RADAR FIELD TEST

A REPORT

07 AUGUST 2003

PREPARED BY CRAIG PETERSON

Report Prepared for

Decatur electronics

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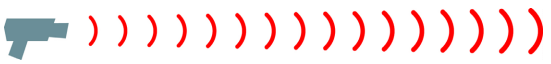
OPTICS PLANET INC

Introduction



Review Process

This evaluation focuses on the operational characteristics of four moving-radar models from as many manufacturers. All have digital signal processing and are similarly configured: Dual Antennae, Same Direction Mode, Fastest Speed Mode, Stopwatch Mode and serial ports to interface with speed displays, laptop computers or MDTs and mobile recording systems.

All of them featured automatic direction sensing and directional operation. Three were Ka band; one was K band. The latter was the newly introduced **Decatur Genesis II Directional**, which at the time of the test was offered only in K band. For comparison purposes a non-directional Ka-band model was also run through the performance tests.

The other units tested were the **Stalker DSR from Applied Concepts**; the **Directional Golden Eagle from Kustom Signals**; and the **BEE III from MPH Industries**. These three were purchased anonymously. Both Decatur Genesis II units were supplied by the manufacturer.

We evaluated each radar's controls, the quality and effectiveness of its mounting brackets, hardware and accessories and also the quality of its audio and functions. Then each radar was road-tested for at least 15 hours in a variety of environments including rural interstates, two-lane state roads, city streets and urban freeways. Each was operated both in daytime and at night and in a range of traffic conditions varying from very light to extremely heavy.

Each operating mode was scrutinized at length: Stationary Bi-Directional, Stationary Directional, Moving/Opposite Lane, Same Direction and Fastest. Last, under controlled conditions we measured performance, verifying their ability to meet our minimum requirements for range and target-acquisition speed.

Following the field tests we performed three additional tests:

- Antenna Water Intrusion
- Thermal Test of the Counting/Display Unit
- Radio Frequency Interference

Test Site

Our test site was an isolated two-lane desert highway 30 miles northwest of Phoenix. A 6,000-foot-long section of the 10-mile-long blacktop road was used. It is die-straight, almost completely flat—save for a slight rise about 5,100 feet from the beginning of the test zone—and devoid of any structures, fences or reflective surfaces capable of influencing the radar. Before testing we verified that no ambient microwave energy or sources of radio-frequency interference were present. Traffic volume averaged about 30 vehicles per hour. Testing was halted in the presence of civilian vehicles to guard against possible interference.

The target vehicle for the Stationary-Mode Maximum Range test was a Special Service Package Ford Expedition. This vehicle was otherwise used as the radar vehicle. For the Moving-Mode Maximum Range and Same Direction Maximum Range tests a Nissan Maxima was used as the target.

Target Range and Target-Acquisition Time Tests

Our minimum range requirements—5,000 feet in Stationary Mode, 2,000 feet in Moving Mode—were substantially greater than target ranges generally experienced in the field. This was done to ensure that the radar would still be capable of delivering adequate range in less favorable circumstances when asked to cope with limiting influences such as roadside foliage, fences, buildings, electrical interference, road irregularities and heavy traffic.

Target-acquisition times were measured in order to verify that the unit wasn't experiencing difficulty in determining target speeds. This test was done in Stationary Mode only since there was no way to exactly replicate every parameter—particularly separation distance between target and patrol vehicle when both were in motion—from one run to the next. However, note was taken during the road tests to see if a radar chronically required an inordinate amount of time to display target speeds.

Target-Acquisition Time Test

Description	Min. Required
• Target-acquisition time, Stationary Mode, at 750 feet	<0.75 sec.
• Target-acquisition time, Stationary Mode, at 1500 feet	<0.75 sec.

Maximum Range Test

- Stationary Mode
- Moving Mode
- Same Direction/Moving Mode

We were less concerned about maximum range than the ability to meet the minimum range requirement, knowing that while one-plus mile of range may be good for bragging rights, in the real world it's purely academic, considering the need to establish a proper tracking history. Similarly, target-acquisition times, so long as they met our minimum requirement, are generally of little importance on the road for the same reason.

In the event, we found that none of the units failed to meet the minimum range requirements and three of the four proved capable of acquiring targets in less than 0.51 second (the remaining unit averaged 0.64 second). Blessed with digital signal processing and a high-gain antenna, every radar could likely acquire targets much faster, probably in a few tenths of a second under most conditions. The times recorded were largely dictated by the individual's reaction times and by the ergonomics of the remote control, since the test called for placing the unit on hold then transmitting and locking the target speed as quickly as possible. The fastest of the test crew had a best time of 0.32 second and averaged 0.39 second over five tries with three of the units.

Those models with Hold or Antenna buttons located close to the Lock button inevitably accomplished this task the fastest. On the slowest unit the Lock button is located on the far upper-left side of the remote, requiring a long reach and slightly more time to perform the sequence.

Fastest Speed

Fastest Speed mode was evaluated both in stationary and moving modes. In the case of one unit that allows Same

Direction Fastest, that mode was also evaluated.

Antenna Water Intrusion

The ever-increasing array of equipment being placed in patrol vehicle interiors has led many departments to relocate the radar antenna to the light bar. With this sensitive equipment exposed to the elements, water intrusion has become an issue. Manufacturers using silicone to seal the joint between the antenna lens and body soon learned that once the sealer had been subjected to sunlight, it often cracked, allowing water inside the antenna and ruining the electronics. Antennae incorporating O-rings have fared better.

To verify that each antenna is watertight we mounted it on a test fixture and secured it to prevent movement. On an adjacent fixture we mounted the wand of a pressure washer capable of generating 2,500 psi. The nozzle was adjusted to a small-diameter stream and aimed at the center of the antenna lens, exactly parallel with it and 96 inches away.

With the radar transmitting, the pressure washer was started, its dense stream of water simulating the effects of driving at 140 mph through moderate rain. At 20-minute intervals we stopped the test to perform a tuning fork test on the radar, verifying proper operation. That done, testing resumed. At the one-hour mark we halted the test and checked a final time with the tuning forks.

None of the units exhibited any sign of water intrusion. We'd offer a caveat here, however: these were new antennae and none had been exposed to the elements.

Thermal Test of the Counting / Display Unit

It's a truism that electronic components react badly to heat. Inside a vehicle there are two types. One is ambient heat produced by outside air and also radiated by sun-heated body panels into the vehicle. The second can be found on the instrument panel surface, ambient air superheated by sunlight shining through the windshield. South of the Mason-Dixon line during summer, temperatures inside out-of-service patrol vehicles routinely reach 120 degrees F and dash temperatures much higher.

We performed a thermal test to evaluate the susceptibility of these radars to the debilitating effects of sunlight-induced heat. One at a time, a unit was mounted on the dash above the instrument cluster of a police Ford Expedition, parked with engine off and windows up. The antenna was secured to a surface-mount bracket near the base of the left A-pillar. With the radar placed in stationary mode and transmitting, the doors were closed. The ambient temperature varied from 103 to 106 degrees.

Monitored continuously for 90 minutes, at 30-minute intervals the vehicle interior and counting/display surface temperatures were measured with a digital pyrometer having an accuracy tolerance of +/- 1%. In the event that a radar stopped working, temperatures and the elapsed time to failure were noted.

Three of the four units displayed no ill effects from heat although all had exceeded 160 degrees F within an hour, by which time the vehicle interior had warmed to 125 degrees. The fourth unit failed after 52 minutes, its case having

reached 177 degrees, tripping a thermal protection switch. It was tested a second time with identical results. With the air conditioning on the highest setting, after 13 minutes, 21 seconds it had cooled to 154 degrees and begun functioning again.

Radio Frequency Interference

Some analog units are known to be inordinately susceptible to RFI. Key the police radio mic and instead of speeds, an RFI warning appears on the display. We evaluated these digital radars' ability to reject the emissions from powerful police radios. To do this we secured the cooperation of a major western US sheriff's department that provided a late model Ford Expedition equipped with radios using three of the most common frequencies: VHF Low, VHF High and 800 Megahertz. We also used a five-watt UHF Icom walkie-talkie.

One radar reacted to both VHF radios, displaying an RFI indicator about 25 percent of the time when the microphones were keyed. None of the other units was affected by any of the radios.

