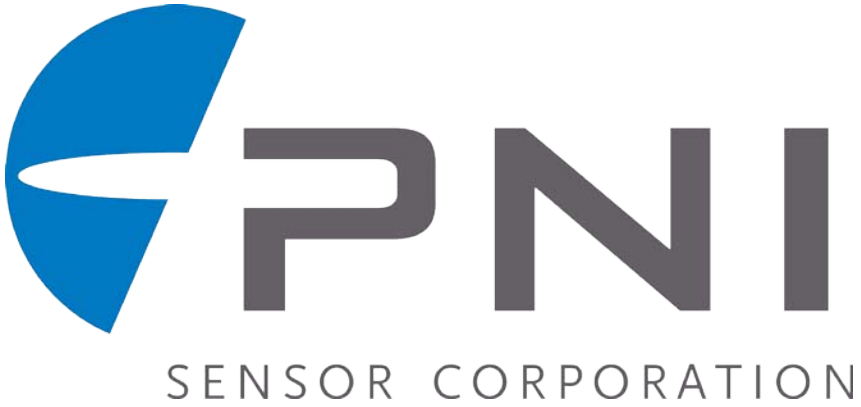

SensorsCon
2013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# Sensor Sensibility: Magnetic Sensors and the Real World

**Becky Oh**
President & CEO, PNI Sensor Corporation

# About PNI Sensor Corporation

PNI Sensor is a leader in magnetic sensor technologies and sensor fusion algorithms with unparalleled expertise in harnessing and fusing data from Earth's magnetic fields into useful military, scientific and consumer applications.

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# Two Key Topics

1. 9-axis sensor fusion

2. Aren’t all magnetic sensors pretty much the same?

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# What is motion tracking?

## Tracking a moving object through space

Up & down

Side to side

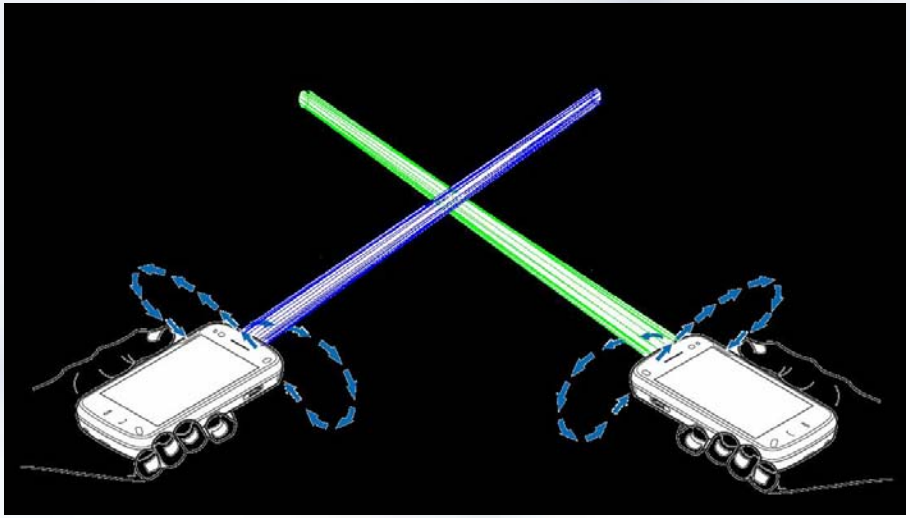
Back & forth

How fast

Where is it facing/pointing

How is it turning

Relative to what



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# What is motion tracking?

## Tracking a moving object through space

| | |
|---|---|
| Up & down | Yaw, pitch & roll |
| Side to side | Gravity/Linear acceleration |
| Back & forth | |
| How fast | Velocity |
| Where is it facing/pointing | Heading |
| How is it turning | Rotational rate |
| Relative to what | Absolute reference |

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# What makes for "good" motion tracking?

- Accurate
  - How closely does it follow real movement?
  - Does it stay accurate over time?
- Responsive
  - How quickly does it react to movement?
  - Lack of lag – low latency
- Noise-free and smooth
  - Not jerky or sudden
- Robust
  - Unaffected by outside disturbances
  - Noise, magnetic anomalies, temp changes

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# How do we track motion?

## 9-axis sensing

Gyroscope

Accelerometer

Magnetic sensors


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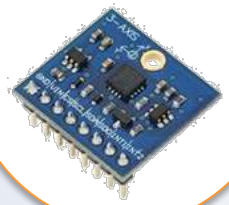
# Sensor Measurements

Gyroscope



Accelerometer

Magnetic sensors

| | Gyroscope | Accelerometer | Magnetic sensors |
|---|---|---|---|
| Yaw | **X** | | **X** |
| Pitch & Roll | X | X | |
| Gravity | | X | |
| Velocity | | X | |
| Heading | | | X |
| Rotational Rate | X | | |
| Absolute reference | | X | X |

