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EXECUTIVE SUMMARY

One Portfolio, Endless Applications: Reliable Position Sensing Solutions to Harsh Environment Challenges

Presenter:
Sandeep Cherukuri, Senior Offering Management Lead, Honeywell

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KEY TAKEAWAYS

- Across industries, several key challenges are shaping the future of heavy machinery.
- OEMs are responding to major challenges through greater autonomy and automation.
- Position sensing is a key enabler of modern heavy machinery innovation.
- Honeywell offers reliable sensing solutions for equipment operating in demanding environments.

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One Portfolio, Endless Applications: Reliable Position Sensing Solutions to Harsh Environment Challenges

OVERVIEW

Construction, agriculture, and mining are faced with operational challenges including labor shortages, increasingly demanding safety requirements, and growing productivity pressures. To help OEMs overcome these challenges, heavy machinery manufacturers are developing new capabilities like autonomy, automation, predictive maintenance, electrification, and functional safety—all of which depend on reliable position sensing.

However, extreme vibration, moisture, thermal stress, EMI, and space constraints create significant design challenges. Solving these challenges requires a combination of reliable underlying sensing technologies with rugged packaging, collaboration between sensing and systems design teams, and extensive performance validation through engineering simulation, field and laboratory testing.

Honeywell Sensing Solutions, a part of Honeywell Technologies, provides a comprehensive portfolio of advanced sensing, switching, and test & measurement technologies designed to meet the diverse needs of industries such as healthcare, transportation, industrial automation, and electric vehicles. Its solutions include the SMART Arc, a line of non-contact, magnetic, absolute position sensors that track the precise angular movement of an object over an arc-shaped path. Built to withstand harsh environments, the sensors are ideal for applications in demanding environments.

CONTEXT

Sandeep Cherukuri explained challenges facing heavy machinery OEMs and how reliable, robust position sensing technology can help overcome these challenges.

KEY TAKEAWAYS

Across industries, several key challenges are shaping the future of heavy machinery.

Although the construction, agriculture, and mining industries serve different purposes, they have a common dependence on heavy machinery equipment operating outdoors in challenging environments, and several key trends are driving new designs for heavy machinery across all three verticals:

- **Labor shortages**. As generations have shifted away from potentially dangerous, physically demanding, unpredictable careers, the pool of available skilled operators has not kept pace with the growing demand for infrastructure, food production, and natural resources. Heavy machinery users are increasingly seeking greater automation, machine assistance, and simplified controls that will enable more tasks to be performed with less human labor.
- **Operator safety.** Each of these industries has grown safer over time as lessons learned from incidents have been incorporated into training, processes, equipment design, and standards and regulations, and the trend toward greater safety continues. Safety is increasingly becoming a responsibility of the machine itself, driving development of new technologies such as advanced machine monitoring, control, and collision avoidance systems.

> "If you look across most industrial sectors, safety performance today is significantly better than it was decades ago. That improvement did not happen by accident."
>
> – *Sandeep Cherukuri, Honeywell*

- **Productivity and uptime.** Higher interest rates and tighter investment environments force companies to focus on deriving more value from assets they already own. Increasing prices is often not actionable, as pricing is typically constrained by competition. Improving operational efficiency often becomes the only feasible option—maximizing machine availability improves yield and speeds timelines for increased profitability.
- **Regulatory compliance and sustainability goals.** Customers and investors increasingly support governmental sustainability and emissions-reduction initiatives; however, standards regulating emissions and environmental safety are continually evolving. Operators are faced with the complex challenge of satisfying changing requirements while maintaining equipment performance and profitability.
- **Predictive maintenance.** Condition-based maintenance strategies identify and remediate issues before failures occur. Reduced downtime and extended component life increase productivity and reduce total cost of ownership.

Figure 1: Mining equipment is among the largest and most demanding



OEMs are responding to major challenges through greater autonomy and automation.

In response to these challenges, heavy machinery OEMs are developing new technologies that enable greater autonomy, automation, telematics, electrification, and functional safety.