Stopwatch Mode

All of the test units had a Stopwatch mode. By entering a distance then using the timer to measure elapsed time, it's possible to calculate average vehicle speed between two points. This function can be used at locations where reference marks have already been laid out for time/distance computers like VASCAR and Tracker, but we're uncertain why the typical officer would use it rather than the radar itself. The proper operation of this function was verified but not field-tested.

Personnel

Craig Peterson is an IPTM-certified radar instructor with 25 years' experience. He also is a qualified lidar and VASCAR operator and an internationally-published author on the subject of speed-measuring technology and mobile electronics. Peterson has performed a number of similar tests over the past two decades, both on production and prototype radar units. He resides in Phoenix, Arizona.

He was assisted by his company employees in performance-testing the radar units included this evaluation. Peterson was the author of this report and the opinions expressed are his alone.

Applied Concepts Stalker DSR

Subjective Evaluation

I. Physical / Operational Characteristics, Features and Ergonomics

The construction of the Stalker DSR differs from most competitors by virtue of the fact that its counting and display units, as well as the antenna, are robust metal castings rather than thin-wall aluminum or steel extrusions. The combined counting/display unit weighs a fraction under two pounds and the antenna tips the scales at 19.2 ounces. Both figures are almost exactly double those of the MPH BEE III and Decatur Genesis II Directional. It is also six ounces heavier than the counting/display unit and antenna of the Kustom Signals Directional Golden Eagle, the next-heaviest unit.

The DSR's digital displays are 10 mm tall and different colors: orange (Target), red (Lock) and green (Patrol). Their generous size and coloring greatly assists in visual identification, easing the operator's task. The only drawback is that the orange and green displays completely disappear in sunlight, particularly if the operator is wearing polarized sunglasses. A sunshade is provided for the DSR display and we found it a requirement for daytime use.

The DSR's display can be separated from the counting unit for remote mounting. Unlike the Genesis II Directional and MPH BEE III, both of which can be pulled apart without the use of tools, on the Stalker two retaining screws must first be loosened, similar to the Directional Golden Eagle. Once separated they are connected by a cable.

Beneath the display windows and running nearly the full width of the lower case is a row of red, backlit icons for mode and status information. Display brightness can be adjusted manually in six steps, allowing greater control of illumination than on the others, each of which dims the display automatically in one step.

A unique DSR feature is voice confirmation of mode, antenna and target direction of travel for locked speeds. We found this very handy as it obviates the need to study the display for that information. The unit also supplies audio tones to confirm mode and antenna selection. Each of its four operating modes has a distinctive tone; selecting the front antenna is greeted with a single beep, the rear antenna with two. The automatic self-tests are announced with a four-beep happy tone. This is an intelligent, well thought-out and extremely useful strategy.

The unit is supplied with a cordless remote (a corded model is available) whose translucent buttons are of a non-slip, rubber-like material. Buttons for the six primary functions are grouped at the top and raised for faster identification. Backlighting is activated by pressing a button and shuts off after seven seconds. Like other cordless remotes, this one has a tendency to drop to the floor and disappear at night. Fortunately, there's a radio microphone stud on the upper rear case, allowing it to be secured on a dash clip.

The infrared transmitter has a wide beam and rarely fails to communicate

with the radar. We noted occasional lapses when the remote was held low and close to instrument panel, blocking its signal from the receiver.

II. Mounts and Hardware

The Stalker is shipped with mounting bales for counter/display and antennae. Optional for the antenna: articulated adhesive windshield mount, headliner mount, rear view mirror clip-on mount and others for side glass, rear deck and dash. The glass mounts hold the antenna securely and allow a great degree of adjustment. Motorcycle mounts are also available. Cables are high quality and the metal, locking connectors are indexed for proper orientation and easy to attach.

III Audio

The DSR's audio accurately depicts target speeds and is clear, static-free and easily interpreted in all operating modes. Same Direction audio in particular ranks as one of the best we've experienced.

IV. Interference

The Stalker DSR showed some susceptibility to fan noise regardless of where on the dash the antenna was located. (For convenience, the front antenna was dash-mounted for this test; by positioning it high on the windshield it's likely that fan noise could have been lowered or eliminated.) Regardless, the DSR showed no sign of fan-noise influence during operations. No susceptibility to RFI from police radios was observed.

Low/high patrol speed options are 5 and 20 mph. Virtually no shadowing was observed and the Stalker showed no susceptibility to low-speed combining or other common errors.

V. Thermal Test

The DSR was the only unit to fail the thermal test, probably a legacy of the display/counting unit's heavy, cast-metal casing. At the 30-minute mark it had already reached 166 degrees and at 52 minutes, with the case at 177 degrees, its thermal protection switch tripped and the unit shut down. The test was repeated with nearly identical results.

Once the vehicle was started, its air conditioning set to maximum cooling, after an average of 13 minutes, 21 seconds the DSR had cooled enough to begin operating again. No lasting effects from the overheating were observed.

A sunshade for the display is provided but none for the counting unit. For thermal protection in harsh environments it must be separated and mounted remotely. This somewhat reduces the DSR's mounting options and entails additional installation time to accomplish.

VI. Same Direction Mode

The DSR performed well in Same Direction Mode, reliably tracking the target while accurately displaying the speed. And its superior audio helped confirm target identification. The Stalker was unaffected by fan noise or other sources of interference in Same Direction mode and almost never displayed an inflated target speed. Its maximum range in this mode trailed the leading Kustom unit by 500 feet and the Genesis II Directional by 398 feet but it was almost dead even with the non-directional Genesis II and BEE III, all three hovering around the 2,000-foot mark.

VII. Fastest-Speed Mode

Fastest Speed operates continuously on this radar and is selected with the Lock/Release button. It cannot be activated once the unit is transmitting and a target is present. Once engaged, the unit reads the fastest target within range. We found that it faithfully tracks faster, weaker targets even in the presence of several stronger targets. The distinct audio assists with target identification. Fastest speeds may not be locked unless they also become strongest.

As with any radar that tracks the fastest target within range, care must be taken to ensure that the observed target is producing the Fastest target speed, not a vehicle farther down the road.

VIII. Directional Operation

Stationary Directional Mode is selected with the Radar Mode button. Like the other units, three modes are available: Approaching, Departing and Bi-Directional. In Uni-Directional mode the DSR reliably tracked targets in the chosen direction while ignoring other traffic. Its directional audio was clear, static-free and corresponded accurately to target speeds.

IX. Performance

The Stalker DSR met the minimum range requirements in stationary and moving modes. It placed second to the Stationary Mode winner, the Genesis II Directional, by some 79 feet and in moving mode, its range trailed the leading Genesis II non-directional's by 447 feet.

It also showed commendable speed in acquiring targets, averaging less than 0.50 second for the two tests.

X. Overall Evaluation

The Stalker DSR has a few weaknesses: a tendency to overheat in hot weather necessitates mounting the counting unit away from the dash area and the display frequently is unreadable in sunlight unless the sun shield is installed. Those caveats aside, the DSR proved to be a well-balanced package with good range, excellent audio, fast target acquisition, good ergonomics, stout resistance to interference and some clever, unique features.

Radar Ratings		Applied Concepts Stalker DSR
I	Physical characteristics	
	Operational characteristics	
II	Mounts and Hardware	
III	Audio Quality	
IV	Interference	
V	Thermal Resistance	
VI	Same-Direction Mode	
VII	Fastest-Speed Mode	
VIII	Directional Operation	
IX	Performance	
X	Overall Evaluation	

Lowest rating Highest rating

Decatur Genesis II Directional

Subjective Evaluation

I. Physical / Operational Characteristics, Features and Ergonomics

The Genesis II Directional was the second-smallest and -lightest unit tested. Mounted as a unit, its extruded-aluminum counting/display unit tips the scales at 20.3 ounces. Separated, the display weighs 6.9 ounces, the counting unit 13.4 ounces.

The Genesis II Directional K-band antenna is weatherproofed by an O-ring and its connector is also waterproof. No water was found to enter the antenna during the water intrusion test.

The Genesis II Directional display has four windows: Target, Lock and Patrol, and a fourth for Mode status. This window displays pictograms denoting the operating mode: Stationary Bi-Directional, Stationary Approaching, Stationary Departing, Moving/Opposite and Moving/Same Direction. In directional operation a "T" or "A" indicates "Toward" or "Away" target direction.