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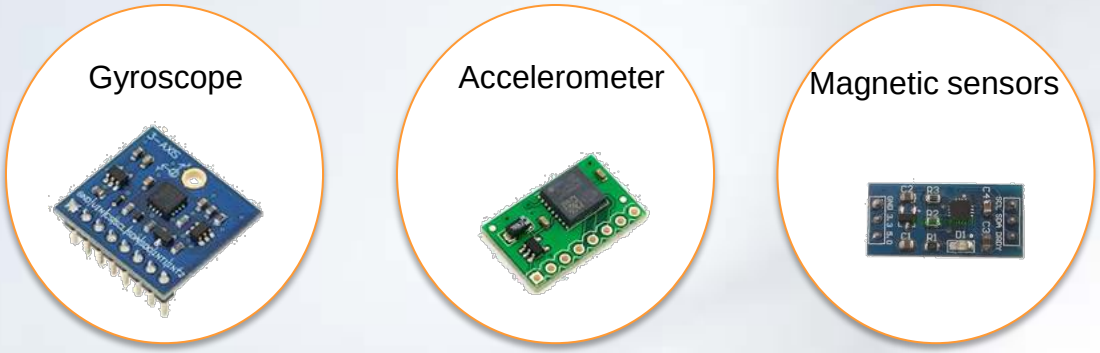
# Sensor data pitfalls




| | | | |
|---|---|---|---|
| Bias drift/error | **X** | | |
| Noise | | X | |
| Magnetic disturbance | | | X |

