# Advanced Compact Test Range for both Radome and Antenna measurement

B. Widenberg*

***Abstract* – A new advanced Compact Test Range (CTR) for both radome measurements and antenna measurements has been installed at Chelton Applied Composites AB (CAC) in Linköping, Sweden. The CTR is designed for a wide range of applications; from small missile radomes up to large fighter radomes, and so forth to waveguide horns and reflector antennas. The CTR have a very advanced positioner which has two particular characteristics; 1) several axes can be moved simultaneously, so that virtual axis can be realized or axes can be counter-steered to each other, 2) radome antenna can be put in monopulse tracking mode so that the antenna automatic and independent track the incident wave. The paper presents the CTR and all its characteristics.**

## 1 INTRODUCTION

This paper presents a new advanced Compact Test Range (CTR) for both radome measurements and antenna measurements. The CTR is located at Chelton Applied Composites AB (CAC) in Linköping, Sweden, and the installation was completed in May 2004. MI Technologies [1] has designed and installed the CTR as a turnkey system.

The specification of the CTR was written during the spring 2002, and in the summer the inquiries were sent to the vendors. During the fall 2002 the proposals from the vendors was evaluated, and during the winter the specification of the CTR was rewritten. In March 2003 the contract for the CTR was written with MI Technologies, and during March and April 2004 the CTR was installed at CAC in Linköping.

The range of applications for the CTR is described in Section 2, and in Section 3 the design of the CTR and the components of the CTR are presented. Finally, the validation is described in Section 4.

## 2 RANGE OF APPLICATIONS

The compact test range is used for both radome and antenna measurements. The radomes are mainly high performance fighter radomes, missile radomes and other military radomes. The antennas are electronically/mechanically scanned arrays, reflector antennas, horn antennas, as well as monopulse and single beam antennas.

The radome measurements include measurements of transmission efficiency, antenna pattern degradation and boresight error. The antennas are measured with respect to antenna pattern, gain, cross polarization, (relative) boresight error, and reflectivity.

## 3 DESIGN OF COMPACT TEST RANGE

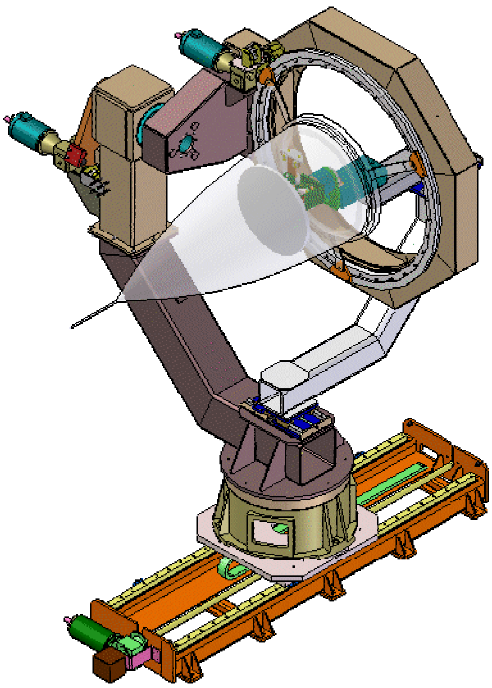

Figure 1: The positioner.

The size of the compact test range is 12m (length) x 6m (width) x 5.4m (high), see Figure 4 and 5. The CTR has a unique radome positioner, see Figure 1, and a computer control system controls the positioner system as well as the RF system.

### 3.1 The quiet zone

The compact test range was designed for the frequency range 8—18GHz (X- and Ku-band), and for a quiet zone with the size; 1.83m (length) x 1.83m (width) x 1.50m (high). In the quiet zone, the amplitude taper is < 1dB, the amplitude ripple is < ±0.3dB, and the phase error is < ±3°. Furthermore, the cross polarization is essentially < -25dB in the quiet zone, and fulfill < -30dB over a cylinder with diameter 1m.

* Chelton Applied Composites AB, P.O. Box 130 70, SE-580 13 Linköping, Sweden. E-mail: bjorn.widenberg@acab.se

### 3.2 Reflector and Feed

The reflector is a standard reflector from MI Technologies, denoted MI-5706 [1]. It is an offset parabolic reflector with serrated edges, see Figure 4 and 5. The size of the reflector is 4.2m width and 3.2m high, and the focal length is 3.6m. The serrations follow the curvature of the reflector and the size of the serrations is 0.6m.

The CTR has a floor mounted feed. The feed is linearly polarized and the feed positioner has a computer controlled roll axes for polarization of the field in the quiet zone. Two feeds cover the frequency band (X-band feed and Ku-band feed) and the feeds are exchanged manually.

