Ascension Technology Corporation

Magnetic Fact Sheet and Video: DC vs. AC Tracking

Overcoming Metal Problems
The Advantage of DC Magnetic Tracking

Many people think magnetic trackers are all the same. Indeed for many years there was just one option: AC electromagnetic tracking technology. Invented by Polhemus Inc., it's been available for almost 30 years. For some, it is the first and only tracker choice – like the automobile brand you always buy because it was your first car. In some cases, an AC tracker may indeed be the best choice, but more often than not, you should look further.

Today third-generation pulsed DC magnetic trackers from Ascension offer new and improved ways to track six degrees-of-freedom sensors in environments once thought unsuitable for magnetic technology. Indeed, DC tracking was invented by Ascension to overcome the metallic distortion problems of AC tracking devices. Customers tend to agree. Over 7,000 Flock of Birds trackers alone have been sold for in use in virtual reality, biomechanics, simulation, and industrial applications, simply because they work better than AC trackers in real-world environments. As one customer recently noted: "On paper, the AC tracker presents better resolution and accuracy than the DC tracker, but not so in the real world where everyday metal and noise ultimately determine performance."

This year, Ascension launched a new DC tracker product-line to meet evolving requirements for high performance 3D tracking. Its new *3D Guidance* product line – *driveBAY*, *medSAFE*, and *trakSTAR* – represent the state of the art in magnetic motion tracking. In competitive evaluations, major medical device companies have consistently selected *3D Guidance* trackers over AC trackers for incorporation into their products. The most often cited reason: the need for high accuracy tracking of sensors, as small as a pencil point, in difficult metallic environments.

Tracking Near Conductive Metals: AC and DC trackers respond *differently* to conductive metals, such as non-magnetic stainless steel, titanium, and aluminum. When a magnetic field is transmitted, "eddy currents" are induced in conductive metals that interfere with the field transmitted by the tracker. This interference pattern affects the position and orientation outputs, resulting in distorted measurements. Of critical importance is the way AC and DC trackers generate magnetic fields and respond to eddy currents.

> **AC Tracking Technology:** Because of their rapidly varying nature, AC fields continuously induce eddy currents in nearby metals. Whenever conductive metal is in the tracking volume, AC trackers measurements will be distorted.
>
> **DC Tracking Technology:** Pulsed DC fields reach a steady magnetic state soon after transmission. Once this condition is reached, no new eddy currents are generated. By sampling the field when eddy currents are decaying or died out, DC trackers operate with minimal or no distortion.

In general, DC tracking technology is 3 to 10 times less sensitive to conductive metal interference than AC technology. DC trackers exhibit no distortion when in the presence of many common metals, such as stainless steel (300) series, titanium, and brass. A DC tracker can also operate without distortion around aluminum, by reducing its default measurement rate.

How to Choose Between the Two Tracking Technologies? Polhemus Inc. has published a partial analysis of the relative degree of metal sensitivity of AC and DC trackers, but it does not contain benchmark tests. Ascension, on the other hand, believes the best way to judge the right tracker for your application is to let you conduct a side-by-side comparison.

To simplify this comparison, we have prepared a brief video that shows you how AC and DC trackers react to different metals. It presents live results of various metal tolerance tests for both trackers.

Click here to watch the video: Ascension Technology – AC vs DC Technologies

The Ferrous Metal Problem: When operating near ferrous metals, such as carbon steel and iron alloys, both AC and DC field technologies are susceptible. Polhemus and Ascension address the ferrous metal problem differently:

AC Tracking Approach: Since AC tracking technology cannot avoid metallic distortion, special techniques have been developed to control the distortion problem. One such procedure is called "mapping and compensation." It includes the collection of hundreds of data points (mapping) to determine the amount of distortion in the operational area. These data points are then used to form a correction (compensation) that is applied to the sensed signals. While this procedure is effective, it is time consuming and costly. As such, it is not generally available for low-cost, desktop applications. And it assumes the AC field transmitter remains stationary and no metallic objects move or are introduced into the area during the tracking session. The corrections are ineffectual, for instance, if you must relocate your transmitter periodically or if someone moves a large metal object into the tracking area.

DC Tracking Approach: DC trackers handle the ferrous metal problem in two ways:

1. For *short-range* applications, Ascension's new *3D Guidance medSAFE* tracker includes a flat-plate transmitter that contains a metal shield. Ferrous and conductive metals beneath the shield are screened out of the magnetic fields that are cleanly emitted above the transmitter's flat surface. This enables accurate tracking of sensors in the volume above the transmitter even when ferrous distorters are nearby.

2. For *long-range* applications, Ascension and its partners have developed a number of tools to help overcome ferrous metal distorters:

    a. An "Environmental Analyzer" is available to qualified customers for finding the best place to locate and use the tracker. It helps localize ferrous metals in floors, walls and ceilings as well as nearby large objects, such as cabinets and desks. It will also sample local noise sources and recommend a measurement rate to minimize their effects.

b. AutoDesk's "Motion Builder" software contains a utility to calibrate out ferrous distorters in Ascension's long-range motion-capture trackers. When combined with a wooden stage and our expert help, it overcomes distortions and delivers clean data for real-time motion-capture applications.

Note: For those cases in which severe environmental constraints prohibit magnetic tracking, Ascension offers two optical tracking alternatives – laserBIRD 2 and ReActor 2. Metallic distorters in your environment will never affect these trackers.

Overcoming Performance Issues
The Advantage of DC Magnetic Tracking

Here is a chart that compares the features of AC vs. DC magnetic trackers.

