INFINITION

BR-3502 Doppler Radar System

A Compact, Cost-Effective Ka-Band Radar for Indoor Ranges, Muzzle Velocity and In-Bore Measurement

Prepared by Infinition Inc.
2965 rue des Prairies, Trois-Rivières, QC, Canada G8V 1W4 •
www.infinition.com
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1. Introduction

This document presents the Infinition BR-3502 Doppler Radar System: a compact, cost-effective Ka-band radar operating at 35.5 GHz for muzzle velocity, in-bore and very short-range velocity measurement, together with TestCenter 7, the latest generation of Infinition's radar signal processing software.

The BR-3502 continuous-wave (CW) Doppler radar is purpose-built for interior ballistic ranges and short trajectories. Working at 35.5 GHz, it provides more than three times better resolution than a 10.5 GHz (X-band) radar and can therefore be used on very small projectile calibres, down to 1 mm, and at very short range, down to a few metres from the muzzle. The complete radar weighs only 4.1 kg and its antenna head fits in the palm of a hand: the BR-3502 is easy to carry, deploy and align, and it is a great alternative to optical chronographs. It can also be used outdoors for short-range measurements, up to about 500 metres on large calibres.

> **The BR-3502 and all Infinition radars are renowned for their reliability over long periods of time, maximizing our customers' operational availability and the efficiency of their measurement campaigns. Our fast, personalized customer service keeps users up and running as much as possible.**

2. System Overview

A complete BR-3502 measurement chain consists of four main elements: the BR-3502 radar antenna with its power supply module, the muzzle trigger (AT-01 acoustic or OT-01 optical) installed near the gun muzzle, the JB-6e junction box that digitizes the Doppler signal, and the TestCenter 7 processing software running on a standard desktop PC. The radar head is small and light, which makes it particularly well suited to the confined space of an indoor range. Figure 1 shows a typical indoor range deployment.