Red digital displays 9 mm tall are used in Target, Locked and Patrol windows while the Mode display is 6 mm tall. A row of five red LEDs depicts target-acquisition range (gain). A green LED indicates Fastest mode; two others depict Front and Rear Antenna selection. These displays are sufficient in size and intensity to be easily seen under all lighting conditions.

An audio tone accompanies any change in operating mode and the engagement and disengagement of primary functions. We found this feature useful, especially when concentrating on driving and other tasks and not wanting to look at the display for confirmation. The Genesis II Directional uses a photocell to automatically regulate display brightness and was found to reliably choose the correct intensity for prevailing conditions.

The Genesis II Directional's display can be separated from the counting unit by pulling the two apart and then linking them by a cable. Unlike the Stalker DSR and Directional Golden Eagle, this can be accomplished without tools, simplifying and speeding up the task. (The BEE III offers this feature as well.)

The display rivals the BEE III's as the smallest and lightest of those tested, allowing it to be mounted either on the dash or windshield, the latter by using the supplied suction-cup bracket. We like the ability to windshield-mount the display since it can be positioned closer to eye level for faster, safer comprehension during moving-mode operation and it also reduces instrument panel clutter.

The Genesis II Directional's wired remote control is unique among those tested in that its 11 buttons control all functions, including Power-On/Off, Mode Selection and Audio Volume. It also holds the speaker. (A cordless remote is not offered.) There are no duplicate buttons on the display.

The most critical functions are operated by the remote's top three rows of buttons that are taller than the others to help identify them by touch. Uppermost are buttons for front and rear antenna which, when pressed, also

start the unit transmitting. A second press puts the unit on hold.

Using separate antenna buttons and combining their function with Transmit both simplifies this primary task and also provides a foolproof way of knowing which antenna is transmitting.

The remote's ergonomics are quite good and its functions are easily learned. Unlike the cordless remotes of the BEE III and Stalker DSR, it's continuously backlit, making it more user-friendly and greatly reducing the chance of its disappearing unnoticed under the seat at night.

A City/Highway option allows either a 5 mph or 20 mph low patrol speed and proved useful on low-speed city streets. By accident we discovered that even when left at the 5 mph setting while working heavy freeway traffic in moving/opposite mode, the unit still ignored right-lane trucks and refused to shadow.

II. Mounts and Hardware

The Genesis II Directional was tested with the standard pedestal antenna mount affixed to the dash with Velcro. Its range of adjustment allowed easy antenna alignment and the base was small enough to let us place it very near the glass, near the A-pillar, the most interference-free point in the test vehicle. A wide variety of alternate mounts is available.

The Genesis II Directional's cables and connectors are high in quality and easy to use. The rubber-insulated cable material is more supple than that on the MPH and Kustom units, both of which use stiff, commercial-grade cables with vinyl insulation. The Decatur's cables are also thinner than the Kustom's and Stalker's—4 mm versus 6 mm and 7 mm, respectively—which make them easier for an equipment installer to route through a vehicle interior.

To show correct orientation, the LEMO connectors have red index marks on top as do all four ports on the rear of the counting unit. The antennas and their LEMO connectors similarly have index marks but the antenna connector, while looking much like those on the counting unit, has a different pin configuration and must only be plugged into the antenna. But every crew member at least once mistakenly tried to plug the wrong connector into the antenna, fortunately without damaging the pins and rendering the unit inoperable.

Color-keyed connectors or identification labels would help avoid confusion here. We also noticed that the brushed aluminum connectors generate a noticeable glare on the windshield during daylight hours. A matte black finish would eliminate this.

III. Audio

We found the Genesis II Directional's audio quality to be excellent, both squelched and unsquelched. The tones, regardless of operating mode, are crisp and distinct and correlate accurately to target speed. Audio for Fastest and Same Direction proved to be of high quality, measurably helping to identify targets, particularly in the presence of multiple, closely spaced targets.

IV. Interference

This Genesis II Directional occasionally picked up fan noise but willingly ignored it in the presence of targets and displayed no tendency for erroneous target speeds or shorter range as a consequence. Only on one occasion

did we notice fan-speed influence on target speed. That was at very low patrol speed in Same Direction mode with a target at extreme range and we observed a 22 mph increase in target speed. This condition is easy to spot and it's unlikely that it would go undetected by any properly trained officer. On all other occasions we found the Genesis II Directional highly resistant to fan noise-induced errors and also to shadowing, low-speed combining and other common phenomena.

No susceptibility to RFI from police radios was observed.

V. Thermal Test

During the thermal test, although this Decatur's counting/display unit reached 172 degrees F, it continued to operate normally. No heat-related damage to the unit was observed, cosmetic or otherwise. The aluminum construction also enabled it to cool down faster than the competing units once the vehicle's air conditioning was turned on.

VI. Same-Direction Mode

The luxury of automatic direction sensing makes Same Direction operation far simpler to use than in conventional radars, With no need to tell the radar if a target is faster or slower than patrol, this type of operator error is eliminated.

Same Direction performance in this Genesis II Directional was quite good, with better range, by nearly 20 percent, over the non-Directional G2 and it narrowly trailed the winning Kustom unit by some 133 feet. More importantly, it faithfully supplied accurate audio for fastest targets and continued to track them even when they were passing a string of eighteen-wheelers and other disproportionately strong targets.

VII. Fastest-Speed Mode

Fastest Speed mode can be selected by depressing and holding the Fast button on the remote. This mode was evaluated both in Moving and Stationary modes and in a wide variety of conditions. As with other models, Fastest operation is heavily influenced by traffic volume.

The Decatur Fastest philosophy differs from all others in that it reads the second-strongest target that is traveling faster than the strongest target. Their contention is that conventional Fastest mode simply reads the fastest target within range, whether it's the closest target or another vehicle farther down the road. To alleviate this possibility other manufacturers either dial back range or prevent the locking of fastest target speeds if they're not the strongest. Some units employ both schemes.

But while either method accomplishes the same task, Decatur's is likely to provide more consistent fastest-target identification. And it's more likely to survive a court challenge. To date there have been no landmark legal precedents handed down regarding Fastest, no doubt due to the general public—defense attorneys included—being unaware of its existence. But that can be expected to change

VIII. Directional Operation

In conventional stationary operation there's the constant problem of traffic entering the radar beam and preventing it from reading the target vehicle. The heavier the traffic volume, the more frequently this occurs. Directional radar handles this

by ignoring vehicles traveling in one direction, concentrating instead on the intended target. We find this to be a major advantage, significantly enhancing a radar's utility while also improving officer productivity.

Directional stationary operation in the Genesis II Directional is selected by depressing the Mode button, after which the unit cycles through Moving/ Opposite and Same Direction before entering Stationary. Once in Stationary, the unit must be transmitting before Directional can be engaged. The first press of the Mode button selects Toward (approaching targets), a second press selects Away (departing targets).

We found this Genesis II's performance to be very good, the unit faithfully tracking targets in the desired direction while ignoring all others. The only suggestion that other vehicles were moving through the beam was an occasional pause in target speed and audio when very large targets blocked the radar's view of the target. Accuracy and range were indistinguishable from bi-directional stationary operation.

IX. Performance

The Genesis II Directional proved to be an excellent performer. Its target-acquisition times were as good as or better than the competitors', its moving-mode range was second only to the conventional G2's; it led the pack in Stationary Mode range and placed a very close second in Moving Mode/Same Direction. In all, a very well balanced performance.

X. Overall Evaluation

The Genesis II Directional's construction appears to be robust and its cables, mounts, hardware and accessories both functional and of very high quality. In these areas it is indistinguishable from its non-directional sibling.

The Genesis II Directional lacks a few of the features found on some of the other units. For example, once the unit stops transmitting, there's no indication of which antenna had been used to record the locked speed. This would be helpful in Fastest and Directional/Stationary modes. And it lacks an indication that Fastest had been used to lock a speed. Both items likely are of more interest to sales and marketing departments but they would be of some practical value in target identification, particularly for inexperienced officers.

In performance, the new Genesis II Directional equals or exceeds that of its forebear in every area and is directly comparable to all its competitors'. Its superior audio, user-friendly ergonomics and resistance to interference are the hallmarks of a well-developed, very competent radar unit.

