

FORI AUTOMATION INC.

Privately held, U.S. Owned
and Operated Since 1984



FORI AUTOMATION CHASSIS MARRIAGE SYSTEMS

13231 23 Mile Road
Shelby Twp., MI USA 48315

email: sales@foriauto.com

586-247-2336

www.foriauto.com

GLOBAL HEADQUARTERS

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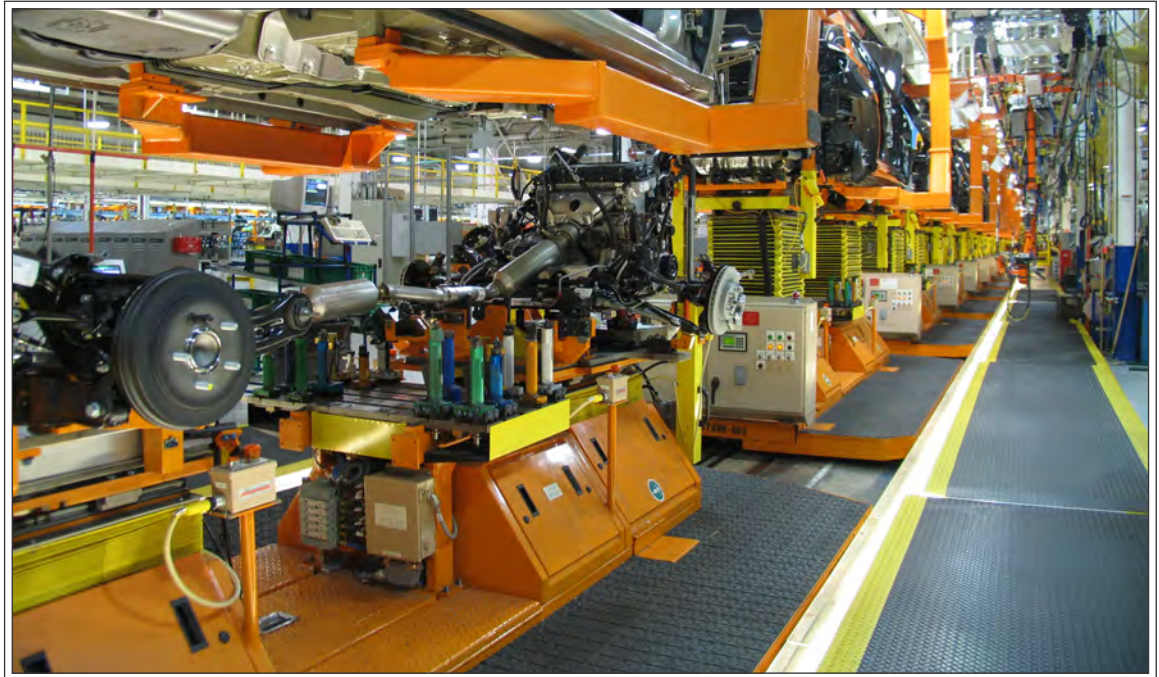
Chassis Marriage Systems

- AGVs - Automated Guided Vehicles
- AirGV - Air-Bearing Guided Vehicles
- Auto / Multi-Fasten
- Cab Pick & Cab Decking
- Fori Low Profile Lift
- Fori Standard Lift
- Operator Gantry
- Pallet Style Chassis Marriage
- Plug & Play Disconnects
- RGVs - Rail Guided Vehicles
- Robotic Chassis Marriage
- Track Switches



