing, clutter, this is often not the case. The cumulative probability of detection is equal to 1 minus the cumulative probability of miss, which is the product of the single scan miss probabilities *at distances with an interval equal to the distance a target travels between successive scans*. These two facts can produce a non-monotonic cumulative detection probability curve.

A numerical example for a radar with a rotating antenna is given in the table below. The single scan detection probability and single scan miss probability at a specific range are specified in the two leftmost columns. The cumulative probability of detection for three different distances (D) that the target travels during the antenna rotation time, is given in the three rightmost columns. Local dips are shown in red. The table illustrates that shape of the cumulative probability of detection diagram depends on target speed.

Range (km)	P_d	$1 - P_d$	Cumulative P_d		
			$D = 2$ km	$D = 4$ km	$D = 6$ km
> 20	0.0	1.0	$1 - 0.0 = 0.0$	$1 - 0.0 = 0.0$	$1 - 0.0 = 0.0$
20	0.2	0.8	$1 - 0.8 = 0.2$	$1 - 0.8 = 0.2$	$1 - 0.8 = 0.2$
18	0.8	0.2	$1 - 0.16 = 0.84$	$1 - 0.2 = 0.8$	$1 - 0.2 = 0.8$
16	0.2	0.8	$1 - 0.128 = 0.872$	$1 - 0.64 = 0.36$	$1 - 0.8 = 0.2$
14	0.3	0.7	$1 - 0.0896 = 0.9104$	$1 - 0.14 = 0.86$	$1 - 0.56 = 0.44$
12	0.7	0.3	$1 - 0.02688 = 0.97312$	$1 - 0.192 = 0.808$	$1 - 0.06 = 0.94$
10	0.9	0.1	$1 - 0.002688 = 0.997312$	$1 - 0.014 = 0.986$	$1 - 0.08 = 0.92$
8	0.9	0.1	$1 - 0.0002688 = 0.9997312$	$1 - 0.0192 = 0.9808$	$1 - 0.056 = 0.944$
6	0.9	0.1	$1 - 0.00002688 = 0.99997312$	$1 - 0.0014 = 0.9986$	$1 - 0.006 = 0.994$
4	1.0	0.0	$1 - 0.0 = 1.0$	$1 - 0.0 = 1.0$	$1 - 0.0 = 1.0$
2	1.0	0.0	$1 - 0.0 = 1.0$	$1 - 0.0 = 1.0$	$1 - 0.0 = 1.0$

Why is there a blind section in the detection probability plots (single scan) that is removed in the cumulative plots?

A blind sections corresponds with a range-interval where a target is 'eclipsed', due to the transmission of a pulse. CARPET 2 assumes that the radar receiver is disconnected when a pulse is being emitted. As indicated by equation (1), the cumulative detection for a specific range is determined by a sequence of probabilities at farther ranges. Blind ranges are left out in the calculation of the cumulative probability of detection. When the target is in a blind zone, the cumulative probability of detection is still defined, due to the previous (farther) ranges at which the target has been looked at, by the radar.

What exactly are 'Transmitted pulses per burst' and 'Number of pulse bursts'?

For a coherent radar, i.e. a radar that is able to determine both phase and amplitude from the received signal, responses from multiple pulses at identical carrier frequency can be integrated (range cell wise) in a so-called Doppler Filter Bank. The Doppler Filter Bank, which might be implemented by an FFT algorithm, subdivides the received signal into a series of components with different Doppler frequency shifts, proportional to radial velocity. Parameter 'Transmitted pulses per burst' denotes the number of pulses that are coherently integrated in this manner. The carrier frequencies of these pulses must be (and are assumed to be) identical. Thus, a series of pulses with identical carrier frequency is referred to as 'burst'. When a pre-FFT taper is not applied, the gain to the received power is proportional to the square of the number of pulses (since the amplitude goes with the number of pulses). This form of processing comes into action when you activate toggle Radar - Doppler Processing and select the Doppler Filter Bank (Receiver Parameters). Obviously, when the number of pulses per burst is set to 1, no gain will be offered. If toggle Radar - Doppler Processing is off, the number of pulses per burst has no effect.

The effectiveness of coherent processing depends on the decorrelation time of the target response. If, for some reason, the target responses decorrelate within the burst duration, effectiveness will degrade. This decorrelation-effect is not modelled in CARPET 2.

There are also radar processors that do not determine the phase of the received signal. One reason might be that the phase of the emitted pulse varies randomly from pulse to pulse, e.g. if a magnetron or a klystron amplifier is used. Such radar systems are called 'noncoherent'. Many marine radars (navigation, VTS) belong to this category. Coherent integration is not possible for such radars. However, one might integrate pulse responses noncoherently, i.e. simply add powers or amplitudes range cell wise. Since the noise power varies from pulse to pulse whereas target responses generally fluctuate less rapidly, noncoherent integration, also referred to as postdetection integration, will also increase the SNR. This technique is, however, less effective than coherent integration. Parameter 'Number of pulse bursts' denotes the number of pulse bursts that are integrated noncoherently. The effect does not show up in the Received Powers diagram, it is only visible in the diagrams involving detection probability and the diagram showing the receiver operating curves of the different Swerling cases.

If the number of pulses per burst as well as the number of pulse bursts is more than 1, a two-step architecture is assumed. First a number of pulses are integrated coherently, then responses from multiple bursts are integrated noncoherently. In order to simulate a noncoherent radar, 'Transmitted pulses per burst' must be set to 1.

Is the Doppler gain applied on target and also on the clutter? I have the feeling that a sort of Doppler gain is computed and applied on every signal with respect to the speed, and then also on the clutter.

If you have enabled Doppler-processing and have opted for the Doppler-filter bank, the output of the Doppler filter that corresponds with the target's velocity is considered. For the target component in the received signal this will result in a

gain (which is proportional to the number of integrated pulses) since the pulse-to-pulse phase change of the target-echo is compensated. In case the radial velocity of the clutter deviates significantly from the radial velocity of the target, no gain is involved for the clutter component. Note that in a maritime scenario, seaclutter can have a distinct non-zero velocity, especially when looking up- or downwind.

How can frequency diversity (RF-stagger) be taken into account?

The effect of RF-stagger on the target response is that a Swerling 2 model (rapid fluctuation, multiple scatterers) is more appropriate than a Swerling 1 model (slow fluctuation, multiple scatterers). Likewise, Swerling 4 (rapid fluctuation, one dominant scatterer) is more appropriate than Swerling 3. With respect to detection capability, this is a favourable aspect, since the chance that a target is not detected during a specific scan decreases.

Can CARPET simulate a M-out-of-N detection criterion?

No, binary integration is not covered in CARPET 2.

I have been running the latest CARPET (2.13) and it appears that adding antenna noise can increase the range.

As explained in the CARPET manual, if the Antenna Noise toggle is off, it is assumed that the antenna points at an absorbing ground surface. The resulting antenna temperature (290 K) may be higher than when the antenna looks at the sky (Antenna Noise toggle on), depending on antenna tilt and ohmic losses of the antenna. To illustrate this, the Antenna Temperature has been added to the Antenna Worksheet since CARPET 2.13, release date 09-03-2007.

Can I use CARPET 2 to evaluate an FMCW radar?

CARPET version 2 is not optimum to simulate an FMCW radar. Clearly, one can mimick such a system, e.g. by ensuring that the product of peak power and duty cycle equals the average power transmitted by the FMCW radar. However, an important aspect as isolation between transmit and receive antenna, is not being modelled. The CARPET results will therefore be rather optimistic.