Radar Ratings		Decatur Genesis II Directional
I	Physical characteristics	
	Operational characteristics	
II	Mounts and Hardware	
III	Audio Quality	
IV	Interference	
V	Thermal Resistance	
VI	Same-Direction Mode	
VII	Fastest-Speed Mode	
VIII	Directional Operation	
IX	Performance	
X	Overall Evaluation	

Lowest rating Highest rating

Kustom Signals Directional Golden Eagle

Subjective Evaluation

I. Physical / Operational Characteristics, Features and Ergonomics

The Directional Golden Eagle was the second-heaviest unit in the group; its combined counting/display unit weighs one pound, 10 ounces and the Ka antenna 13.5 ounces.

If the display remains attached to the counting unit, the case forms a horizontal "L" shape with the display nearly twice the height of the compact and very slim counting unit. This enables the counting unit section to be mounted flush with the top of the dash, with the display hanging over the edge. So positioned, even on a reverse-sloping dash the front of the display remains nearly vertical. In contrast, the other radars, all of them rectangular boxes, when mounted on a sloping dash will have their displays angled more toward the headliner. We're uncertain if Kustom's engineers had this in mind, but it does make for a more readable display.

The counting unit can be separated to permit remote mounting although that entails the use of a separate kit (supplied with the unit) containing a block-off plate, extra screws, some angle brackets and three pages of instructions, along with the usual connecting cable and mounting bales.

The display has three windows for Target, Lock and Patrol. All are red in color and 8 mm in height. The display is easily read in most lighting conditions although sunlight at some angles can wash it out. To remedy this, the unit ships with an aluminum sun shade. No mounting hardware is supplied, however, only some Velcro strips. An inelegant method of attachment, perhaps, but the shade works well.

A row of seven switches on the lower case handles secondary functions: Test, 10/20 mph Low Patrol Speed, Audio Volume, Range, Stopwatch and Power. There's also a Lock button that duplicates the one on the remote.

The Directional Golden Eagle depicts Antenna Selection, Operating Mode and Target Direction with five red LEDs representing targets and patrol vehicle, all positioned on a roadway. This simple, effective design remains among the best we've seen.

Two additional red LEDs, arrows pointed north and south, denote Fastest mode. They're steady-burn when Fastest is engaged and flash when a Fastest speed is being displayed or has been locked. In Bi-Directional Stationary mode both are lit; in Moving Mode one lights to denote the direction of Fastest targets. When a Fastest speed has been locked, the appropriate light flashes as verification. In light of the heightened potential for mistaken target identification when using Fastest, this is a welcomed feature.

One-step display brightness is adjusted automatically via photocell. It doesn't offer the degree of control afforded by manual adjustment but handled the task adequately.

The Directional Golden Eagle's corded remote control is the smallest of those tested. Its six switches are continuously backlit and distributed in two vertical rows, all of the buttons equally spaced. These are uniform in

height and identical in shape, size and texture, requiring the operator to locate them entirely by their relative positions. This method is less intuitive than some we've seen and makes the learning curve somewhat slower.

Separate buttons are used for Transmit/Hold and Antenna selection. From an ergonomic perspective this scheme is less efficient than combining those functions in a single button. And having them located at the upper right and lower left corners requires a longer reach for the operator.

There's an audio confirmation for Lock but none for engagement or disengagement of a mode or function. As a result, the operator must check the display for visual confirmation. In particular, audio confirmation for antenna selection and mode would be helpful. A single button is used to select the antenna and without studying the display, there's no way to verify which is active.

II. Mounts and Hardware

Mounting bales are supplied for counting and display units but this radar is unique in that it comes only with glass mounts for the antenna. Once glued to the glass, these articulated arms offer a wide range of adjustment and hold the antenna rock solid. Motorcycle mounts are also available.

Antenna connectors and output jacks are of a plastic material. They're indexed and screw-on for quick installation and positive retention but don't look particularly robust, leading us to wonder if they'll absorb as much punishment as the metal, Mil-spec-quality connectors found on the Genesis II Directional and Stalker DSR.

The antenna housing is a substantial, thick-wall metal extrusion that suggests good durability. No water was found to enter the antenna during the water intrusion test.

III. Audio

With vehicle fan shut off, this Eagle's audio is clear and distinct and corresponds accurately to target speeds. With fan on, however, it can generate a scratchy static. In unsquelched audio, fan noise was often noted.

A Fan Interference switch is provided to lower the gain and reduce this interference although it works only in Same Direction mode. We tested it but noticed no improvement in audio quality.

IV. Interference

We found the Directional Golden Eagle somewhat susceptible to fan noise in Same Direction mode. Little interference was noted in other modes, however. There was no apparent effect on its moving/opposite and stationary-mode performance, only the quality of the audio.

No susceptibility to RFI from police radios was observed.

V. Thermal Test

After sitting on the dash in intense sunlight for 45 minutes the Directional Golden Eagle's counting/display unit had heated to 171 degrees. At the 90-minute mark it had reached 181 degrees, but the unit continued to operate normally and showed no ill effects.

VI. Same-Direction Mode

In moderate-to-heavy traffic, in Same Direction mode the Directional

Golden Eagle frequently displayed a combined speed. At low patrol speeds it occasionally added fan noise-generated speed to target speed, usually at long-range targets. We engaged the Fan Interference Switch without noticing an improvement. Much of this behavior we attribute to the difficulty this radar exhibited in establishing accurate patrol speed. However, range in this mode was the best of the group, averaging over 2,500 feet.

This radar is the only model to offer Same Direction Fastest, a feature we found very useful. It enables the radar to continue tracking a target even when stronger targets are between radar and target.

VII. Fastest-Speed Mode

Fastest Speed worked well in stationary mode, reliably tracking a Fastest target even in the presence of multiple targets. In moving mode this function was affected by the radar's frequent inability to determine patrol speed when operated on featureless roads. On those occasions it was slow to acquire a target speed and often displayed it intermittently or as a constantly varying number.

Through its menu options the Directional Golden Eagle can be set to operate full-time in Fastest or only when the Fastest button is depressed. Unlike the other radars, with the Kustom it's possible to lock a Fastest speed when a target is not the strongest. Experienced officers will probably like this but we see the potential for incorrect target identification in the hands of a rookie.

VIII. Directional Operation

This radar worked well in Directional mode, showing good target discrimination and providing accurate audio. We noted no difference in target range among the three Directional modes.

IX. Performance

In stationary mode the Directional Golden Eagle showed itself to be quick in acquiring targets, its maximum range within feet of the others'. By a small margin, range in moving-mode and Same Direction were the best of the group. Its range in Directional/Stationary and Same Direction was very competitive as well.

However, we noticed some weaknesses in this radar. For example, in some environments it frequently was unable to acquire accurate patrol speed. During road testing in southwest Arizona, for instance, while traveling across a hundred-mile stretch of straight and level interstate it declined to display a constant patrol speed for the entire distance. Even with cruise control engaged to precisely maintain 70 mph, patrol speed continuously fluctuated between 69 and 72 mph. Target speeds consequently jumped around in unison, making target identification difficult or impossible when multiple targets were present. The Directional Golden Eagle was also very prone to shadowing and combining.

The patrol-speed anomaly was most noticeable on flat, featureless terrain. When operated on roads in hilly or forested areas and other locations where roadside clutter was abundant, the radar more reliably established the correct speed.

It's likely that these tendencies, particularly shadowing and combining,

would have been tamed had we used the Tru-Track speedometer pulse cable that's standard equipment. Connected to the vehicle speed sensor (VSS) circuit, it supplies road speed to the computer. Now the radar has only to look for a patrol speed that's plus or minus a few mph from that reference.

We chose not to use Tru-Track because it has been our experience that many departments, particularly smaller ones that rely on the local mechanic to equip their vehicles, are prone to ignore it. For that matter, we know of a number of large vehicle outfitters that don't install it either.

Installation involves locating the VSS wire buried in the main harness in the engine compartment, routing the extra wire from the counting unit under the dash, through the firewall and tapping into the harness. Done properly, the wiring should then be covered with plastic wire loom and secured to the OEM harness with wire ties. The manufacturer's Website provides wiring diagrams for commonly used police vehicles but not every vehicle is covered. A pricey manual from the vehicle manufacturer will probably be required in those cases. Once installed, the car must be driven at a constant speed between 30 mph and 70 mph while patrol speed is synchronized with vehicle speed.