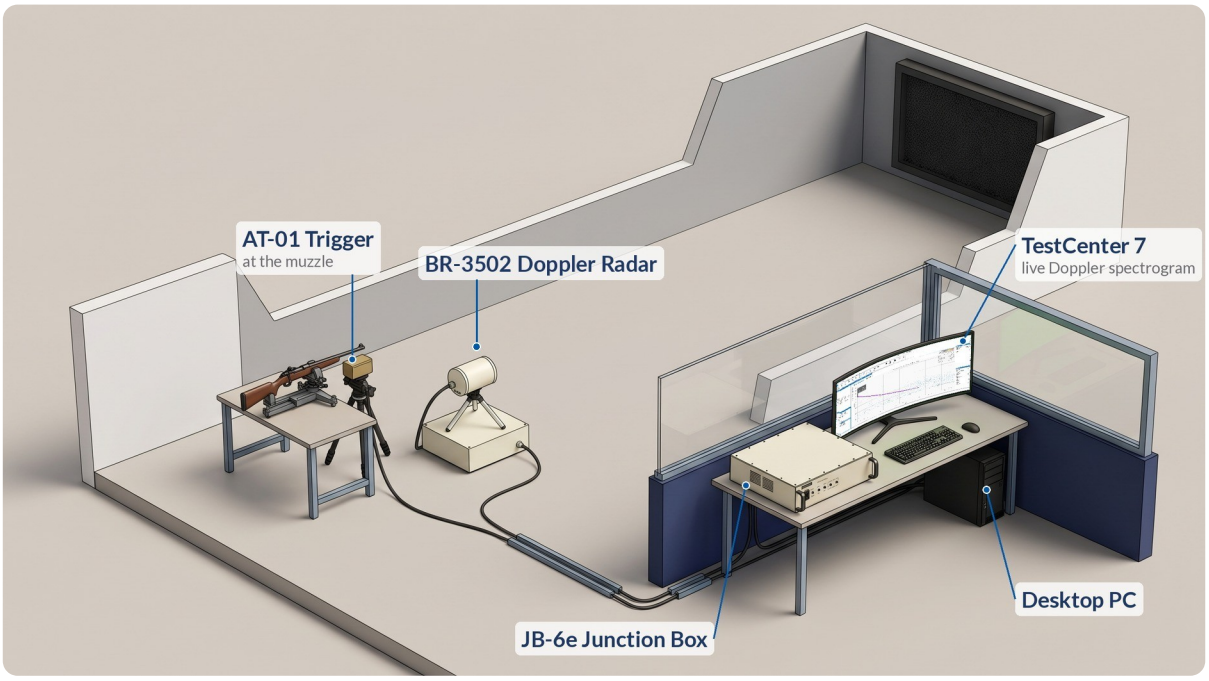

Figure 1 – Typical set-up of a BR-3502 radar system.

The measurement sequence is fully automatic:

- The weapon is fired and the muzzle trigger instantly provides the precise time-zero reference for the shot.
- The BR-3502 radar, placed beside the line of fire, illuminates the projectile; the Doppler shift of the reflected signal is a direct measure of the projectile velocity along the whole visible trajectory.
- The JB-6e junction box digitizes the radar signal with 16-bit resolution and streams it over Ethernet to the acquisition computer; recording time is virtually unlimited on a high-performance network.
- TestCenter 7 processes the signal in real time: muzzle velocity, velocity at any distance, acceleration, rate of fire and complete ballistic results; drag analysis is available with the Advanced version of TestCenter 7.

Choice of trigger. The AT-01 acoustic trigger senses the muzzle blast, and the OT-01 optical trigger senses the muzzle flash. Both connect to the same trigger input and only the connecting cable differs, so a single acquisition set-up can use either. One trigger is used at a time, and the operator selects the one best suited to each firing position. The AT-02 trigger is also available for low-noise and subsonic shots, such as suppressed weapons, air rifles, quiet ammunition and subsonic ammunition.



AT-01 acoustic trigger (left) and OT-01 optical trigger (right).

3. BR-3502 Doppler Radar

The BR-3502 uses a circularly polarized lens horn antenna operating in the Ka-band at 35.5 GHz nominal, with a 12° × 12° beam and 22 dBi of gain. The transmitter is a Gunn oscillator working in continuous wave without modulation. The wide beam is an advantage at close range: the projectile is acquired within a few metres of the muzzle and alignment on the line of fire is quick and forgiving.

The radar is compact as well as easy to deploy: the antenna head measures only 11.1 cm in length by 8.5 cm in outside diameter and is permanently attached to its power supply box; the complete radar weighs 4.1 kg. It is powered from the AC mains, in a 115 VAC 60 Hz or a 230 VAC 50 Hz version, and operates from -20 °C to +55 °C.

3.1 Range performance

Calibre	Range performance (typical / maximum)
4.7 mm (-43 dBsm RCS)	38 m / 45 m
5.56 mm (-40 dBsm RCS)	46 m / 54 m
7.62 mm (-34 dBsm RCS)	62 m / 74 m
20 mm (-18 dBsm RCS)	164 m / 194 m
155 mm (0 dBsm RCS)	> 500 m

Typical range is computed with an FFT size of 1024 and maximum range with an FFT size of 2048, both with a 10 dB minimum signal-to-noise ratio. The radar cross section (RCS) shown for each calibre is the value used in the calculation, at the radar frequency of 35.5 GHz – higher than at 10.525 GHz for the same projectile – assuming a flat trajectory with the radar viewing the projectile base. Values marked ">" are deliberately limited: at long range the projectile is no longer seen from its base, its radar cross section falls below the calculated value, and the published range is capped accordingly. These are calculated sensitivity limits, not guaranteed values: actual performance varies with projectile shape and material – particularly base geometry – trajectory profile, radar alignment and test conditions.