Rail Guided Vehicle (RGV) Chassis Marriage System

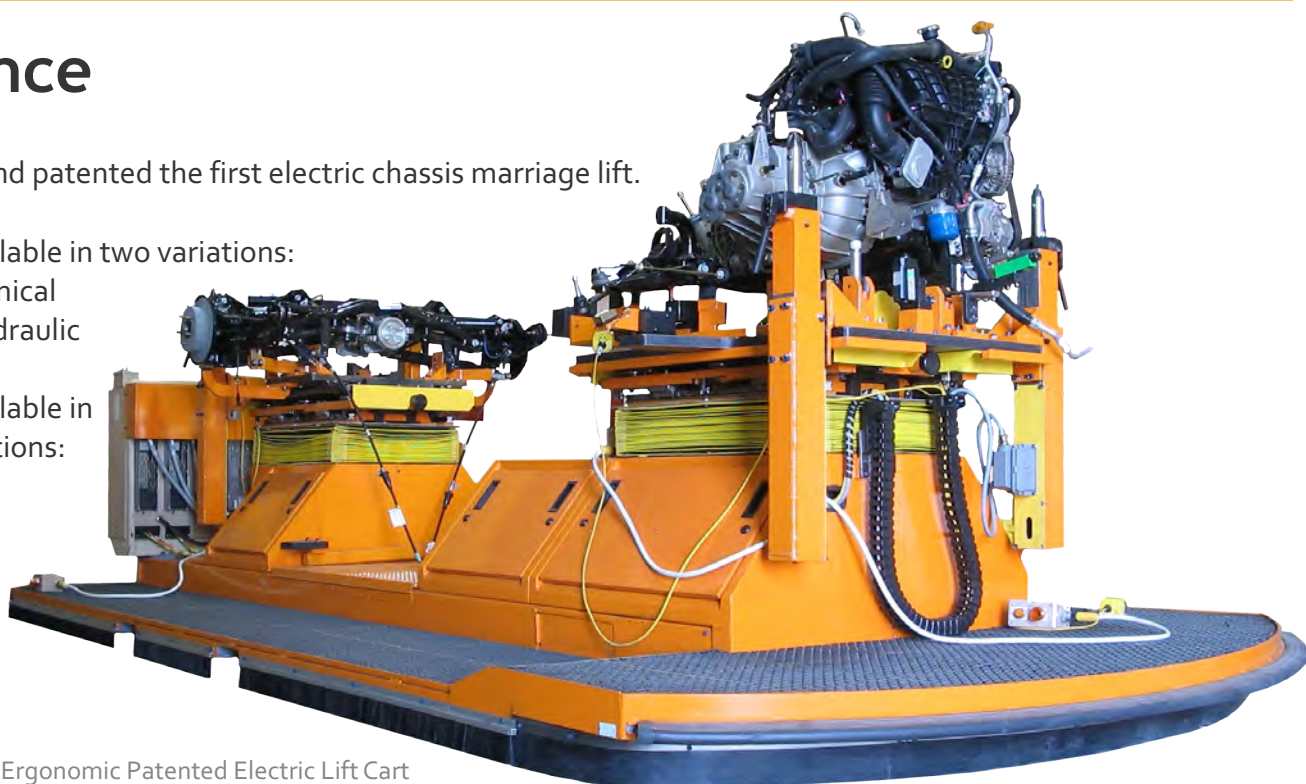
Effortless and repeatable decking of the front & rear module is accomplished through position-speed programmability of both the cart travel and vertical lifts. Each cart includes a front & rear Fori Patented Electric Lift, floating plates, and tooling plates. The Fori power cart decking accommodates up to four operators to assist with the dynamic decking and fastening process. Cart travel is designed for a "high speed" 12 in. / 305 mm per second maximum speed



with a lift capacity of 4,000 lbs. / 1,814 kg. Top tooling is designed to float +/- 5" fore/aft and +/- 3" cross car for any sync-build variation potential. The Fori patented electric lifts provide manual or automatic lift positioning up to a 38" 965 mm lift height. Pre-drilled holes on the front and rear tooling plates provide for easy and low cost modifications as future product requires. The chassis marriage system can include several assembly stations followed by a decking system that incorporates both bottom and topside securing. All operations are monitored through an advanced diagnostics station which provides "real time" data and fault recovery notifications.

Experience

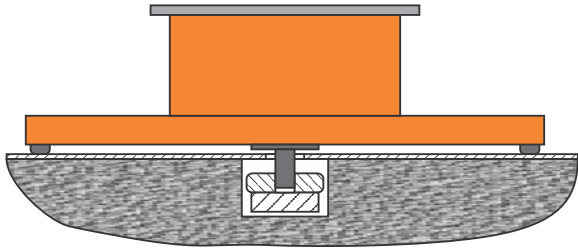
- Fori pioneered and patented the first electric chassis marriage lift.
- Systems are available in two variations:
 - Electro / Mechanical
 - Pneumatic / Hydraulic
- Systems are available in the following options:
 - Hydraulic Lift
 - Towable Lift
 - AGV - RGV