### 3.3 Positioner

At microwave measurements in the CTR, the device under test (DUT, radome or antenna) is mounted on a very advanced positioner with 7 computer controlled axes, see Figure 1. There are 3 axes for moving the radome, and the axis order is roll-over-elevation-over-azimuth. On the antenna post is a sophisticated gimbal mounted and the gimbal has 3 axes for moving the radome antenna with the axis order elevation-over-azimuth-over-roll. The accuracy for the gimbal axes and for the radome azimuth is ±0.005º, and the accuracy is ±0.05º for the other axes. The remaining computer controlled axes is the lower slide which can move the complete positioner 1.8m in down-range direction.

Furthermore the radome antenna post can manually be moved 0.2m in both down range and cross range direction. The gimbal can also simply be exchanged for other gimbals to fit particular radomes or radome antennas.

For antenna measurements, the antenna under test (AUT) is mounted either on the radome antenna post or on the radome roll ring. If the AUT is mounted on the roll ring the gimbal can be dismounted.

The positioner is constructed very robust because it shall be able to carry radomes up to 150kg without bending more than 0.1mRad.

### 3.4 Virtual axis and Counter-steering

Several computer controlled axes can be moved simultaneously, so that virtual axis can be realized or axes can be counter-steered to each other. It is a necessity for transmission measurements, because the radome antenna post is attached to the radome azimuth. The counter-steering is applied in order to keep the boresight of the radome antenna in the down range direction.

### 3.5 Tracking

A very unique characteristic of this positioner and this control system is that the radome antenna can be put in monopulse tracking mode. This means that the antenna automatically and independent tracks the incident wave and find the boresight. This is very useful during boresight measurements, because then the control system moves the radome, the radome antenna automatically compensates for the boresight error and this compensated angles are recorded by the system.

### 3.6 Reflectometer

Another large quality of the CTR is that a reflectormeter is integrated in the CTR so that the reflection coefficient for the radome or antenna can be measured while the DUT is mounted in the CTR. This reduce the handling of the DUT, and by placing the reflectometer near the DUT, the measurement uncertainty intrinsic to long cable runs can be minimized. Details about the reflectometer can be found in [2].

### 3.7 RF system and position control system

The position control system is a MI Technologies standard system [1], and consists of two position controller MI-4193 complete with PAUs, see Figure 2. The RF system is also a system from MI Technologies, and consists of two RF sources, MI-3102, and a receiver, MI-1797, together with a LO/IF distribution unit. There are four measurement channels provided with a 4-channel-switch which is mounted on the radome antenna post.

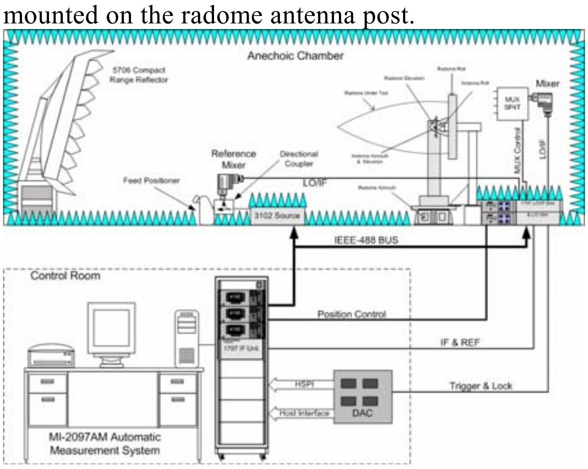


Figure 2: The control system and RF system.

The positioner and the RF system are controlled by an automatic measurements system MI-2097 on a workstation PC.

# 4 VALIDATION

A range of measurements have been made in order to assess the performance of the Compact Test Range. They are divided into four main groups; 1) Positioner Alignment, 2) Amplitude and Phase aperture scans, 3) Reference Antenna Diagrams, 4) Reference Radome Measurements,. The first two tests were included in Acceptance Test Procedure, ATP, and was performed by MI Technologies before and during the installation. The other two tests were performed by CAC after the installation. CAC did also validate the dynamic range for the RF system and check the performance of the tracking system.

## 4.1 Positioner Aligment (FAT)

The verification of the positioner, axes, alignment, and accuracies was already completed by MI Technologies at time of installation of the test site. This measurement set was carried out by MI Technologies as part of the ATP but in the factory before shipping to Chelton (Factory Acceptance Test, FAT).

There were only 2 failures, and these two failures were only marginal failures of the reverse limits for the Antenna Roll and Azimuth axes.