3.2 Technical specifications

Antenna gain	22 dBi
Antenna type	Lens horn
Beamwidth	12° × 12°
Polarization	Circular
Transmitter output power	> 0.1 W
Transmitter source	Gunn oscillator, CW
Modulation	None
Frequency	35.5 GHz (nominal)
System precision	± 0.1 %
Data acquisition	JB-6e junction box – 16-bit, Ethernet output
Receiver noise figure	< 8 dB
Radial velocity coverage	30 – 3 000 m/s (standard), up to 5 000 m/s (optional)
Operating temperature	-20 °C to +55 °C
Storage temperature	-30 °C to +55 °C
Humidity	0 % to 100 % relative humidity, operating and storage
Power supply	115 VAC 60 Hz 0.3 A or 230 VAC 50 Hz 0.15 A
Dimensions (antenna head)	11.1 cm (L) × 8.5 cm (OD)
Dimensions (power supply)	20 cm × 15 cm × 6 cm
Weight	4.1 kg (antenna head and power supply box)
Approvals	FCC

3.3 In-bore measurement

Projectile velocity can also be measured inside the gun barrel by using the BR-3502 in combination with a reflector, typically a metal plate made of standard 1/8 inch thick aluminum sheet. Special accessories can be provided to properly align the radar beam and the reflector and to achieve optimum results. In-bore measurement can be performed on bores of 16 mm diameter and above. Combined with the very short minimum measuring distance of the radar, in-bore travel, muzzle exit and the first metres of free flight are captured within a single Doppler record.

3.4 BR-3502 or BR-3503?

Infinition offers two Ka-band radars that share the same frequency, the same JB-6e acquisition and the same TestCenter 7 workflow. The BR-3502 is the compact, portable and economical choice for indoor ranges and short trajectories; the BR-3503 adds a larger, higher-gain antenna and a narrow beam for longer distances.

	BR-3502	BR-3503
Antenna gain	22 dBi	28 dBi
Beamwidth	12° × 12°	4° × 4°
Antenna head	11.1 cm × 8.5 cm; 4.1 kg with its power supply box	35.5 cm × 19.0 cm, 6.35 kg (complete unit)
Range, 20 mm (typical / maximum)	164 m / 194 m	320 m / 380 m
Best suited for	Indoor ranges, muzzle velocity, in-bore, short trajectories; portable set-ups	Indoor and outdoor ranges, short and medium trajectories

4. JB-6e Junction Box – Data Acquisition

The JB-6e junction box is the data-acquisition heart of the system. Installed next to the acquisition computer, it conditions and digitizes the radar signal and communicates with TestCenter over a standard Ethernet link.

This separation is a deliberate design choice: by keeping the acquisition out of the radar head, the radar itself remains as robust and simple as possible, maximizing its operational availability – in contrast with competitor systems that integrate the acquisition inside the radar head.



JB-6e Junction Box

- **16-bit** analog-to-digital converters with integral filtering.
- **Dual antenna inputs** – two radars can be connected and acquired by the same unit.
- **100 Mb/s Ethernet** connectivity to the acquisition computer.
- **Analog trigger input and BNC trigger output** – the input accepts an Infinition trigger (AT-01, OT-01 or AT-02) or, with the optional BNC adapter, an external TTL trigger signal supplied by the range; the TTL output triggers other range instrumentation – or a second measurement system – on the same event.
- **Velocity acquisition coverage** from 30 m/s up to 10 000 m/s with X-band radars, 5 000 m/s with Ka-band radars and 1 550 m/s with the 122.5 GHz BR-12201.
- **Virtually unlimited recording time** on a high-performance network – the recording time depends on the network transmission speed, the sampling frequency and the internal FIFO memory of the JB-6e.

Two radars, one workstation. The second acquisition channel is delivered with every JB-6e and simply remains unused until a second radar is connected. Two radars are then acquired together, on the same time base, under a single TestCenter 7 workstation – a second radar covering a different firing position, or two radars on the same trajectory, one at the muzzle and one downrange. Adding the second radar requires no change to the acquisition hardware, to the software or to the operating procedure. Infinition supplies the two radars on distinct operating frequencies, so that they operate side by side without mutual interference.

5. TestCenter 7 – Radar Signal Processing Software

TestCenter 7 (released in 2024) is the latest generation of Infinition's Doppler processing software and the productivity benchmark of the industry. It runs on Windows 10 and 11, supports every Infinition radar, is compatible with the JB-6e junction box, and opens TestCenter 6.3.x files.

