The Ubisense Assembly Control Solution for BMW

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The Ubisense Precise RTLS Product

World leading precise Real-time Location System (RTLS)

Ubisense delivers a precise real-time location system (RTLS) utilizing ultra-wideband (UWB) technology that locates assets and people precisely in 3D up to 30 cm spatial accuracy generating up to 10 positions per second.

The Ubisense RTLS consists of
- Hardware
- Middleware
- Applications

and is generating data, process visibility and control at new levels of granularity.
Precise RTLS Requirements in Automotive Final Assembly

Production line automation
- Tool control
  - Eliminate bar code scan of vehicle
  - Enable / disable wireless tool depending on location
  - Ensure tool operations related to correct location on vehicle
  - Associate control data to vehicle
- Event triggering
  - Trigger events when vehicles reach pre-defined points along the assembly line using vehicle identification (e.g. tool enable / disable)
- Identification
  - Initiate PLC with vehicle production data
- Relate component to production unit
  - Eliminate bar code scan of vehicle
- Quality control of critical processes
  - Electronic signature for completed tasks

Finishing process
- Process monitoring
  - Find vehicles
  - Visibility of vehicle status
  - Alert if vehicle out of sequence
  - Recording and reporting
- Identification
  - Initiate PLC with vehicle production data
BMW Plant 6 in Regensburg

- >1,000 vehicles produced per day in two shifts running from 5:00 to 24:00 5-6 days per week
- 1 series, variants of the 3 series (e.g. M3, Coupé) and the Z4 roadster are produced on the same 1.8 Km long assembly line
- Vehicles are manufactured in the sequence in which orders are processed by the ERP system
  - On the assembly line a 1 series may be followed by a Z4 and then by an M3 requiring the DC tools used along the line to be reprogrammed for each vehicle at each station
- BMW uses the International Production System (IPS) as the Manufacturing Execution System in all plants. The module IPS-Q, developed by IBS AG of Höhr-Grenzhausen in Germany, handles quality control and in particular tool control
BMW objectives for Plant 6 in Regensburg

• Increase efficiency of assembly process by eliminating unproductive seconds taken to scan the Vehicle Identification Number barcode for every tool interaction
  • In Regensburg per day 1000 cars * 150 tools * 6 Seconds

• Simplify process by reducing the need to use barcode scanners
  • Less chance of error

• Permanently track vehicles in the production process
  • Use car position to trigger PLCs at tacts along the line
  • Use same tag on the vehicle to trigger PLCs off line

• One infrastructure, multiple applications in the plant
  • Reduce IT cost by reducing number of different location / identification systems supported in the plant
History

- Many attempts to solve the problem using Infra-red, ultra-sound, passive and active RFID technology
- Trial with Ubisense UWB system in 2006 led to purchase in 2007 for the Regensburg plant
- System went live in Q4 2008 covering entire production line with 150,000 tool operations per day being controlled
- Several reconfigurations as assembly line has evolved to meet new requirements
- New applications to drive PLCs on and off line introduced
- Ubisense system introduced into the Spartanburg plant on the new line to manufacture the new X3 in summer of 2010
Why Ubisense Precise Location Tracking is based on UWB

- Locating precisely in real-time especially inside buildings is a difficult problem
  - Determining location with radio is done by measuring the path from transmitter to receiver
  - Only the direct path signal determines the true location, reflections are errors

With conventional RF, reflections in in-building environments distort the direct path signal, making accurate pulse timing difficult.

With UWB, the direct path signal can be distinguished from the reflections, making accurate pulse timing easier.

- $-41.3 \text{ dBm/Mhz}$
- $200ps = 6cm$ resolution
Ubisense Precise Location Tracking principles (1)

New radio technology ultra wideband (UWB) delivers up to 30 cm accuracy of location in 3D even in challenging environments.

