

The background of the entire page is a photograph of a modern warehouse. It features high ceilings with a complex metal truss structure and numerous industrial lights. In the foreground, there are several blue metal shelving units filled with cardboard boxes. A white automated guided vehicle (AGV) is positioned on the left, carrying a yellow pallet with a single cardboard box. To the right, a robotic arm is visible, reaching towards the shelving units. A large, semi-transparent orange and red circle is overlaid on the left side of the image, containing the text.

**Smart Warehousing
with Automated
Guided Vehicles and
SAP S/4HANA ERP**

Manufacturing experts predict the extensive usage of hi-tech machines in the near future at large factories and warehouses. It is quite evident with the adoption of AGVs for manufacturing and warehouse automation. With Industry 4.0, new vistas are opening up on how we use such high-speed precision machines for the betterment of day-to-day operations. However, what needs to be unfolded is a roadmap to build an intelligent factory replenishment solution utilizing the versatility of AGVs.

Most of the major warehouses and logistics operations use SAP ERP applications. Smarter ERPs like SAP S/4 HANA open up their digital core easily to Industry 4.0 devices and sensors that in turn open the gates to a huge opportunity connecting the business logic schematics with the devices on the floor. Adding technologies like AI, IoT, ML, leveraging SAP Leonardo, help going further to build an Intelligent Enterprise by creating a mix that uses intelligence to control things moving across the floor.

Advancement to AGVs

AGVs have come a long way from simple tow trucks in the 1950s, which followed wires, laid on the floor to ones that followed invisible floor marked UV signs and to the most recent ones that are AMR & LiDAR AGVs (Laser guided). Other technologies like vision guidance and geo-guidance have also become popular to 'recognize' objects in their path, plot the course to their target using predefined path, learning routines and handle battery charging autonomously. On an average for one hour of usage, industries require 12 minutes of high speed charging. Options like automatic battery swaps, wireless charging and solar powered batteries are adopted for quicker back-to-business operations.

The digital concert

AGVs, state-of-the-art SAP S/4HANA systems and SAP's cloud offerings are the crux for manufacturing and Industry 4.0. However, the challenge is synergizing them all. It creates an opportunity to bring in immense changes to the legacy warehouses and production lines. How can we bring this together?

ERPs have MRPs giving data-driven plans on how supply chain processes can run efficiently along with production, given sales forecasts and inventory intelligence. In a conventional manner, warehouse managers use their pick/pack list and accordingly, materials are picked up or stored depending on the nature of the transaction. The physical inventory is checked and results updated into the ERP. This process is run on a periodic basis to ensure stock consistency. Most of these activities are manual, which increases the chances of errors, lower efficiency and slow speed. Being a periodic and programmable task, such activities can be automated using AGVs so that they can run round the clock with interruption.

Similarly, entry and stocking of new goods is done uninterruptedly depending on the storage placement schematics. In such a scenario, AGVs store goods at different levels of the warehouse depending on the master data & material code. The automation can also be extended to stock movement & issues across the warehouse, using the planning / order data from SAP S/4HANA ERP. The entire activity can leverage SAP Leonardo's machine learning capabilities to learn continuously and the application starts dishing out optimal pick / load targets for the vehicles almost in real time. SAP Leonardo can also talk to the AGV controller software using its APIs and be the central brain of the activity. This provides a digital command center for the entire activity.

Topic	Conventional	AGV Based
Pick/ Load times	Slow & Human dependent	High performance, round the clock and without a break.
Dynamic Work lists	Mostly static lists	Easy to rejig lists on the go.
Cost	Human labour costs	Initial investment pays off with speed and efficiency many times over.
Inbuilt Intelligence	None - follow pre charted lists	A truly mobile intelligence unit. Will have eyes on OMS and pick goods for fulfilling sale orders (finished goods) or production orders. AGVs will also have an eye on the WMS – checking stock levels as needed for different categories, triggering reorder levels in coordination with the MRP.
Sudden spike handling	Difficult - involves coordination amongst various parties in the human labour hierarchy along with system intervention.	Very easy and quick as the AGV is able to realign priorities on the fly. Enables rapid pick/load operations and resumes BAU once urgent orders are replenished.
24*7*365 Operations	Needs advanced human resource and contingency planning. Will involve costs to run full time.	Designed to operate all time - any time. Can also be tasked to pick during peak hours of operations and load during lean hours thereby increasing the efficiency of the whole operation. Checking stocks during such operation can also save time and give accurate stock value back to the ERP.
Continuous Optimization in routes and pick/load strategy	Mostly static routes and static data driven - limited opportunities	Continuously learning ML models increase efficiency to very high levels. The instruction set for an AGV is based on loading patterns and will be self-driven in terms of their creating their “to-do” list of tasks and will dynamically change the tasks based on various operational parameters like work load, new incoming goods, urgent order picking etc.