Note there are two columns for the DC trackers.

1. Polhemus Inc. often cites the first two columns in comparing its AC trackers to Ascension's DC trackers. For argument's sake, we present the first DC column exactly the way it appears in the Polhemus White Paper "AC & DC Motion Trackers." Footnotes are provided to correct obvious errors in the Polhemus paper.

2. The second DC column, prepared by Ascension, reflects major improvements in DC tracking now available with our *3D Guidance* trackers.

Feature	**AC Magnetic**	**Old DC Trackers (Legacy Products)**	**New DC Trackers (3D Guidance Tracker Line)**
Accuracy	high–very high	medium high	high
Resolution	high–very high*	medium*	high – very high*
Speed	high–very high	low-high	ultra high[1]
Latency	low-very low	medium-high	low-very low
Initialization	no	no	no
Range	short-medium	short[2]	short-medium
LOS Limits	none	none	none
Noise/Interference	in-band signals	power mains, base band	minimal[3]
Small Sensors	yes	yes	yes
Microminiaturized Sensors	no	no	yes[4]
Tethered Sensors	yes	yes[5]	yes
Cost	low-medium	low-medium	low-medium
System Size	small	small-medium	small-sub compact[6]
Calibration	self-cal	self-cal	self-cal & run-time monitoring/ self diagnostics
Metals That Distort Measurements	good conductors[7]	earth-ferromagnetics & conductors unless update rate reduced[8]	magnetic metals not shielded by flat transmitter[9]
Multiple systems	yes	no[10]	yes[11]

* Ascension and Polhemus define resolution using different methodologies.

- Ascension measures it using Cook and Rabinowicz's traditional definition: "the smallest amount of the quantity being measured that the instrument will detect."
- Polhemus, on the other hand, derives resolution using the *standard error of the estimate*, determined from a linear regression of finely incremented position data. The *standard error of the estimate* is defined as the standard deviation of the differences between the actual values of the dependent variables (in our case, the position data as reported by the tracker) and the predicted values (actual positions). As a result, it is not required that the tracker actually report each position value with the stated resolution for each increment, but that, **given enough data**, a statistic can be generated that implies it. For example, given a linearly increasing set of noisy integer data (resolution equals "1" according to Cook and Rabinowicz's traditional definition), the resolution (or standard error of the estimate) will be calculated to be something less than one. Assuming a Gaussian distribution, this method will yield resolution, seemingly out of thin air, of 0.68.
- Using the Polhemus definition, we can calculate *3D Guidance* tracker resolution to be 0.00075 inch (0.019 mm) at 12 inches (30cm) range. While this result is comparable to Polhemus' Liberty specification for resolution, it is not a practical result for real world 3D tracking applications in which even minute amounts of background noise exceeds this value. Ascension will therefore continue to specify resolution using the generally acceptable definition. 3D tracker shoppers should be wary of making a tracker buying decision based solely on specifications in product flyers.

1 *driveBAY*, *trakSTAR* and *medSAFE* iteratively compute a new six degrees-of-freedom tracking solution after each transmitter axis excitation. This means that by the time each transmitter axis has been energized, three solutions have been derived and output to your host computer. If you set the tracker's measurement rate at 80 Hz and are using a dipole transmitter, you will receive 80Hz X 3 or 240 solutions in each measurements cycle. The tracker's maximum update rate is 420 Hz.

2 Several Ascension DC magnetic trackers (*Flock of Birds, MotionStar, MotionStar Wireless LITE*, and *3D Navigator*) operate over long ranges. Depending on the environment, trackers using dual Extended Range Transmitters (ERTs) simultaneously track up to 20 sensors in a space 10 feet (3m) x 12 feet (4.2m).

3 *3D Guidance* trackers support a new and improved wide notch filter that dramatically filters out 50 Hz and 60 Hz "power line" noise without exacting a noticeable penalty in dynamic performance.

4 Six degrees-of-freedom sensors are now available in four miniaturized sizes with outer diameters of 8mm, 2mm, 1.5mm, and 0.9mm.

5 *MotionSTAR Wireless LITE* and *3D Navigator* are untethered (wireless) trackers. They enable tracking of sensors that are not connected by cables to their processing electronics unit.

6 *3D Guidance driveBAY* eliminates the requirement for an external processing unit and a power supply. Its electronics fit into the drive bay of your PC chassis and draws it power from the PC's supply. Tracker outputs are immediately available through your computer's USB interface.

7 AC tracker measurements are affected by all metals as well as composite materials. They also are badly distorted by what Polhemus calls “earth ferromagnetics (e.g. carbon steel, iron alloys and similar magnetic metals). Not citing susceptibility to ferromagnetic metals in the Polhemus White Paper is a glaring omission.

8 DC trackers are unaffected by common non-magnetic metals that are low in conductivity. Stainless steel (300 series), titanium, and brass have no affect on DC magnetic tracking. There is no need to reduce measurement rate to obtain accurate, undistorted measurements. Measurement reduction is required only when tracking in the presence of highly conductive, non-magnetic metals, such as aluminum.

9 *3D Guidance medSAFE* is the only magnetic tracker with a built-in shield to overcome the distorting effects of ferrous metals that may be present beneath its planar surface.

10 *Flock of Bird, MotionSTAR Wireless LITE, and MotionStar (Tethered Model)* sync multiple systems together.

11 *3D Guidance medSAFE* and *trakSTAR* sync dual electronics units together to simultaneously track up to eight sensors each.

Contact: For more information about the right magnetic tracker for your application, contact us at:

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