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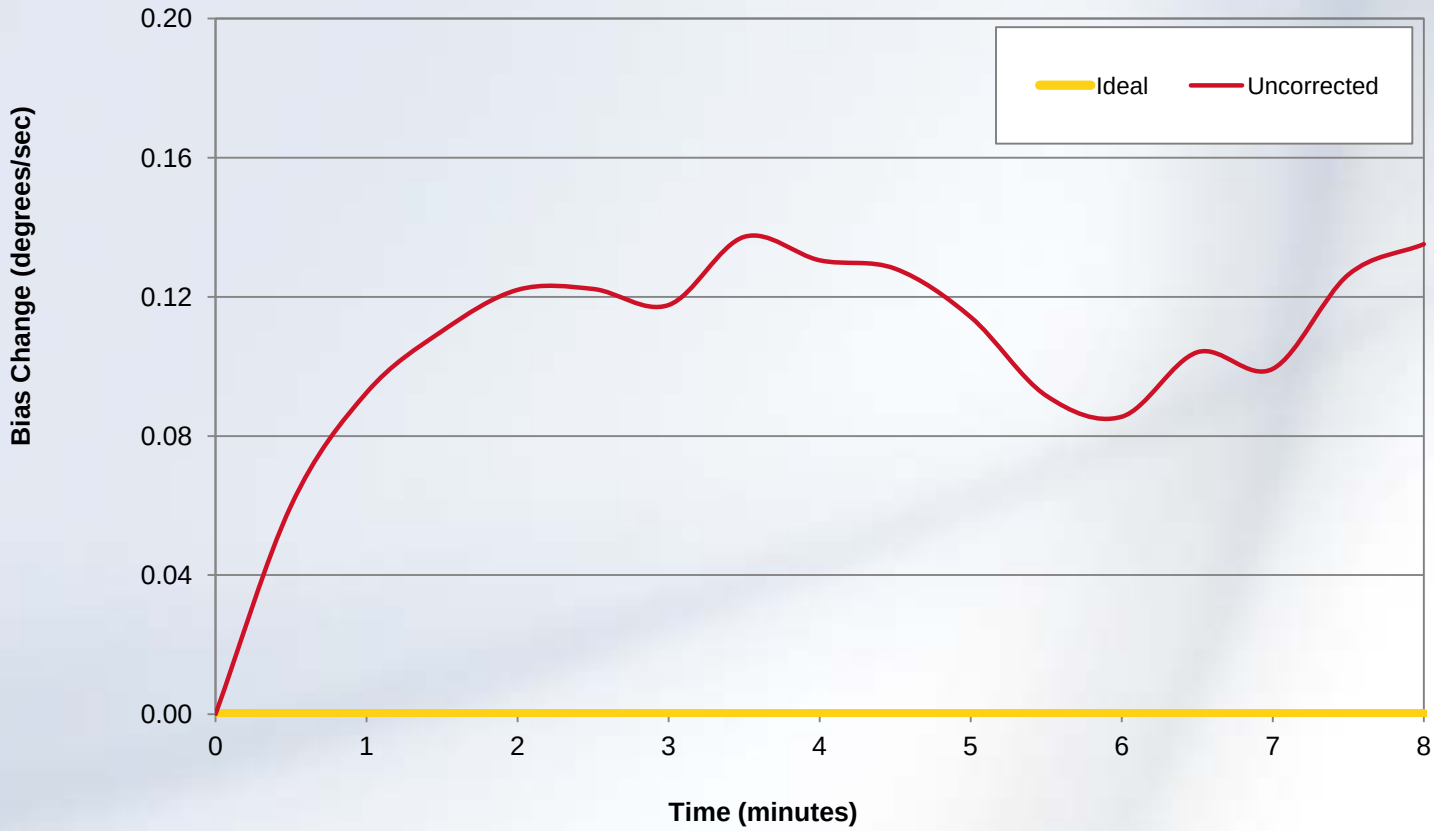
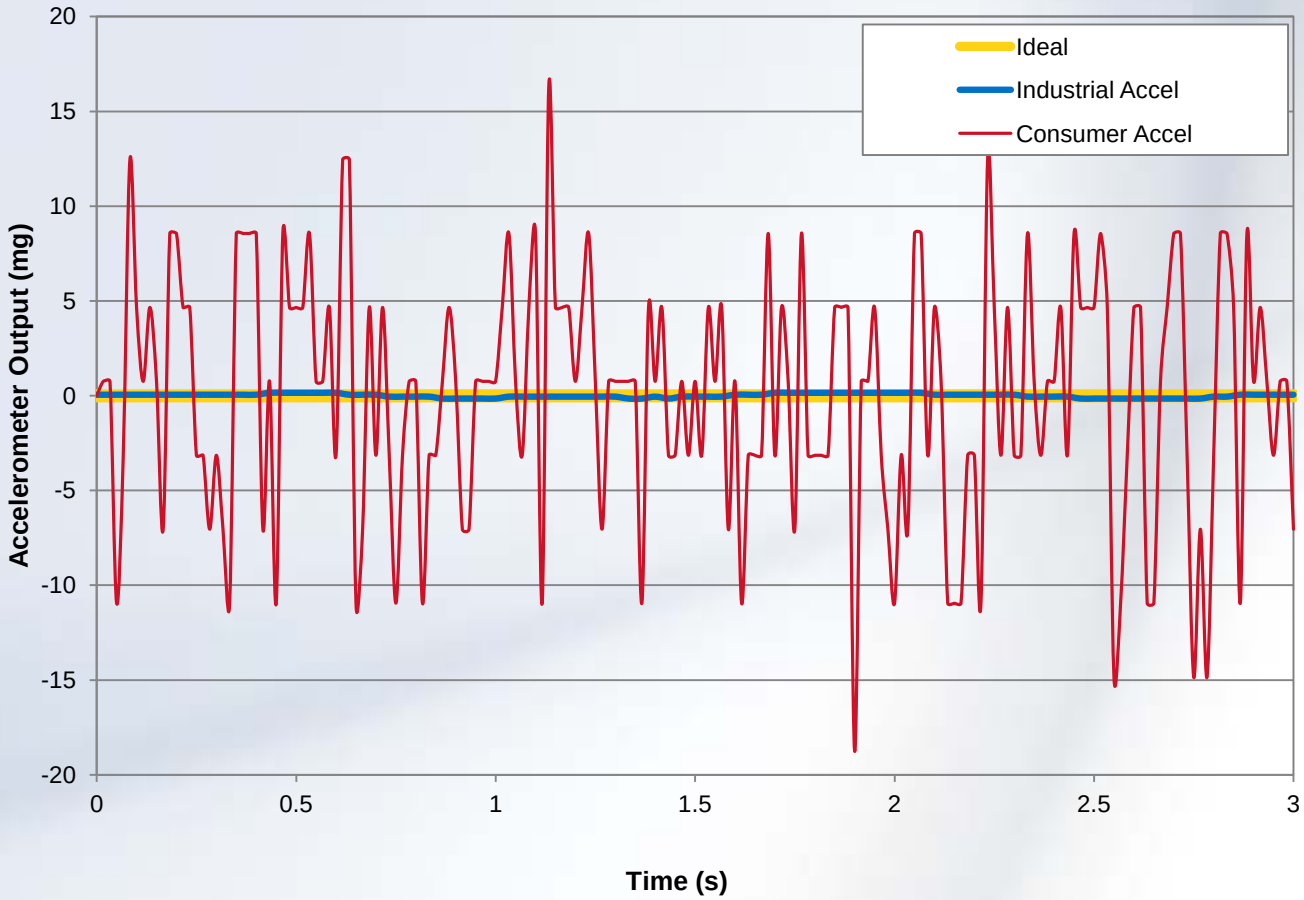
# Gyro Bias


0.20
0.16
0.12
0.08
0.04
0.00
Bias Change (degrees/sec)
Ideal
Uncorrected
0
1
2
3
4
5
6
7
8
Time (minutes)

# Accelerometer noise

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# Magnetic interference

# How to improve motion sensing?

- Better signal capture from sensors
- Better fusion to compensate for sensor inadequacies

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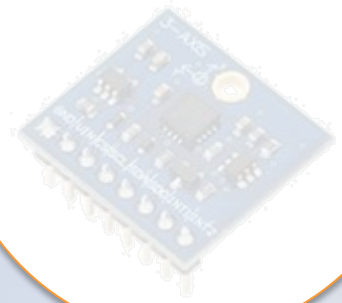
Gyroscope



Accelerometer



Magnetic sensor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# Hall-Effect