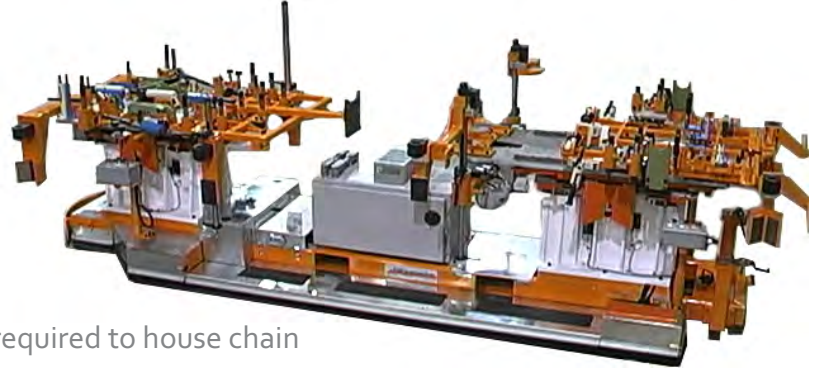
Ergonomic Patented Electric Lift Cart

Cart Power / Motion Options

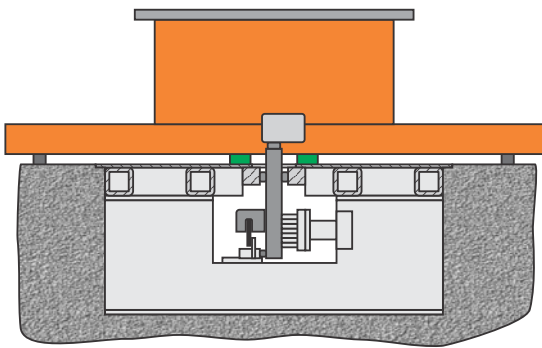
Floor Chain with Pin



Small pit required to house chain

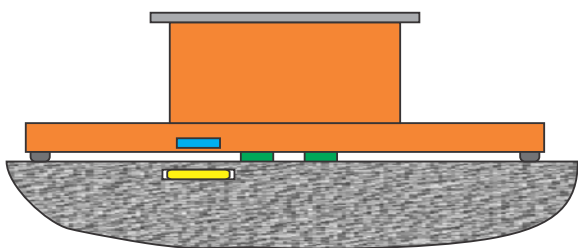


Floor EMS System with Power Rail



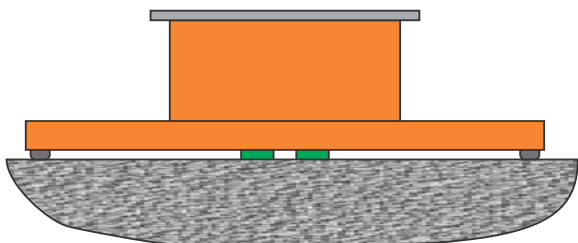
In-Floor pit which houses the electrified rail system as well as the position strip. A rabbit device reads the location strip and picks up power from the rail and delivers it to the system