Autonomous equipment minimizes labor utilization and increases safety, as machines are no longer constrained by operator fatigue and shift schedules, and workers can be removed from dangerous environments. For example, Komatsu's autonomous haulage systems and teleoperation capabilities allow operators to remotely operate machines, even from hundreds of miles away. Komatsu's autonomous trucks have already moved roughly two billion tons of material across four continents.

New developments in sensors, algorithms, and AI are accelerating the adoption of autonomous technologies. Other industries, including agriculture, are also increasingly using autonomous machinery to address labor shortages.

Figure 2: The John Deere 9RX tractor operates autonomously



Autonomy is not practical for every application, though. It works best in highly structured, predictable environments where the ROI justifies the significant investment required to establish the infrastructure needed to support autonomous equipment. Automation, however, has much broader applicability.

Automation keeps the operator in control while assisting with specific machine functions, thus reducing workload, improving machine repeatability, and increasing operator efficiency. Examples range from Caterpillar's semi-autonomous onboard assist technologies that help operators dig, load, and grade with higher confidence, speed, and accuracy, to its JCB IntelliAssist solution, which automatically controls agricultural telehandler booms with far greater precision and safety.

Telematics, electrification, and functional safety are also playing a larger role in the future of heavy machinery. Through continuous monitoring of machine health and operating conditions, operators can identify and remediate potential issues before they become costly failures. Electrified equipment supports manufacturers' sustainability goals and can improve efficiency. Stricter safety regulations enable shifting safety responsibility to the machine from the operator, forcing manufacturers to rely on redundant sensing technologies to create an overall safer environment.

Position sensing is a key enabler of modern heavy machinery innovation.

For each of these advanced and emerging capabilities, position sensing is a foundational enabling technology. To achieve successful outcomes when utilizing autonomy or automation, a critical requirement must be met: the machine should be able to understand both its external environment and its own physical state.

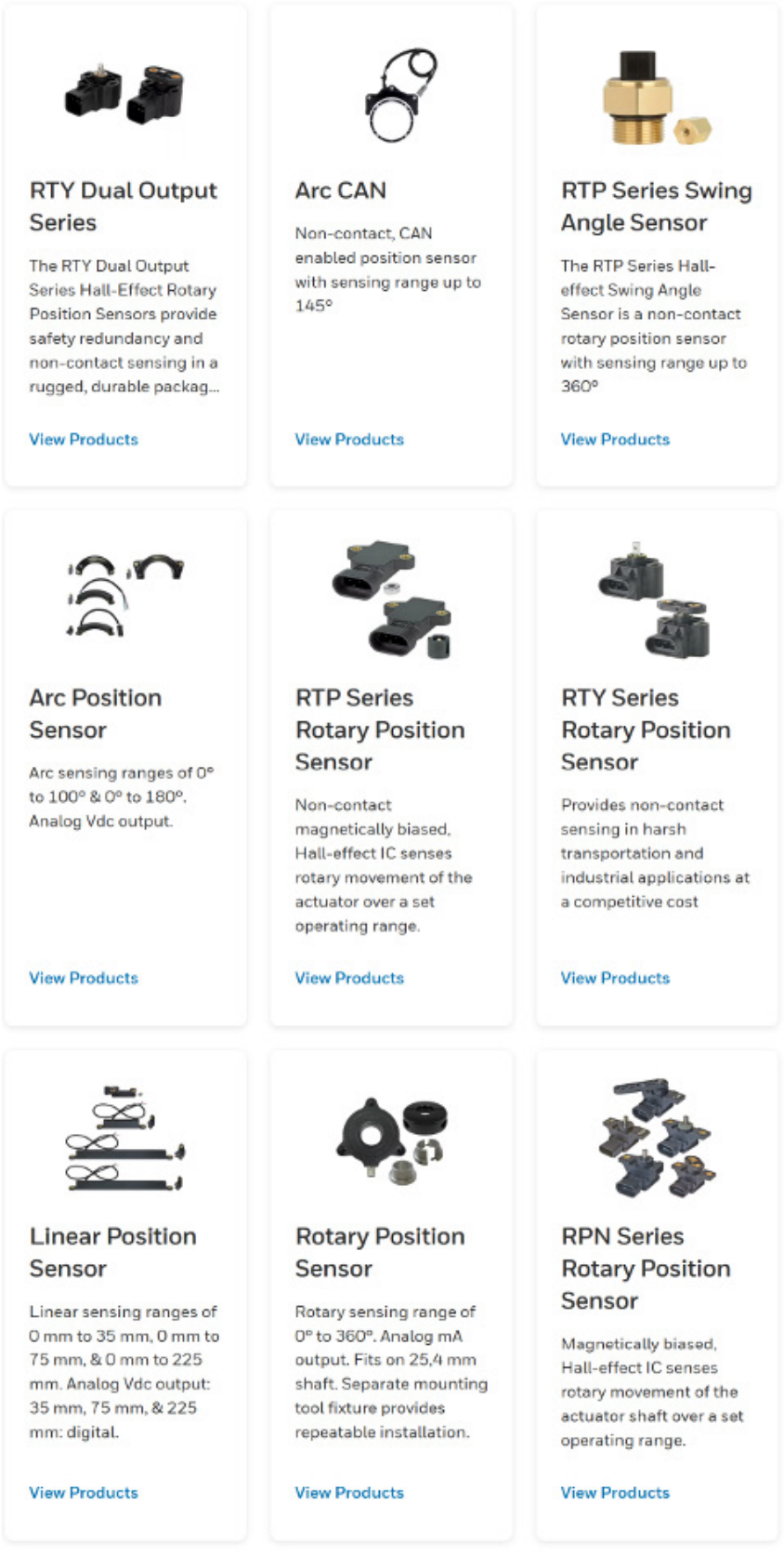
Position sensing continually monitors equipment and provides the closed-loop feedback necessary to accurately control steering, bucket positioning, boom movement, articulation, and other machine functions. Cameras, radar, and lidar help an autonomous machine understand the environment, while position sensors placed throughout the equipment tell the machine what it is doing.