# Magneto-Inductive

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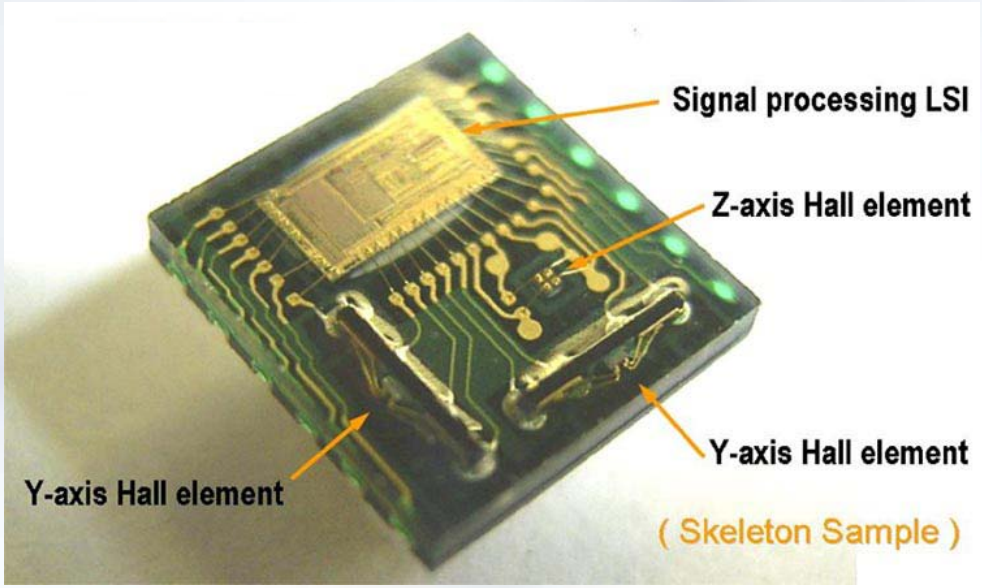
# Magnetic Sensor

## Hall-Effect "compass" sensor most widely deployed

- Small Size
- Low power
- Low cost



# Magnetic Sensor

## Hall-Effect "compass" sensor

- Small Size
- Low power
- Low cost
- ***Noisy***
- ***Low resolution***

| | Hall-Effect Sensor |
|---|---|
| Range | ±1200 μT |
| Resolution | 300 nT/LSB |
| Noise | 500 nT |
| Current @ 8 Hz | 0.3 mA |
| Operating Temp. | -40 to +85 °C |

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# Magnetic Sensor

## Magneto-inductive magnetic sensor

- Low power
- Low cost
- 15x better resolution
- 28x less noise

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# Comparison

| | Hall-Effect Sensor | Magneto-Inductive Sensor |
|---|---|---|
| Range | ±1200 μT | ±800 μT* |
| Resolution | **300** nT/LSB | **20** nT/LSB |
| Noise | **500** nT | **30** nT |
| Current @ 8 Hz | 0.3 mA | 0.2 mA |
| Operating Temp. | -40 to +85 °C | -40 to +85 °C |

**Increased range can be traded off against reduced resolution for the magneto-inductive sensor, but ±800 μT of range is sufficient for most applications.*

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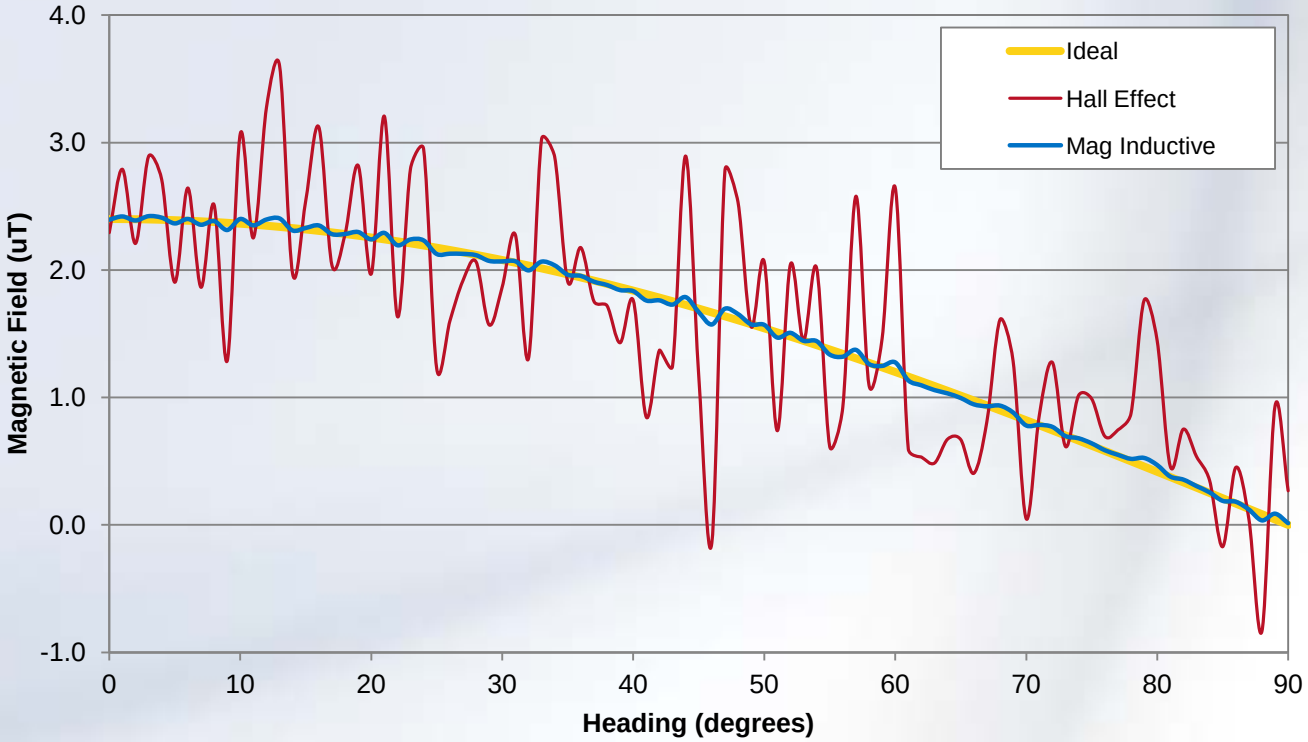
# Mag Comparison