Tapping into the VSS wire isn't to be taken lightly. The usual method is to pierce the insulation with a 3M Scotchlok connector. Once this is done, the wire is open to the atmosphere and, unless adequately coated with heat- and oil-resistant, airtight insulation, it gradually deteriorates. Disrupting this circuit will incapacitate a late model vehicle, for with road speed absent or inaccurate, the powertrain computer doesn't know when to shift gears, lock or unlock the torque converter or perform other basic functions.

A second reason for not testing the unit with a VSS connection is that while some competitors offer one as an option, none includes it as standard equipment. We suspect that this radar's signal-processing software could benefit from some refinement.

X. Overall Evaluation

The Directional Golden Eagle has a number of strengths: an excellent display, great range, fast target acquisition—in most circumstances—and unique, very useful Same Direction Fastest capability. It's housed in an attractive case that reflects quality materials and careful construction.

Its only shortcomings of note are the need to glass-mount the antenna to reduce fan noise and tap into the vehicle speed sensor to reliably acquire patrol speed.

Radar Ratings		Kustom Signals Directional Golden Eagle
I	Physical characteristics	)))
	Operational characteristics	)))
II	Mounts and Hardware	)))
III	Audio Quality	)))
IV	Interference	))
V	Thermal Resistance	))))
VI	Same-Direction Mode	))
VII	Fastest-Speed Mode	))
VIII	Directional Operation	))))
IX	Performance	))))
X	Overall Evaluation	)))

Lowest rating) Highest rating))))

MPH Industries BEE III

Subjective Evaluation

I. Physical / Operational Characteristics, Features and Ergonomics

The BEE III was the smallest and lightest unit to be tested. Its counting unit weighs 10.9 ounces, the display 5.8. The Ka-band antenna weighs 6.8 ounces and was also the smallest of the group.

The counting unit can be separated from the display by pulling the two apart; no tools are required. Once separated, it can be mounted either with Velcro or the supplied dash bracket and linked by cable to the computer.

There are four display windows: Target, Lock, Mode and Patrol. Target employs red digits 10 mm tall; the 8 mm-tall Lock digits are yellow and the green Patrol digits also 8 mm in height. The red digits remain legible under most lighting conditions although the yellow and pale green wash out badly in sunlight. A metal sunshade is provided for this purpose. It has slots on the rear, enabling it to be slipped over the retaining screws without having to remove them. Display brightness is photocell-controlled and was found to do an adequate job of dimming the display at night.

Only one control, Power-On, is located on the display. All others reside on the cordless remote. The Mode window uses pictograms and arrows to denote antenna selection as well as mode. A pictogram of a patrol car appears on the right; red arrows above and below it show mode and antenna selection. Mode also is indicated by MOV and STA that appear under the Lock window.

When a speed is locked, under the Lock window a "T" appears along with the pictogram of a lock. Mode and antenna indicators also are displayed. If a Fastest speed is locked, the word "Fast" also appears. A single audible tone confirms a change in mode, antenna selection and lock. A one beep/two beep tone signals Fastest on/off. We find this design to be very comprehensive and one of the best we've seen.

The cordless remote (a wired version is optional and can be used in conjunction with the cordless remote) has two groups of switches. The upper group controls all primary functions, its buttons constructed of the same translucent, rubberized material as those on the Stalker and Decatur units. Each is uniquely contoured and positioned with considerable attention to ergonomics. Same and Opposite buttons are positioned on the right and left, respectively; front and rear antenna buttons are front and rear, respectively. RF Hold is in the center. When an Antenna button is pressed the unit begins transmitting. This is by far the most elegant and effective design we've seen—highly intuitive and easy to use.

The Fastest button is at the upper right on the remote and Lock is located at the upper left. We feel the two should have been reversed because the Lock button is too long a reach for an average-size hand, forcing operators to alter hand position to reach it. And since the BEE III will operate in full-time Fastest, we feel that function

is of lesser importance. The distant location of the Lock button accounts for the longer times recorded for the BEE III in both target-acquisition tests.

On the lower portion of the remote are eight pressure-sensitive membrane switches for secondary functions. One button controls Moving/Stationary and Stopwatch mode, another handles Patrol Speed Blank and City/Highway-Low/High Patrol Speed. (Neither speed is identified in the manual or shown in the display; only the abbreviation "Cty" or "Hwy" appears.) The Menu button controls three functions: Audio, Range and POP Mode. Pressing the Backlight button produces seven seconds of illumination.

II. Mounts and Hardware

Shipped with the MPH BEE III is a dash fixture that doubles as an antenna mount, plus a rear-deck antenna L-bracket. The former is a curiously shaped affair with a 1.75-inch-deep, 11-inch-wide lower plate connected to an upper tray measuring 3.75 inches deep and 5.25 inches wide. The combined counting/display unit or only the display is intended to drop into the tray, secured by a knurled hold-down bolt on each side. The antenna bolts onto either side with an L-bracket.

MPH recommends using this bracket to reduce fan noise and it was installed according to directions in our police Ford Expedition. Once the vehicle was in motion, however, the counting/display unit and antenna vibrated uncontrollably, creating a significant visual distraction. We suspect this mount was originally designed to slip over the vehicle's sun visor. Indeed, it slipped perfectly over the Expedition's—and the BEE III brochure has a picture of the components mounted exactly in this manner.

But once installed we found that the spring-loaded visor flipped back into its stowed position, pointing the display at the headliner. We inserted a wedge to keep the visor horizontal but then found that the display was less than 10 inches from the driver's forehead. In this location it was far above the driver's line of sight and would also pose a safety hazard in the event of a collision.

For testing we elected to mount the counting/display unit on the dash with Velcro and used a windshield suction-cup bracket to install the antenna. (The rear antenna was placed on the factory-supplied bracket.) According to the manual, MPH offers other mounting brackets, which we feel would be worth investigating.

Antenna connectors are the plastic twist-on type like those on the Kustom. They're perfectly functional but don't give the impression of being as durable as the metal connectors used by the other radars. The antenna cables are stiff vinyl-insulated affairs that plug into the counting unit with indexed, locking connectors. Another such connector secures the power cord. We noted two anomalies on the test unit. Both antenna jacks were indexed 180 degrees opposite to the power jack, requiring them to be installed upside down. And the front antenna cable's insulation was split where it met the connector, exposing the bare coaxial wire.

III. Audio

In all modes the BEE III's audio proved to be of superior quality, corresponding well to target speeds. Unsquelched, fan noise was usually

heard on the front antenna and surprisingly, occasionally on the rear antenna. With targets present, however, fan noise was unnoticeable.

IV. Interference

The BEE III showed no sign of being influenced by fan noise while in Stationary Bi-Directional and Moving/Opposite modes. In the absence of traffic, fan noise often generated phantom target speeds and in Same Direction, occasionally inflated the speed of a distant target. This phenomenon is readily apparent to an experienced operator and isn't unknown in other radars.

Some susceptibility of the BEE III to RFI was observed. Once out of every four times when we keyed the microphones of both low- and high-band VHF radios, an RFI indicator appeared. The BEE III was unaffected by the 800 Megahertz and UHF radios.

V. Thermal Test

Temperature of the counting/display unit reached 164 degree F within 30 minutes during the heat test and peaked at 171 degrees at the 90-minute mark. There was no apparent effect on normal operation.

VI. Same Direction Mode

Same Direction operation proved to be somewhat problematic for the BEE III. In most circumstances it performed this task with dispatch. However, it occasionally displayed target speeds as high as 80 mph with no vehicles present. It was also noticed that when opposite-lane vehicles drove between target and patrol vehicle, it often combined speeds, inflating target speed by as much as 75 mph. This occurred most often on nearly deserted two-lane roads with only one or two vehicles present.

Range is automatically reduced in Same Direction but the BEE III was able to meet the 2,000-foot minimum range requirement.

VII. Fastest-Speed Mode

Once Fastest is selected, the BEE III will operate in Fastest until it's manually disengaged or when a speed is locked. It will display this speed in the Lock window, providing that it's not also the strongest, in which case it appears in the Target window. Like the Stalker and Kustom, it looks for the fastest target within range that's traveling faster than the strongest target. A Fastest speed can't be locked unless it's also the strongest. Fastest isn't available in Same Direction.

Fastest worked reliably in all modes and the audio accurately depicted both strongest and fastest targets.