Position sensors also enable continuous monitoring of component movement for predictive maintenance. Rich real-time data helps identify deviations in movement patterns that may indicate abnormal behavior or impending equipment problems.

In safety-critical systems such as steer-by-wire, brake-by-wire, electronic throttle control, and machine stability, position sensors provide both accurate measurements and diagnostics, redundancy, fault detection, and predictable failure behavior necessary to meet stringent functional safety compliance requirements such as ISO 13849.

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Figure 3: Position sensors enable autonomy and automation



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Honeywell offers reliable sensing solutions for equipment operating in demanding environments.

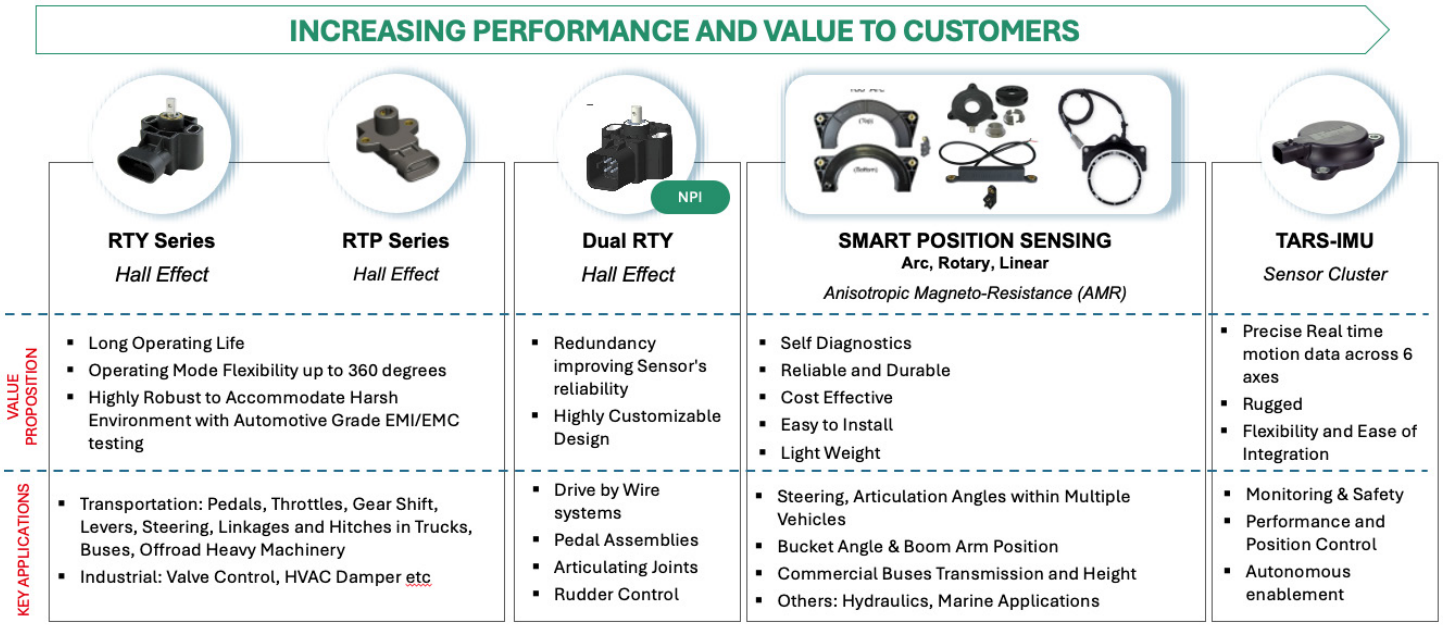
Designing reliable position sensing solutions for heavy machinery is difficult, as these machines do not operate in controlled environments. They function almost nonstop under multiple stressors simultaneously, including mechanical stress, environmental impacts, chemical exposure, thermal extremes, and electromagnetic interference. Sensors must tolerate the combined effects from all of these while continuing to provide reliable feedback over the span of the machine's operating life.

At the same time, developing successful heavy machinery sensing solutions requires balancing performance, reliability, serviceability, and cost, rather than optimizing any single characteristic in isolation.

With over 30 years of in-depth expertise in sensing technology, Honeywell Sensing Solutions has developed a proven design approach that delivers robust, high-performing sensors for demanding environments. Honeywell prioritizes inherent sensing principles to minimize reliance on algorithmic corrections and ensure greater reliability from the outset and works closely with OEMs throughout development to ensure effectiveness in a real operating environment.

Honeywell relies heavily on engineering simulation, modeling, and structured design processes, and conducts robust field testing alongside extensive laboratory testing. Many of Honeywell's sensors also include built-in diagnostics so that an OEM's control system can recognize a sensor problem, supporting predictive maintenance.

Figure 4: Honeywell sensing solutions enhance performance, reliability, and control



Honeywell Smart ARC Position Sensor

Originally developed for a specific customer as an alternative to an in-cylinder solution, the Honeywell Smart ARC position sensor simplifies installation and maintenance while reducing system costs.

To ensure the sensor could withstand exposure to harsh conditions, it was designed and packaged from the ground up to perform in demanding environments and extensively tested in both the lab and field for thermal stability, thermal and mechanical shock, vibration, EMC, and EMI.

Smart ARC is a highly accurate, non-contact position sensor mounted externally on a pivot joint to measure angular displacement. Smart Arc uses magnetoresistive technology and an array of sensors in a robust package and comes in both a 100- and 180-degree configuration.

Today, the Smart ARC has expanded to numerous applications beyond its original use case, delivering accurate and reliable feedback with a linearity of 0.4% resolution as fine as 0.06 degrees in the 180-degree version.

Figure 5: Example Smart ARC position sensing applications



Diggers or Excavators



Front End Loaders



Aerial Work Lifts



Mobile Cranes



Refuse Trucks



Scissor Lifts



Timber Harvesting



Onboard Loader Weighing

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Sandeep Cherukuri is Senior Offering Management Lead at Honeywell.

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