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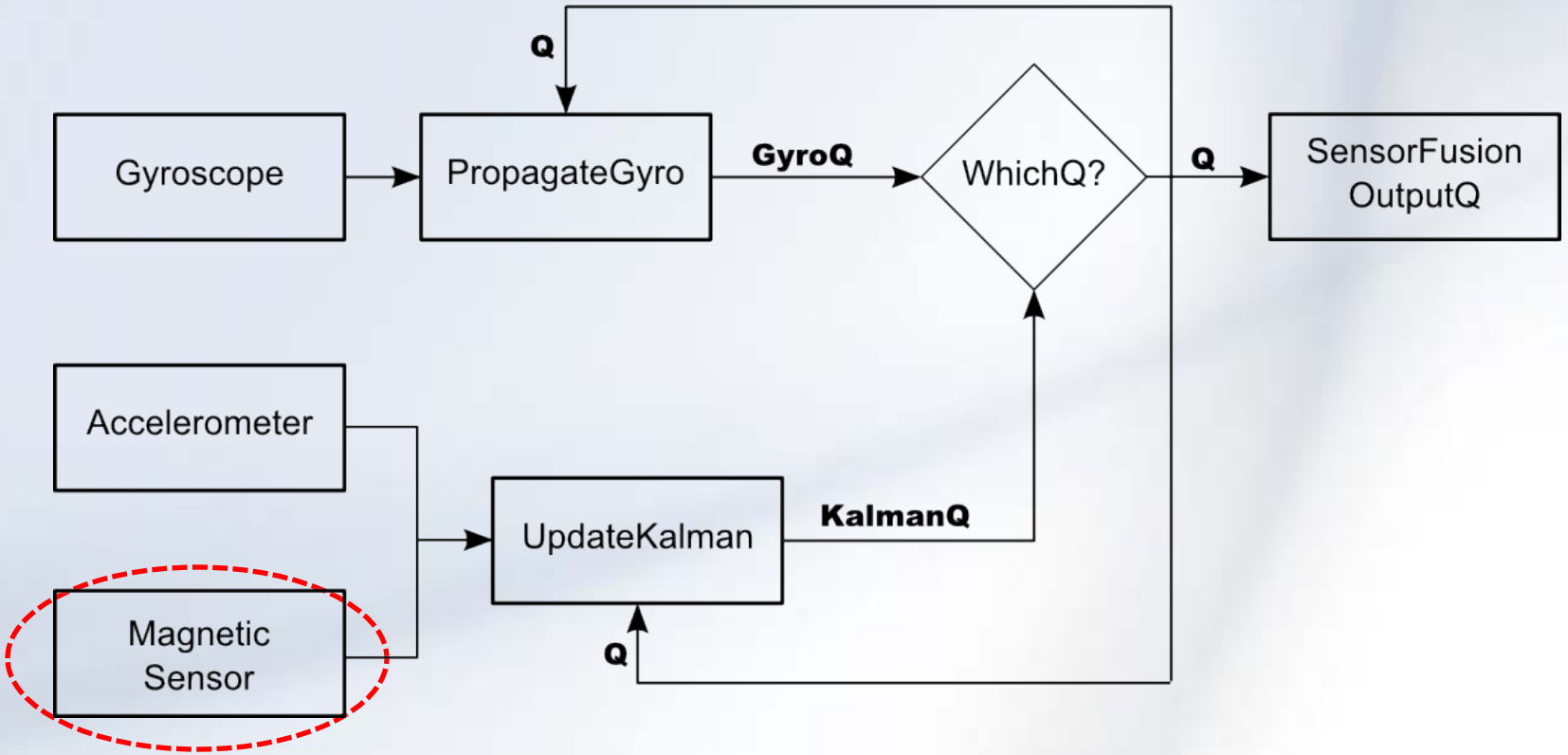
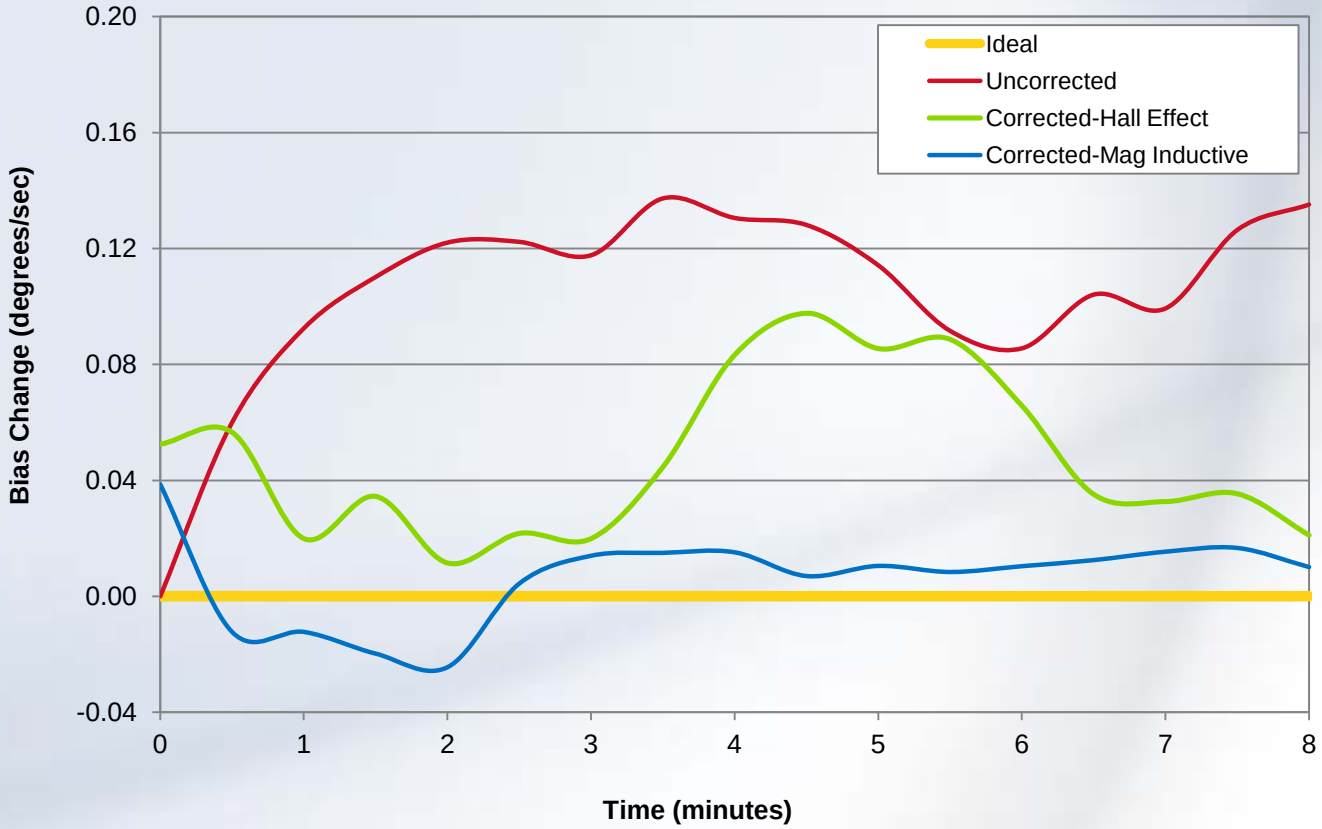
# Sensor Fusion