VIII. Directional Operation

Bi-directional operation was reliable and accurate. In Directional, however, the BEE III was frequently influenced by other vehicles driving into the beam. For instance, when working approaching-only targets, the speed of a vehicle coming from behind the patrol car, as soon as it passed the cruiser and came between radar and target, would frequently be added to the target speed. This influence disappeared once the intruding vehicle had put some distance between itself and the radar. The inflated target speed was easily recognized but it disrupted tracking history and the effect was distracting.

IX. Performance

The BEE III had competitive range in every test and was generally quick to read targets. We also evaluated one of its unique features, POP Mode.

This function can be used in Moving/Opposite and in all Stationary modes. Its purpose is to outwit radar detectors and it accomplishes this by sampling target speeds in milliseconds-long bursts too brief for detectors to spot. We tested POP mode by powering-up half a dozen new radar detectors ranging in price from the $399 Valentine One to the $60 Cobra 6060. Each detector was hit five times with the radar at point-blank range and none reacted to it.

No audio is provided in POP mode, target speed disappears after two seconds and the speed can't be locked, safeguards to reduce the possibility of operator error. The manufacturer cautions against using POP mode for enforcement purposes and directs the operator to use it only to identify targets of interest. At that point, the officer is to press the Transmit button a second time to exit POP mode and place the unit in Continuous-Transmit mode.

Some officers might find favor with this feature but it may be a mixed blessing. Without tracking history or audio we feel there's a potential for misuse. Inevitably some officer will use POP mode for citation purposes and a sharp defense attorney will raise the specter of mistaken target identification. Not that the officer would volunteer that he'd used POP mode. But if such a case ever reaches an appellate court, the fallout could affect all BEE III users.

X. Overall Evaluation

The MPH BEE III offers an array of compelling virtues: good performance, high-quality audio; lightweight, compact construction, superior ergonomics and the best remote control in the business.

Conversely, its performance in Same Direction and Directional modes suggests a few software glitches. We also found the dash-mount bracket troublesome and noted some quality control lapses. But having observed MPH since the late Seventies, we suspect that this relatively new model will enjoy future refinements to address these issues.

Radar Ratings		MPH BEE III
I	Physical characteristics	
	Operational characteristics	
II	Mounts and Hardware	
III	Audio Quality	
IV	Interference	
V	Thermal Resistance	
VI	Same-Direction Mode	
VII	Fastest-Speed Mode	
VIII	Directional Operation	
IX	Performance	
X	Overall Evaluation	

Lowest rating Highest rating

Comparative Test Results

Interference (RFI) Test

	VHF Low [1]	VHF High [2]	UHF [3]	800 MHz [4]
Applied Concepts Stalker DSR	O	O	O	O
Decatur Electronics Genesis II Directional	O	O	O	O
Kustom Signals Directional Golden Eagle	O	O	O	O
MPH BEE III	X	X	O	O

[1] Motorola Syntor X9000, 110W
[2] Motorola MaxTrac, 40W
[3] Icom F21GM, 5W
[4] Motorola Astro Spectra, 35W

O = No RFI X = RFI noted

Test Parameters

- Radar vehicle: Sheriff's Department 1999 Ford Expedition.
- Radar and antenna mounted in same location on dash as in radar vehicle used in tests.
- Unit was powered-up, tested and placed in transmit mode.
- One radio at a time was keyed for five seconds while radar was observed for RFI.
- Test repeated five times for each radio.

Thermal Test

	Ambient Temperature at Start of Test (°F)	CDU Case Temp. / Vehicle Interior Temp. (°F)			Notes
		At 30 minutes	At 60 minutes	At 90 minutes	
Applied Concepts Stalker DSR	106°	166° / 125°	— / —	— / —	**Failed at 52 minutes: Case temp. = 177°**
Decatur Electronics Genesis II Directional	103°	150° / 116°	161° / 125°	172° / 125°	Passed
Kustom Signals Directional Golden Eagle	103°	152° / 116°	173° / 125°	181° / 123°	Passed
MPH BEE III	106°	164° / 125°	169° / 125°	171° / 130°	Passed

Test Parameters

- Each radar was tested individually by mounting the counting/display unit (CDU) and antenna on the dash of a 1999 Ford Expedition parked facing the sun between noon and 3 p.m. on successive, cloudless days in mid-July in Phoenix.
- Temperature readings of the CDU case and vehicle interior were recorded at 30-minute intervals with a calibrated pyrometer.
- A tuning fork test was performed at 30-minute intervals to verify proper operation.

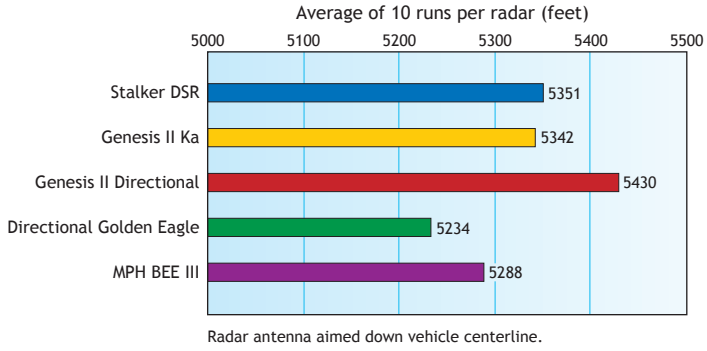
RADAR FIELD TEST REPORT

Results Summary

1. Radar Comparison Ratings	Applied Concepts Stalker DSR	Decatur Genesis II Directional	Kustom Signals Directional Golden Eagle	MPH BEE III
I▫ Physical characteristics	)))	)))	)))	)))
▫ Operational characteristics	)))	)))	)))	)))
II▫ Mounts and Hardware	))))	))))	)))	))
III▫ Audio Quality	))))	))))	)))	))))
IV▫ Interference	))))	))))	))	))
V▫ Thermal Resistance	)	))))	))))	))))
VI▫ Same-Direction Mode	))))	))))	))	))
VII▫ Fastest-Speed Mode	))))	))))	))	))))
VIII▫ Directional Operation	))))	))))	))))	))
IX▫ Performance	))))	))))	))))	))))
X▫ Overall Evaluation	))))	))))	)))	)))

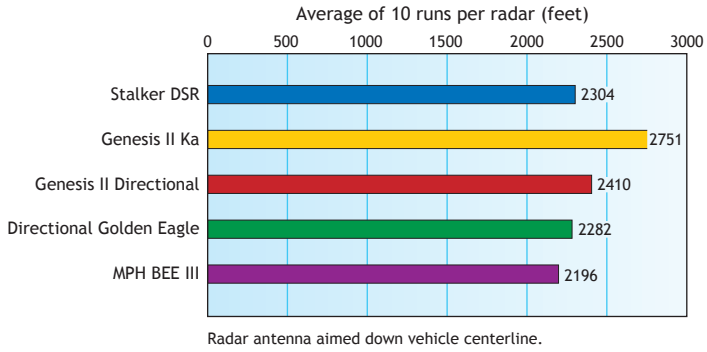
Lowest rating) Highest rating))))

2. Stationary Mode Maximum Range



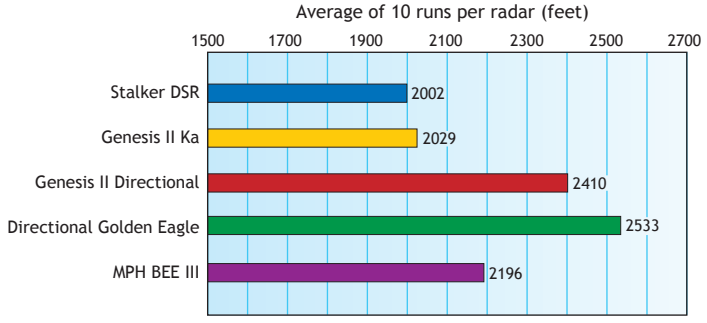
Radar antenna aimed down vehicle centerline.

3. Moving Mode Maximum Range

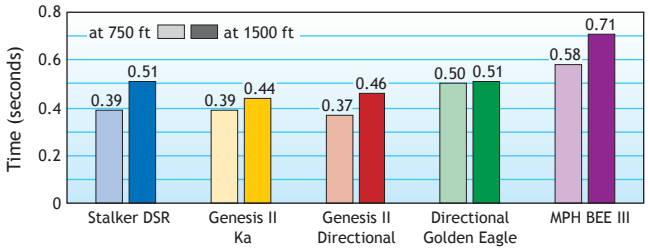


Radar antenna aimed down vehicle centerline.