## 4.2 Quiet zone scans (ATP)

The verification of the Quiet Zone, Co and Cross polar, Amplitude and Phase Scans was completed by MI Technologies during time of installation of the test site.

This measurement set was made using special quiet zone scanning equipment which is not part of the supplied test facility. It was therefore carried out by MI Technologies as part of the ATP before the antenna/radome elevation positioner was installed. There are two sets of data – one set (the quiet zone) fully analyzed by MI Technologies and a second set not analyzed. This second set for the extended area outside the specified quiet zone (2.4m x 2.4m) is for get knowledge of the performance outside the quiet zone.

The main conclusions can be summarized as the amplitude and phase scans generally meet the requirement with the exception of the cross polar component, which were a few dB to high for some positions on edges in quiet zone.

## 4.3 Golden Antenna Measurements

The reference antenna measurements were performed by CAC, and measurements were made using high gain antennas at different slide positions.

The Figure 3 shows the reflectivity in the CTR. The cause of the asymmetry in the reflectivity within ±20° is thought to be associated with the compact reflector. The conclusion is that the site reflectivity is better than -60dB over the range ±20° to ±90°.

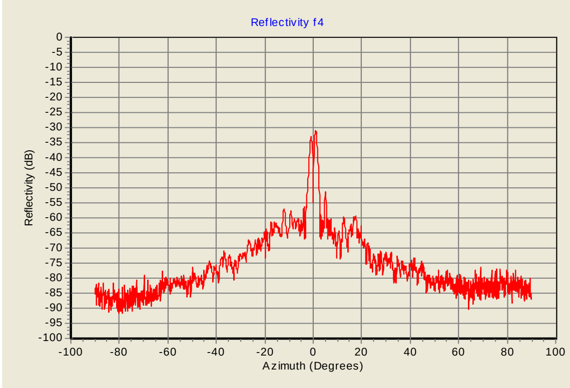


Figure 3: Reflectivity at 15 GHz H-pol.

A number of plots were made with the antenna rotated 180° showing that the patterns reverse over the scan range of ±60°. Beyond ±60° the major asymmetry is due to the blockage effect of the radome positioner gearbox. The conclusion is that Antenna pattern measurements are good out to ±60°.

## 4.4 Air Radome Measurements

The Air radome measurements gave that the variation in transmission was better than ±0.09dB, with the majority better than ±0.05dB. The variation in BSE was better than ±0.046mRad in Azimuth and ±0.11mRad in Elevation, with the majority better than ±0.03mRad over the frequency and scan angle range.

# 5 CONCLUSIONS

This Compact Test Range is a very good example of how an advanced test range for both radome measurements and antenna measurements can by specified, designed, and installed in a short time and to a reasonable low cost.

## References


[1] MI-Technologies, Suwanee, Georgia USA. http://www.mi-technologies.com/.

[2] J. McKenna, D.M. Kokotoff, and B. Widenberg, "A Reflectometer for Antenna Measurements", In Proc. 26th Antenna Measurement Techniques Association Symposium, Atlanta, 2004.