# Mag Comparison

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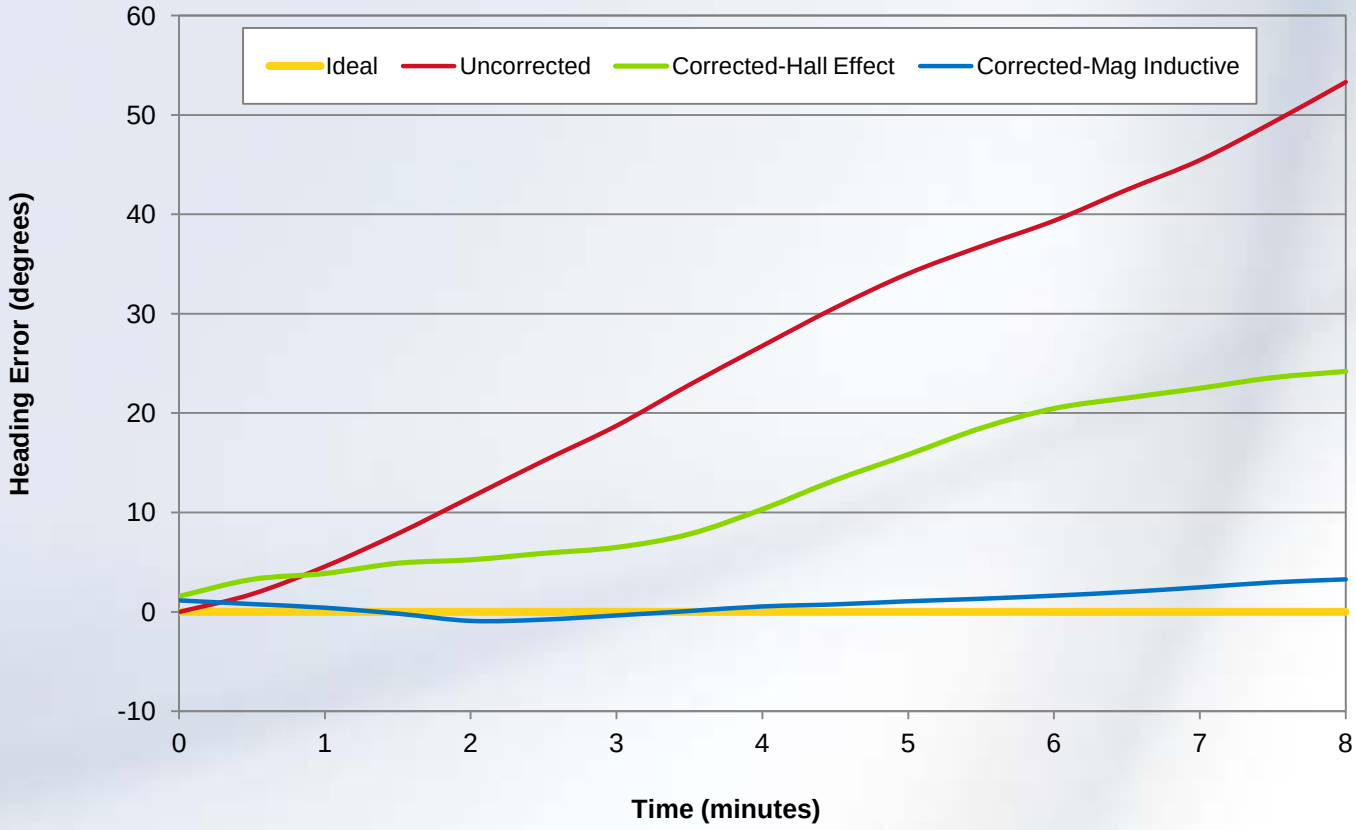
# ...for more accurate heading



# Slow Rotation Test



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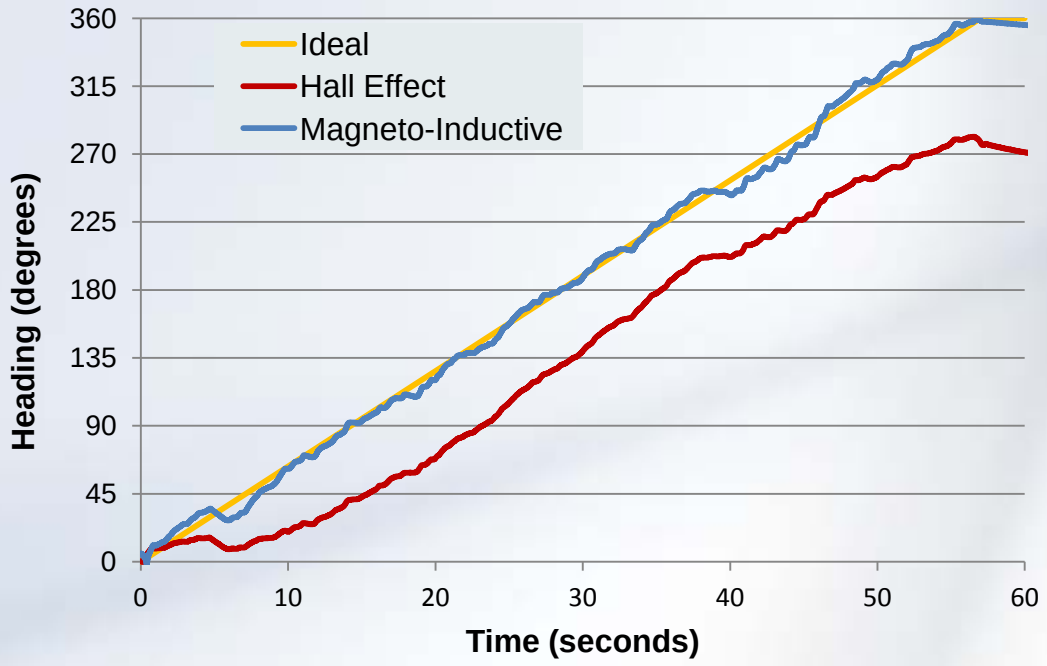
# Slow Rotation Test