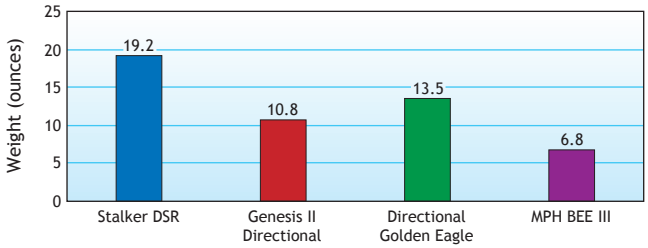
4. Same Direction Maximum Range



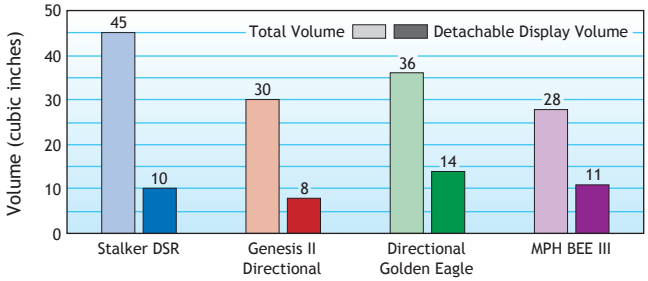
5. Target-Acquisition Time



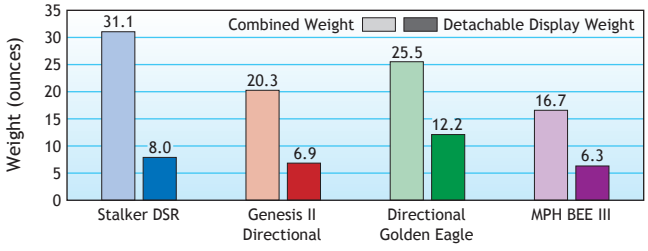
6. Antenna Weight



7. Counting/Display Unit Volume



8. Counting/Display Weights

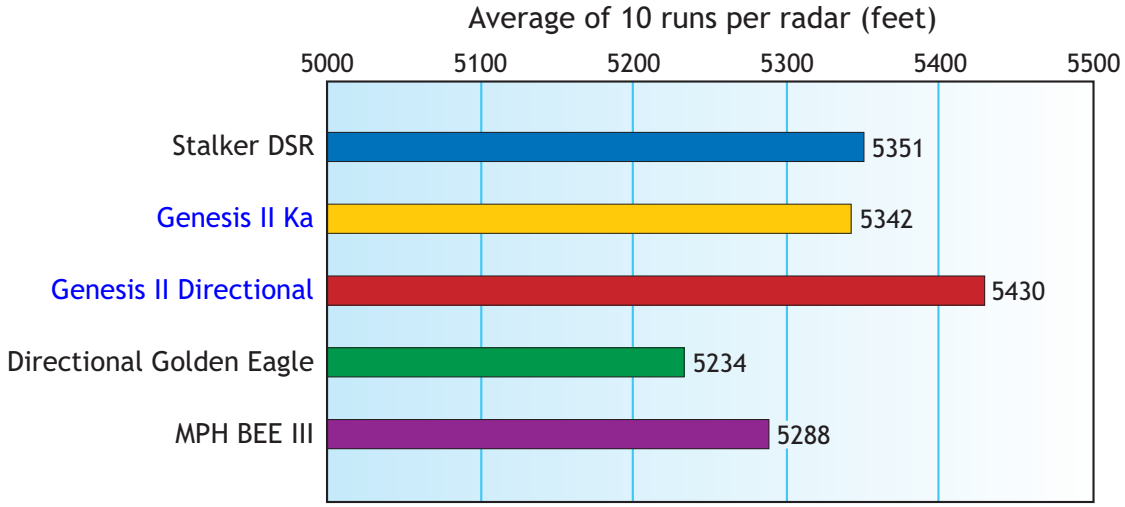


1. Radar Comparison Ratings

		Applied Concepts Stalker DSR	Decatur Genesis II Directional	Kustom Signals Directional Golden Eagle	MPH BEE III
I	Physical characteristics	)))	)))	)))	)))
	Operational characteristics	)))	)))	)))	)))
II	Mounts and Hardware	))))	))))	)))	))
III	Audio Quality	))))	))))	)))	))))
IV	Interference	))))	))))	))	))
V	Thermal Resistance	)	))))	))))	))))
VI	Same-Direction Mode	))))	))))	))	))
VII	Fastest-Speed Mode	))))	))))	))	))))
VIII	Directional Operation	))))	))))	))))	))
IX	Performance	))))	))))	))))	))))
X	Overall Evaluation	))))	))))	)))	)))

Lowest rating) Highest rating))))

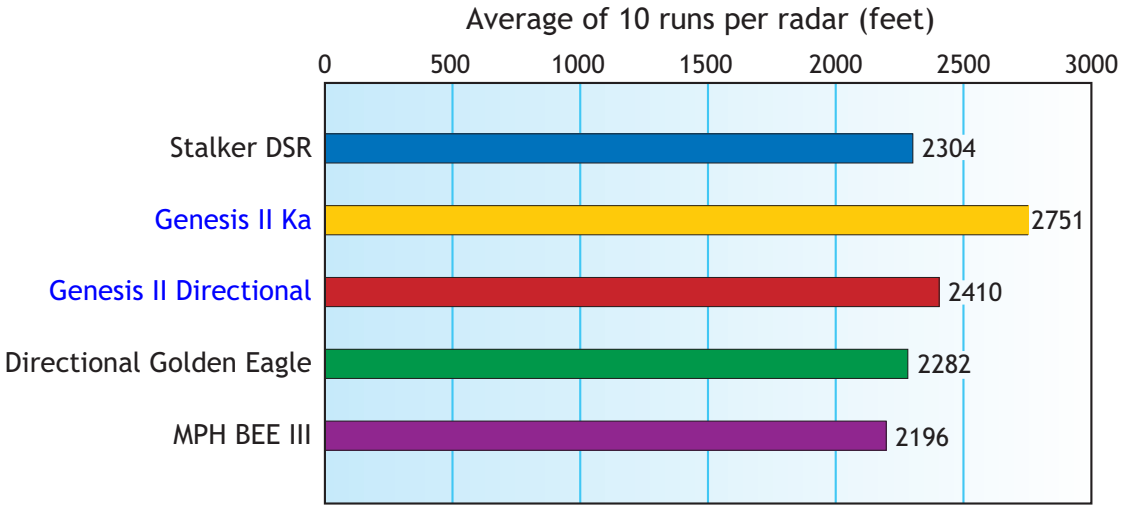
2. Stationary Mode Maximum Range



Radar antenna aimed down vehicle centerline.

Radar antenna aimed parallel to centerline of patrol vehicle and horizontally. Radar vehicle's engine and climate control system off during testing. Target vehicle starts each pass from staging area at 6,500 feet, moves toward radar at steady 25 mph. Target range measured at point where steady target speed first observed.

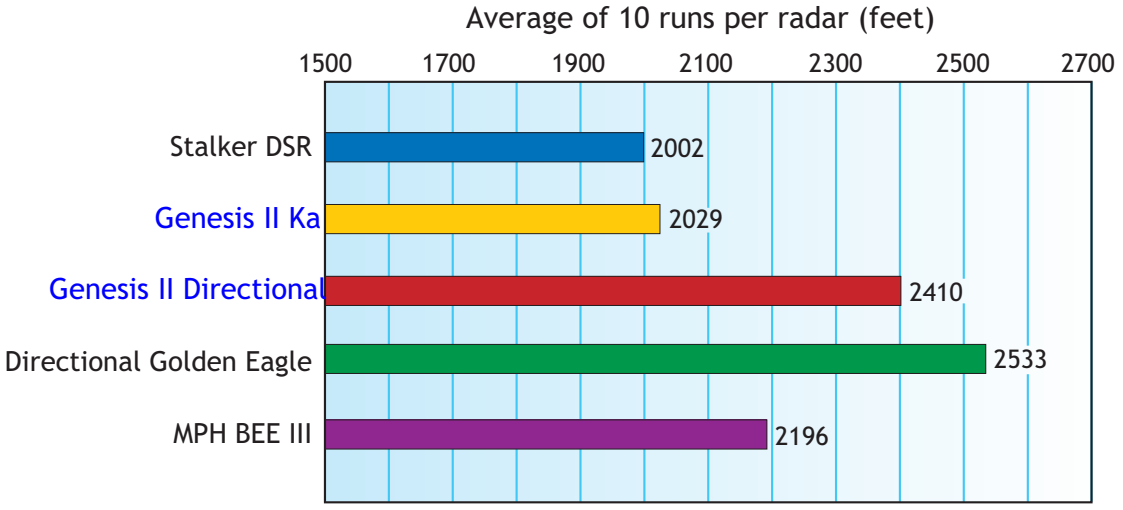
3. Moving Mode Maximum Range



Radar antenna aimed down vehicle centerline.