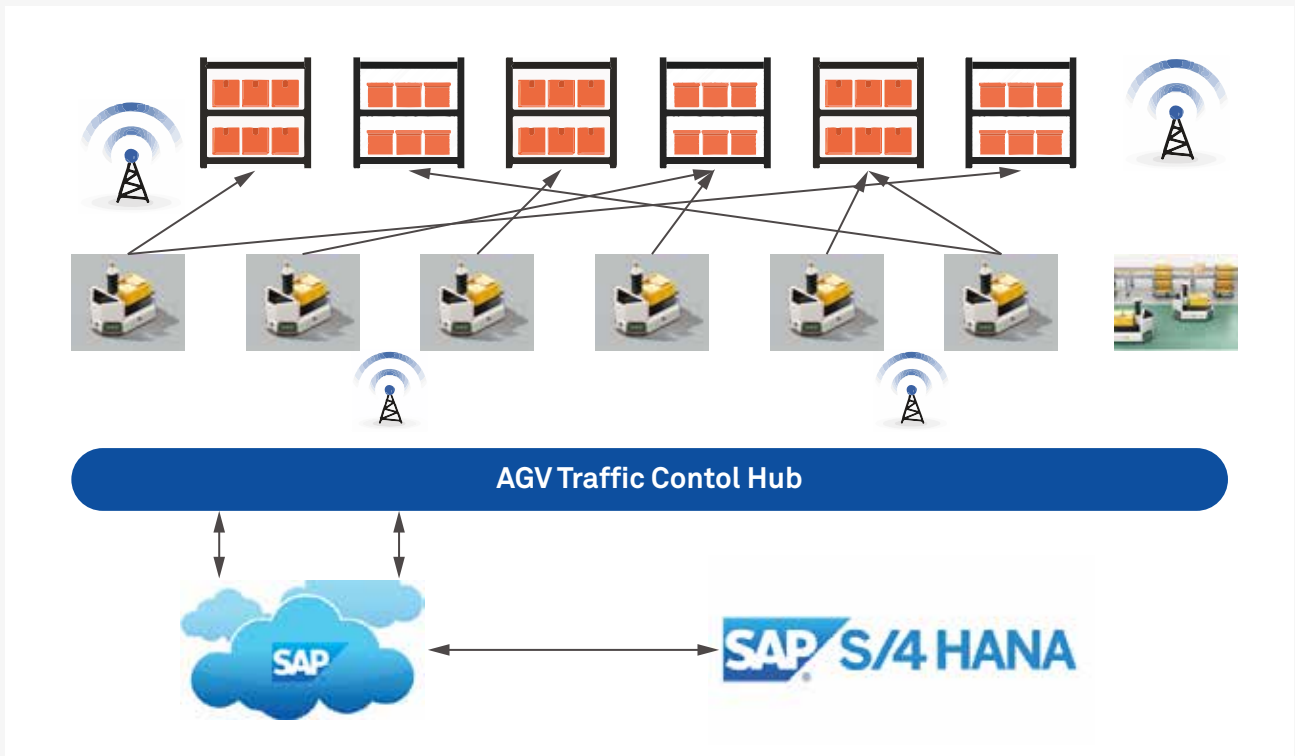


Fig: Illustrative high-level architecture of AGV – SAP Cloud-Leonardo and S/4HANA system

Design Approaches - Centralized and Decentralized

Two approaches are possible depending on the hardware/software potential and feasibility. The decentralized option will become a reality in the coming years.

Topic	Centralized	Decentralized
Pick/Pack List	Central cloud app to be the nerve center to determine priority, routes and items.	AGVs to use its embedded intelligence to pick up its task list and determine the route to do so.
ML Usage	Routes/Items and consumed centrally	Use central repository for reference and decide autonomously the route and list of items.