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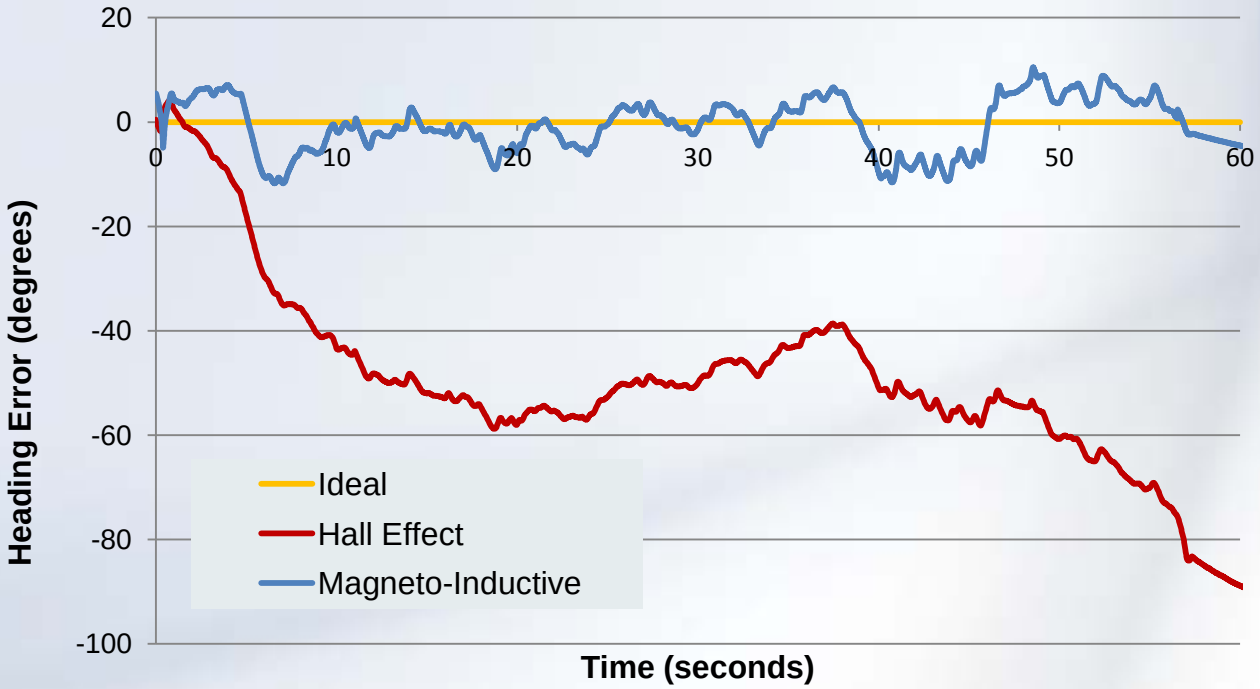
# Heading Error during Rotation



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# Adding a Magnetic Distortion





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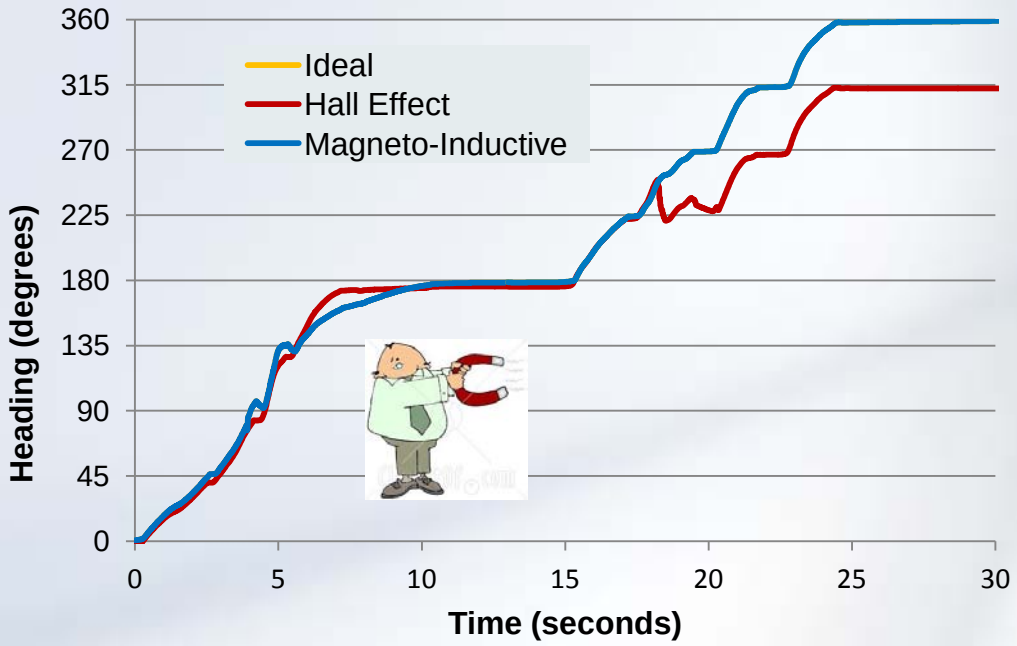
# Slow Rotation Test – *More Weighting for Hall Effect Mag*



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# Magnetic Sensors

The performance of the magnetic sensor ***does*** make a difference

- 15x better resolution
- 28x less noise

# 9-axis motion tracking

*with higher performance magnetic sensors….*

- Accurate
  - How closely does it follow real movement?
  - Does it stay accurate
- Responsive
  - how quickly does it react to movement?
  - Lack of lag
- Noise-free and smooth
  - Not jerky or sudden
- Robust
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# Summary

## Accurately tracking a moving object through space is possible...

| | |
|---|---|
| Up & down | Yaw, pitch & roll |
| Side to side | Gravity |
| Back & forth | |
| How fast | Velocity |
| Where is it facing/pointing | Heading |
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Thank you

Any questions?

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