- Sensors within the cellular Ubisense network communicate with the Tags on conventional radio and ask to generate a UWB pulse depending on their profile up to 20 times a second.
- UWB signals are received at the sensors and are used to calculate the Angle of Arrival (AOA). So only 2 Sensors receiving a tag signal deliver a location.
- If Sensors are synchronized, then Time Difference of Arrival (TDOA) between each pair of Sensors is calculated. This makes the location robust.
- Software of the third generation enables tuning and configuration of the system to increase stability and reliability using e.g. motion model filters.
Sensors installed along line in zig-zag pattern – e.g. line 44
Tagging production objects

- Industry tags fixed to products (e.g. car bonnet)
  - Custom mounting brackets (magnetic, adhesive, ...)
  - Define tact / station for tag-product association and dis-association
  - Tag remains on product if off-line monitoring / control required

- Fix tags on devices
  - Compact tag attached to cable
  - Tag module embedded in tool vendor accessory
Radio interference investigation

Ubisense system fits inside any radio strategy

- UWB transmissions at 6.4 – 7.6 GHz
- 2.4 GHz control telemetry narrow band (600 kHz) at any convenient slot
Eliminate bar code scan to identify vehicle

- 470 sensors installed along the 1,800m line

- Tags placed on vehicles to track their position as they move along the line. Tags removed at end of line
  - Associate tag ID with Vehicle Identification Number (VIN)
  - Define expected movement of vehicles in each segment

- Tags fixed to 165 DC tools to generate events when they approach vehicle for fastening operation
  - Tag ID associated with tool ID / controller

- Define product type and spaces (spatial zones defining where tools may operate on product)

- Send IP telegramme to IPS-Q with VIN / tool ID when tool enters product space
On and off line identification

- Multiple sensors can cover an area with several stations to be activated when the vehicle arrives at the correct location.

- Alternatively, a single sensor can control one discrete station and recognize when the tagged vehicle arrives and use the associated VIN to initiate a production step.
Advantages of the Ubisense technology at BMW

- The detection of the co-incidence of tool and vehicle is not dependent upon a single radio transmission between the vehicle and the tool which can easily be disturbed (as is the case with passive or active RFID)
- The continuous location of tools and vehicles is accomplished with high precision (30cm)
- High reliability and robustness of the location measurement due to the fact that only two sensors need to detect the signal from the tag in order to generate a 3D location
- The usage of the system may easily be expanded to other applications using the same infrastructure by simply defining new spatial relationships and events
- The location system is based on a fully distributed architecture (each sensor is a processor in its own right) and therefore scales easily with increased usage
Summary of Assembly Control System Functionality

- Flexible product identification / tracking along assembly line, sending product ID when product reaches any defined location along the line
- Control tethered tools, ensuring that they are enabled and programmed for specific product
- Control wireless tools, ensuring that they are being used in correct location and on correct product
- Automatic association of data captured with scanners and PDAs to specific product
- Automatic association of button press with task / operator / product
- Track vehicles delivering materials to line to ensure quality and timeliness
- Actuate other control systems on and off line when product in correct position
- **Proven extremely high reliability > 99.9998% of events without defect**
Benefits of introducing the Ubisense Assembly Control System

- Eliminate time used to scan vehicle ID to enable / program tools
- Eliminate time used to scan vehicle ID to relate to scanned components
- Eliminate paper based sign-off to record successful task fulfillment (e.g. installation of safety-critical component)

- Improve quality by restricting use of tools to permitted areas of vehicle
- Enable quality by restricting use of wireless tools to permitted areas

- Reduce IT and maintenance costs by replacing legacy active and passive identification systems with one flexible infrastructure
- Improve flexibility of line design by liberating tools from tacts / stations
Virtual Car Tracking
BMW Spartanburg
Russ Chandler
CEO Americas, Ubisense
BMW Spartanburg: Quick Facts

- X5’s and X6’s currently built in Hall 50
- New hall 52, a second plant built in Spartanburg in 2009
- 180+ sensors covering 14 bands
- Totals 2010:
  - * Total X3 Units: 2,086
  - * Total X5 Units: 8,281
  - * Total X6 Units: 3,820
- Current production in Hall 52: about 200 cars planning to produce 250/day.
Ubisense Implementation of Virtual Car Tracking

- BMW LIS “ACS Lite” – tracking vehicles as they enter each takt (station).
- Vehicles are tracked but not the tools.
- Integrated with IBS Tool Controller and sends VIN location events to IBS.
- Tool torque instructions are automatically adjusted to the specifications of each car based on VIN number.
- Integrated with about 50 tools currently.
Virtual Car tracking enables additional features to be incorporated to the line, such as a camera station, which takes pictures as the car in near the end of the assembly line.

LIS system also planned for logistics trains, in order to gain a better understanding of time it takes to cover routes.
Key Benefits

- Ubisense solution able to identify vehicle in time to activate tools with correct torque settings.

- Plant is enabled to support full Assembly Control System functionality = complete LIS tool assistance similar to Regensburg.