Sl.No.	Priority	Mode	Rack	Material	Status	Timestamp
1	Normal	Pick	42-1	KX435B	Closed	82104101119
2	Normal	Pick	42-1	KX435B	Closed	82105101119
3	Normal	Pick	42-1	KX435B	Closed	82106101119
4	Normal	Pick	42-1	KX435B	Closed	82107101119
5	Normal	Pick	45-7	43ART1	Closed	82308101119
6	Normal	Pick	21-8	PX129K	Open	
7	Normal	Load	92-1	YC672B	Open	
8	Normal	Load	92-1	YC672B	Open	
9	Normal	Load	92-1	YC672B	Open	
10	Normal	Load	92-1	YC672B	Open	
11	Normal	Load	92-2	YC672B	Open	
12	Normal	Load	92-2	YC672B	Open	
13	Normal	Load	92-2	YC672B	Open	
14	Normal	Load	92-2	YC672B	Open	
15	Normal	Load	94-1	AB544K	Open	

Pic 1: A normal pick list

Sl.No.	Priority	Mode	Rack	Material	Status	Timestamp
1	Normal	Pick	42-1	KX435B	Closed	82104101119
2	Normal	Pick	42-1	KX435B	Closed	82105101119
3	Normal	Pick	42-1	KX435B	Closed	82106101119
4	Normal	Pick	42-1	KX435B	Closed	82107101119
5	Normal	Pick	45-7	43ART1	Closed	82308101119
6	Urgent	Pick	31-3	29TUN1	Open	
7	Normal	Pick	21-8	PX129K	Open	
8	Normal	Load	92-1	YC672B	Open	
9	Normal	Load	92-1	YC672B	Open	
10	Normal	Load	92-1	YC672B	Open	
11	Normal	Load	92-1	YC672B	Open	
12	Normal	Load	92-2	YC672B	Open	
13	Normal	Load	92-2	YC672B	Open	
14	Normal	Load	92-2	YC672B	Open	
15	Normal	Load	92-2	YC672B	Open	
16	Normal	Load	94-1	AB544K	Open	

Pic 2: Inclusion of an urgent request (in red)

Sl.No.	Priority	Mode	Rack	Material	Status	Timestamp
1	Normal	Pick	42-1	KX435B	Closed	82104101119
2	Normal	Pick	42-1	KX435B	Closed	82105101119
3	Normal	Pick	42-1	KX435B	Closed	82106101119
4	Normal	Pick	42-1	KX435B	Closed	82107101119
5	Normal	Pick	45-7	43ART1	Closed	82308101119
6	Urgent	Pick	31-3	29TUN1	Closed	82852101119
7	Normal	Pick	21-8	PX129K	Open	
8	Normal	Load	92-1	YC672B	Open	
9	Normal	Load	92-1	YC672B	Open	
10	Normal	Load	92-1	YC672B	Open	
11	Normal	Load	92-1	YC672B	Open	
12	Normal	Load	92-2	YC672B	Open	
13	Normal	Load	92-2	YC672B	Open	
14	Normal	Load	92-2	YC672B	Open	
15	Normal	Load	92-2	YC672B	Open	
16	Normal	Load	94-1	AB544K	Open	

Pic 3: Resumption of original pick list after servicing the urgent request

Benefits and Conclusion

Using machine-learning capabilities, AGV cloud control apps will utilize AGVs efficiently. Same with the S/4 HANA MRP functionality, using it to the maximum, and bringing in best of world features to the warehouse. The fully automated facility also ensures higher safety standards and extremely high performance levels from the machines. This synergy between robots, smart warehouses and smarter ERPs like S/4 HANA can also be path breaking in terms of moving away from batch-based and intervention-based actions. Adding newer automation tools like IRPA can make core activities like Procure to Pay seamless, leading to a fully self-driven ERP solution.

Harnessing the power of all these systems together with high speed round the clock, AGVs & ERP together create the **Digital Kanban** thereby giving full control of the process and results. The whole process can be very easily optimized for lean and JIT leading to huge cost savings as well as tremendous increase in operational efficiency.

It is only imperative that such devices and systems come together giving customers immense benefits in efficiency, automation, tremendous cost savings, safety and flexibility.

About the author

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Prasanna has more than 19 years of experience in various SAP technologies as well as vast experience in the automotive industry. He is also part of Wipro's SAP Digital Innovation Group focused on SAP's cutting-edge technologies. He works with customers, Wipro thought leaders and SAP to usher in newer technologies, paradigms like Industry 4.0 and go-to-market strategies. He can be reached at

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