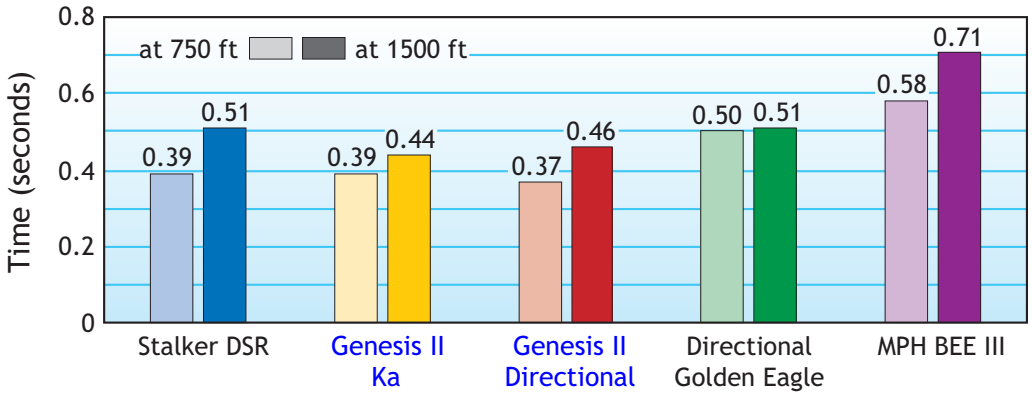
Radar antenna aimed parallel to centerline of patrol vehicle and horizontally. Radar vehicle's climate control system off during testing. Target vehicle starts each pass from staging area at 6,500 feet, moves toward radar at steady 25 mph. Radar vehicle departs simultaneously, drives at 35 mph toward target. Target range measured at point where steady target speed first observed.

4. Same Direction Maximum Range



Target vehicle and radar vehicle are parked in same lane, 2,000 feet apart. Target vehicle accelerates to 25 mph and its driver radios the radar operator/driver upon reaching 2,500-foot marker. Radar vehicle accelerates to 35 mph, gradually closing distance between the two vehicles. When target speed acquired, radar operator instructs target vehicle to stop and simultaneously activates Distance switch on Kustom Signals Tracker time/distance computer installed in patrol vehicle. Distance to rear of target vehicle is measured.

5. Target-Acquisition Time

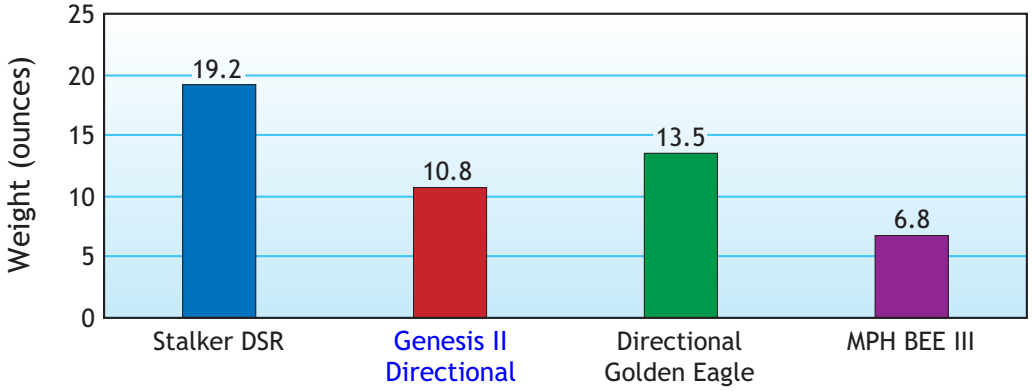


Radar vehicle was parked on shoulder of two-lane county highway, parallel with road. Radar antenna was aimed down vehicle centerline. Radar vehicle's engine and climate control system were shut off.

With no other traffic present, the four-door, mid-sized Nissan Maxima target vehicle began driving toward the radar from a staging area 2,000 feet distant. On command, the vehicle accelerated to 25 mph and, as it approached a traffic cone placed exactly 1,500 feet from the radar antenna, its driver radioed the operator, giving a "3-2-1-Mark" countdown. At the "Mark" command, the radar operator simultaneously pressed the front antenna Transmit button and started a stopwatch. When a target speed appeared, the operator simultaneously pressed the Lock button and stopwatch. The elapsed time was recorded.

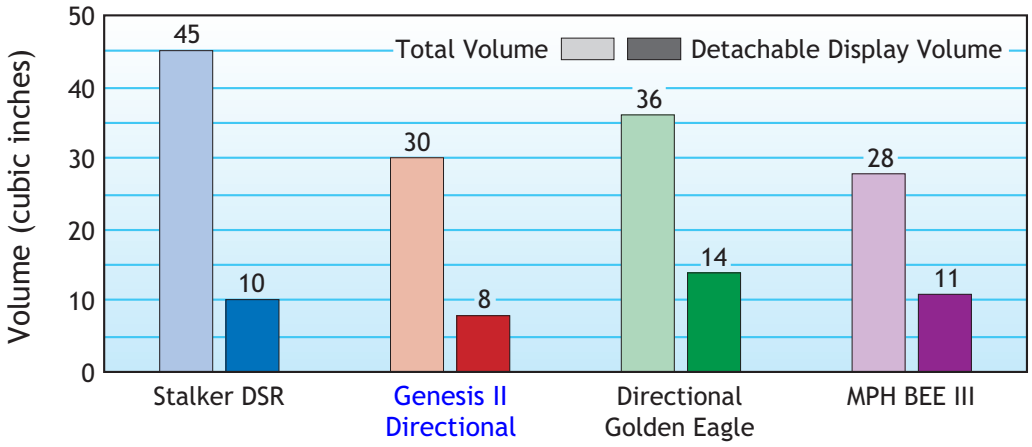
Five runs were made and their times averaged. With no other changes, the test was repeated against the same radar, this time at 750 feet. Those times were also averaged.

6. Antenna Weight



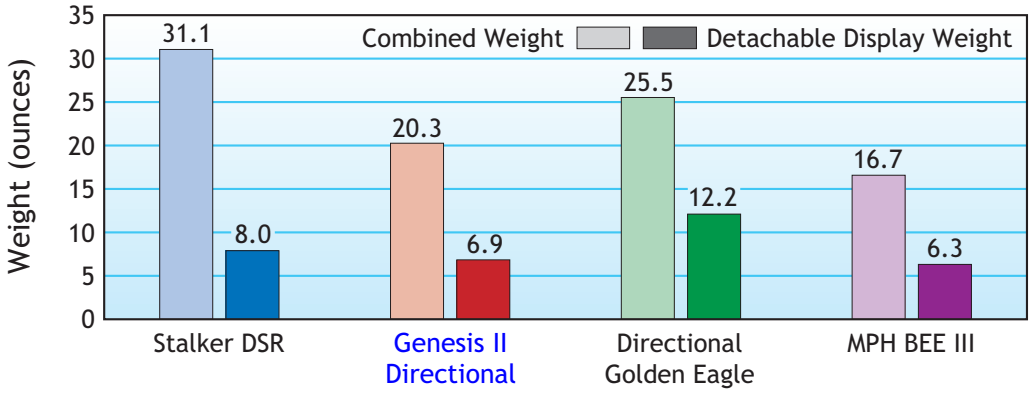
Antenna, with no cable, bracket or hardware attached, was weighed on a digital scale.

7. Counting/Display Unit Volume



Volume was calculated by measuring the external dimensions of the counting and display units. Cables, brackets and hardware were not attached to the units.

8. Counting/Display Weights



Weight was measured with counting and display unit combined, and that of the display separately.

A digital scale was used. Cables, brackets and hardware were not attached to the units.