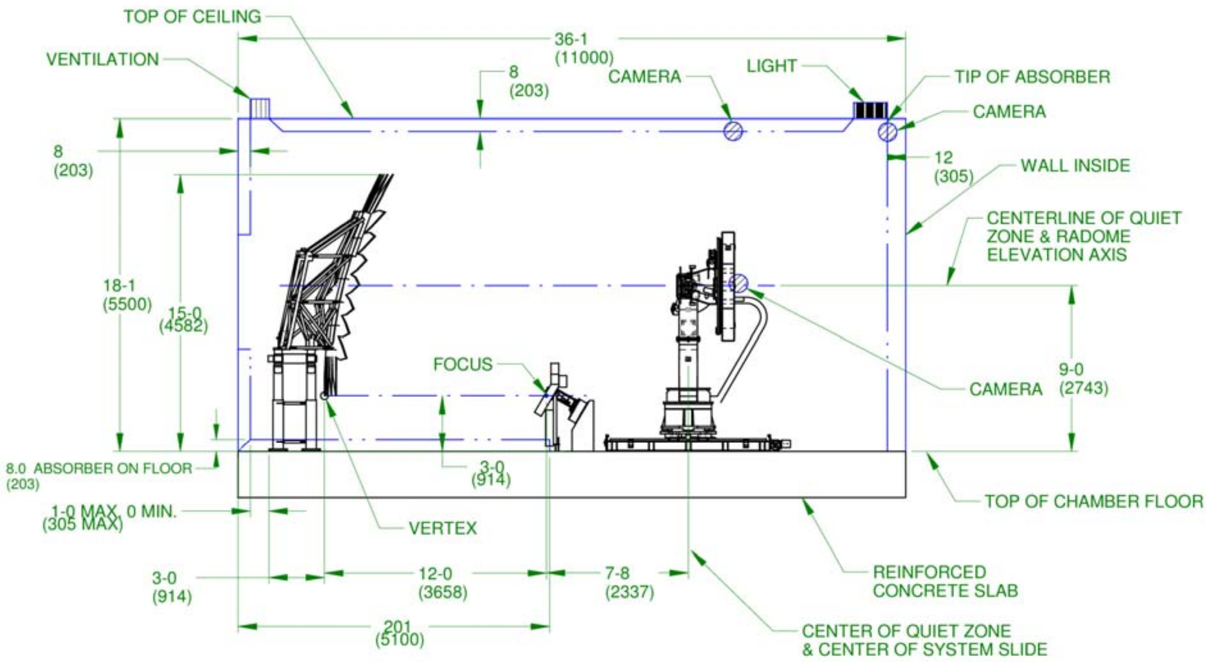


Figure 4: Side view of the Compact Test Range.

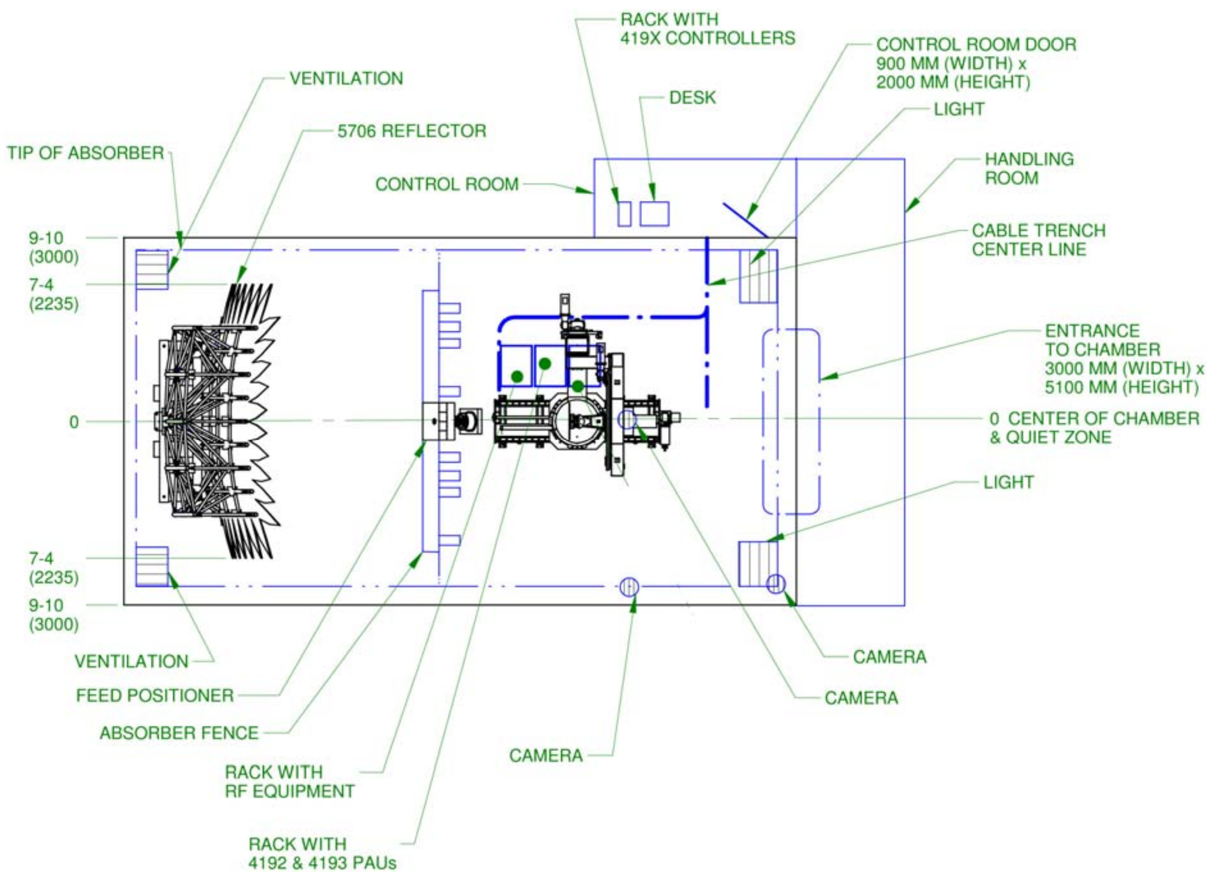


Figure 5: Top view of the Compact Test Range.