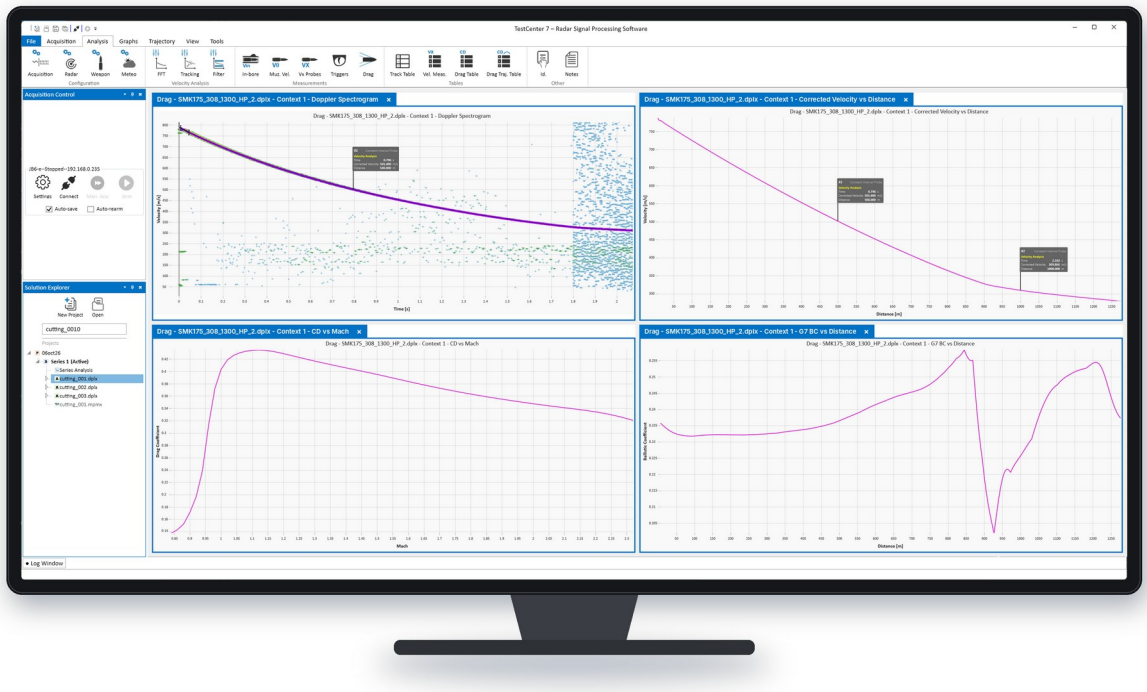

Figure 2 – TestCenter 7 on a wide-screen display: Doppler spectrogram with automatic tracking, velocity versus distance, drag coefficient (Cd) versus Mach through the transonic zone, and G7 ballistic coefficient, all from the same shot.

5.1 What sets TestCenter 7 apart

- **New user interface** – a modern ribbon interface with dockable windows and simplified dialogs; the complete workflow (acquisition, spectrogram, velocity, drag) fits on a single ultrawide display, as shown in Figure 2.
- **Dynamic graphic engine** using 3D acceleration, with layer management and dynamic display: results are viewed and manipulated fluidly even on very large data sets. You can act directly on the graphs – a single click adds or optimizes measurement cursors right on screen.
- **Automatic analysis** – V0 and Vx measurements, track detection and burst tracking are fully automatic; a complete shot analysis takes seconds.
- **Project and series management** – a complete Project Manager including series and shot management: information is filed as the trials are performed, so you always know exactly where you stand in the current project during a firing campaign. Compare tracks across a series and get live statistics (average, extreme spread, standard deviation) as shots accumulate.
- **Batch processing** – modify analysis parameters and apply them to an entire series in a single operation, to uniformize results quickly and efficiently, with instant statistics update.
- **Reporting** – export every result table and curve to CSV, and copy any graph in one click for fast sharing of information. CSV is an open format, read by any analysis, reporting or database software, so results can be merged with data from other range instrumentation – no proprietary format and no dedicated import tool.

5.2 Ballistic analysis capabilities

On every shot, TestCenter 7 provides:

- **Velocity, distance and acceleration** – velocity vs time, velocity vs distance (derived using Integrated Velocity Ranging), distance vs time, acceleration vs time and acceleration vs distance; every curve and its underlying values are exportable to CSV.
- **Spectrogram** – the full Doppler signal is displayed as a velocity/time spectrogram. The automatic tracker locks on the projectile and measurement cursors (V0, V500, V1000 or any custom distance) are placed automatically, with velocity, distance and time reported for each.
- **Drag analysis (Cd vs Mach)** – available with the Advanced version of TestCenter 7, which includes the drag analysis module: measured drag coefficient as a function of Mach number, computed through the transonic zone, with trajectory prediction based on PM or MPM ballistic models. This measured-drag capability is a decisive advantage for ammunition characterization and acceptance testing.
- **Burst and rate of fire** – automatic tracking of every round of a burst, with the rate of fire and per-round statistics, and velocity tracking on multiple simultaneous projectiles.
- **In-bore measurement** – velocity and acceleration of the projectile along its travel inside the barrel, up to muzzle exit.

6. Scope of Supply and Support

6.1 Standard configuration – 1 complete set

The BR-3502 system is supplied as a complete, ready-to-operate set. A typical complete set includes:

- **BR-3502 Doppler radar antenna** – with its power supply module, 115 VAC 60 Hz or 230 VAC 50 Hz version.
- **JB-6e junction box** – data acquisition, Ethernet connection to the computer.
- **TestCenter 7 software license** – radar signal processing and ballistic analysis.
- **AT-01 acoustic trigger** – installed near the gun muzzle, with trigger cable.
- **Antenna cables, tripod and accessories** – everything required for deployment.
- **User documentation** – operation and analysis manuals.

Available options: TestCenter 7 Advanced (drag analysis module), OT-01 optical trigger, AT-02 trigger for low-noise and subsonic shots, in-bore measurement accessories (reflector and alignment kit), rugged transport case. For longer trajectories and extended range, Infinition also offers the BR-3503 Ka-band radar and the BR-29015 and long-range BR-33030 X-band radars.

6.2 Acquisition computer

TestCenter 7 runs on a standard desktop PC with the following minimum configuration: Windows 10 and 11, Intel Core i5 processor or better, 16 GB RAM, SSD drive and Ethernet port. An ultrawide display is recommended to take full advantage of the TestCenter 7 workspace shown in Figure 2.

6.3 Calibration and service

Calibration is supported directly by the manufacturer. The recommended approach is to return the equipment to Infinition's laboratory in Canada for a complete verification; the system is shipped back fully functional with its calibration certificate. Combined with our fast, personalized customer support, this keeps your system measuring – and your teams up and running.

7. Why Infinition

Infinition is a Canadian company in operation for more than 30 years, with a reputation proven around the world by the most reputable clients in the industry.

- **A complete radar range** – from in-bore measurement at 122.5 GHz and Ka-band laboratory radars to X-band radars for small arms, medium calibres and artillery, Infinition covers every calibre and every range with one family of instruments.
- **Proven reliability** – Infinition radars are extensively field-tested and recognized for a reliability that keeps our customers measuring, campaign after campaign.
- **Productivity** – TestCenter 7 automates the complete analysis workflow; results that used to require manual processing are produced in seconds, by any trained operator.
- **Investment protection** – all Infinition radars share TestCenter 7, TestCenter 6.3.x files can be opened, and a system grows with your needs: a second radar on the same JB-6e, a TH-1000 tracking head or optional analysis modules.
- **Single-source support** – Infinition designs and manufactures the radar, the acquisition hardware and the software in-house, and provides installation, on-site training and calibration services worldwide.

8. Contact

Request a quotation, a demonstration or technical information

sales@infinition.com

www.infinition.com

Infinition Inc. · 2965 rue des Prairies, Trois-Rivières (Québec) G8V 1W4, Canada · +1 819-719-2999