Non-Contact Induction



Non-contact inductive power with pickup device on the cart

AGV Battery Powered

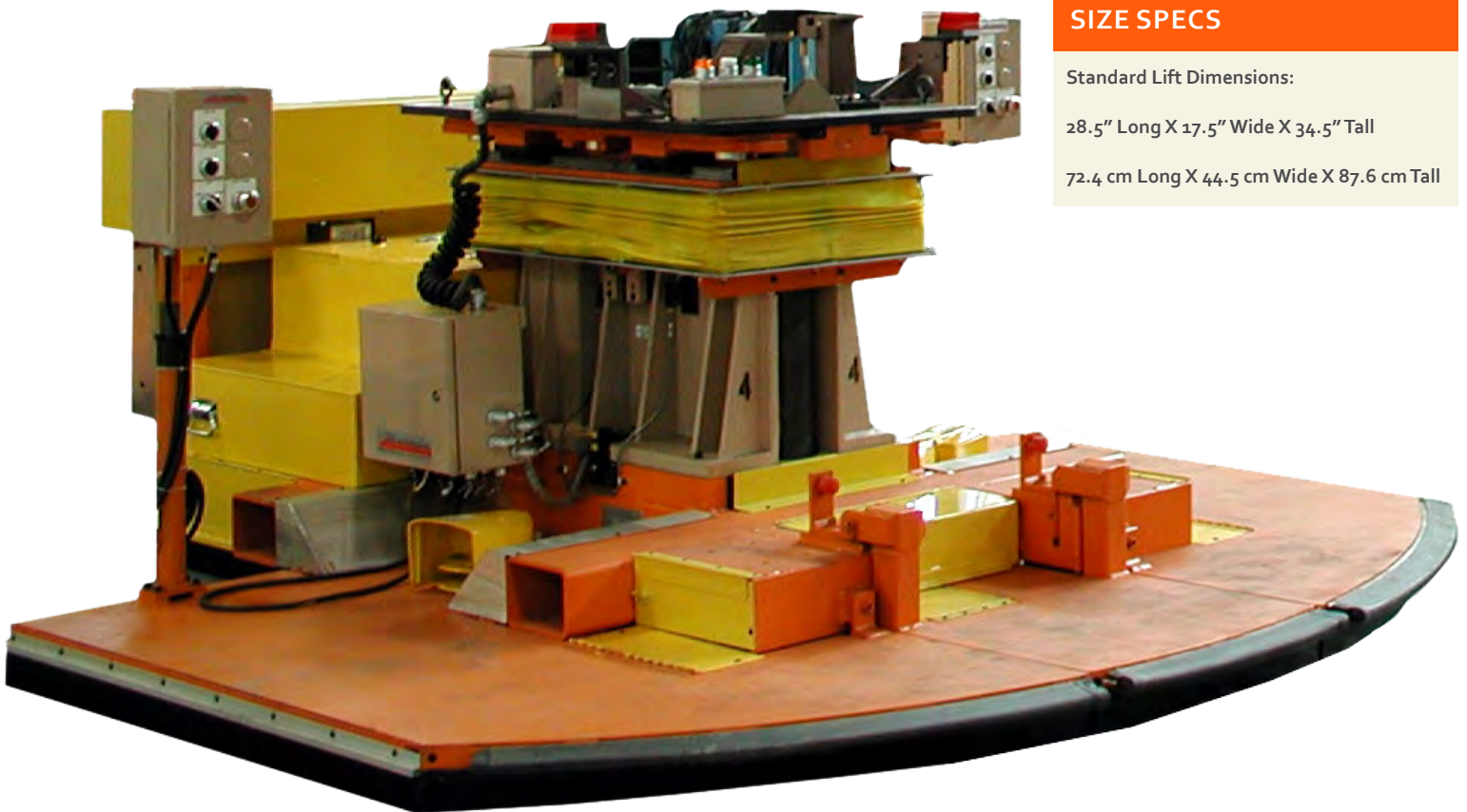


Battery powered AGV with re-charge stations. This system can follow in-floor magnets or magnetic strips to allow multitude of cart paths



Fori Standard Lift

- Lift stroke: 38 in / .97 m – 2 stage
- Lift speed: 4 in / 102 mm per second
- Lift capacity: 4,000 lbs / 1,815 kg with large offset load capacity
- Minimum - Collapsed Work Height: 34.5 in / 87.6 cm
- Electrical requirements: 480 V, 3 ph, 60 Hz. Servo driven lift motor with safety brake and encoder feedback
- Footprint (X-Y) 28.5" / 72.4 cm x 17.5" / 44.5 cm



SIZE SPECS

Standard Lift Dimensions:

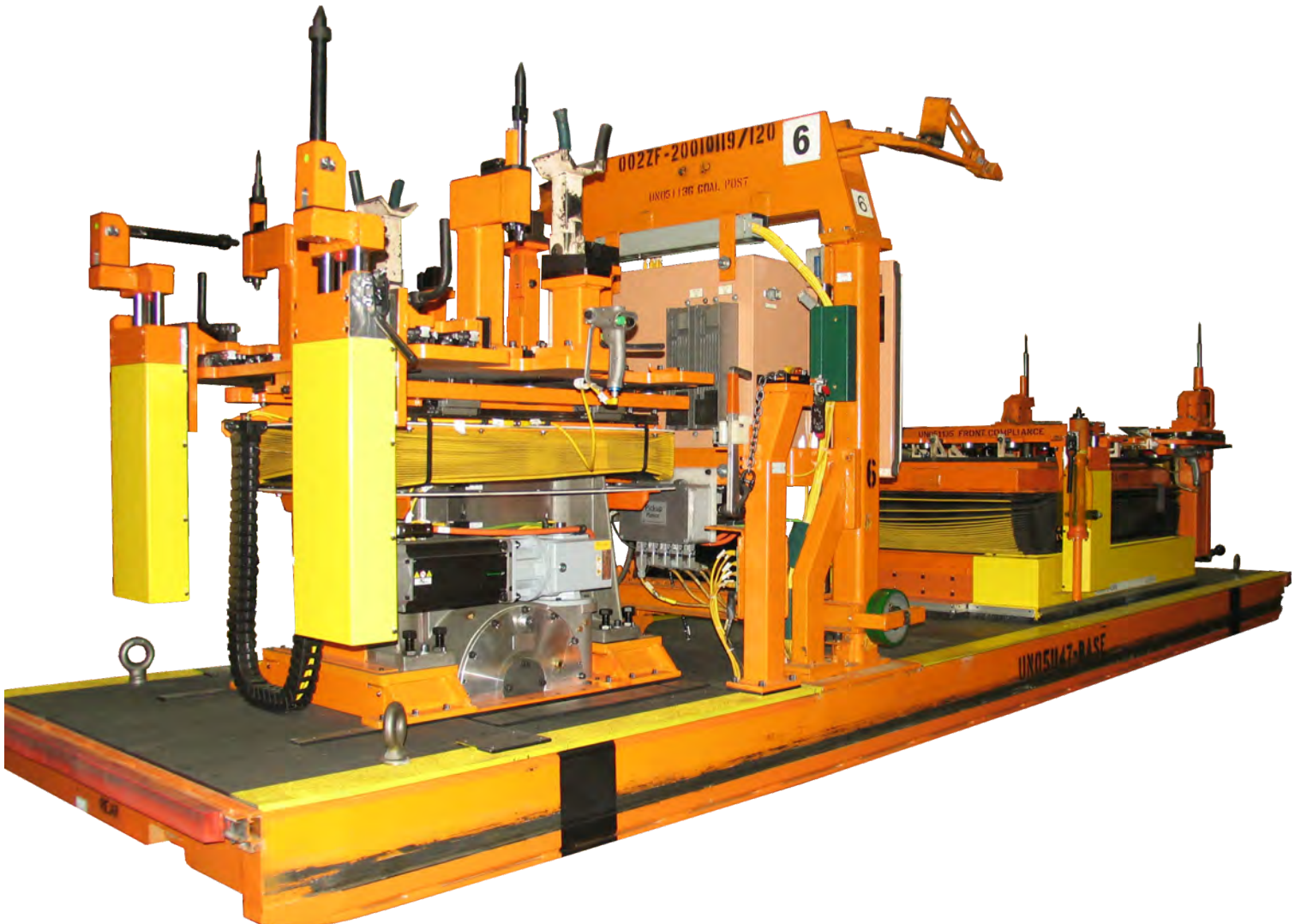
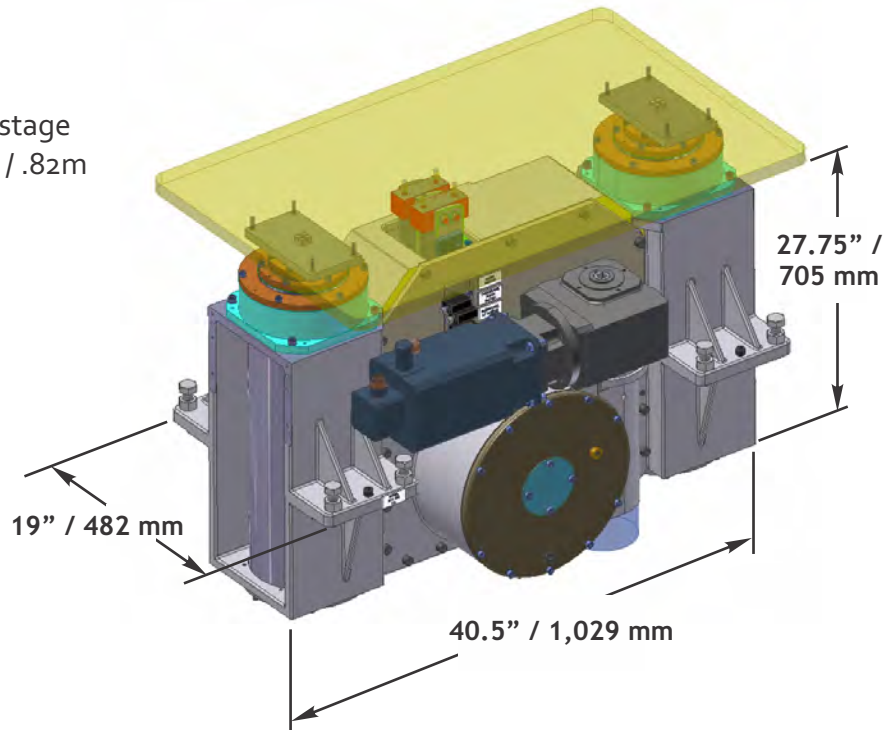
28.5" Long X 17.5" Wide X 34.5" Tall

72.4 cm Long X 44.5 cm Wide X 87.6 cm Tall

The simple construction begins with a single piece aluminum cast housing and internal components including Guide Tubes (2), Worm Gear Drive, Self-Locking Lift Chain and Servo Motor. Redundant Safeties include internal servo brake and anti-backup driving worm gear for any power interrupt and/or mechanical failure.

Low Profile Lifts

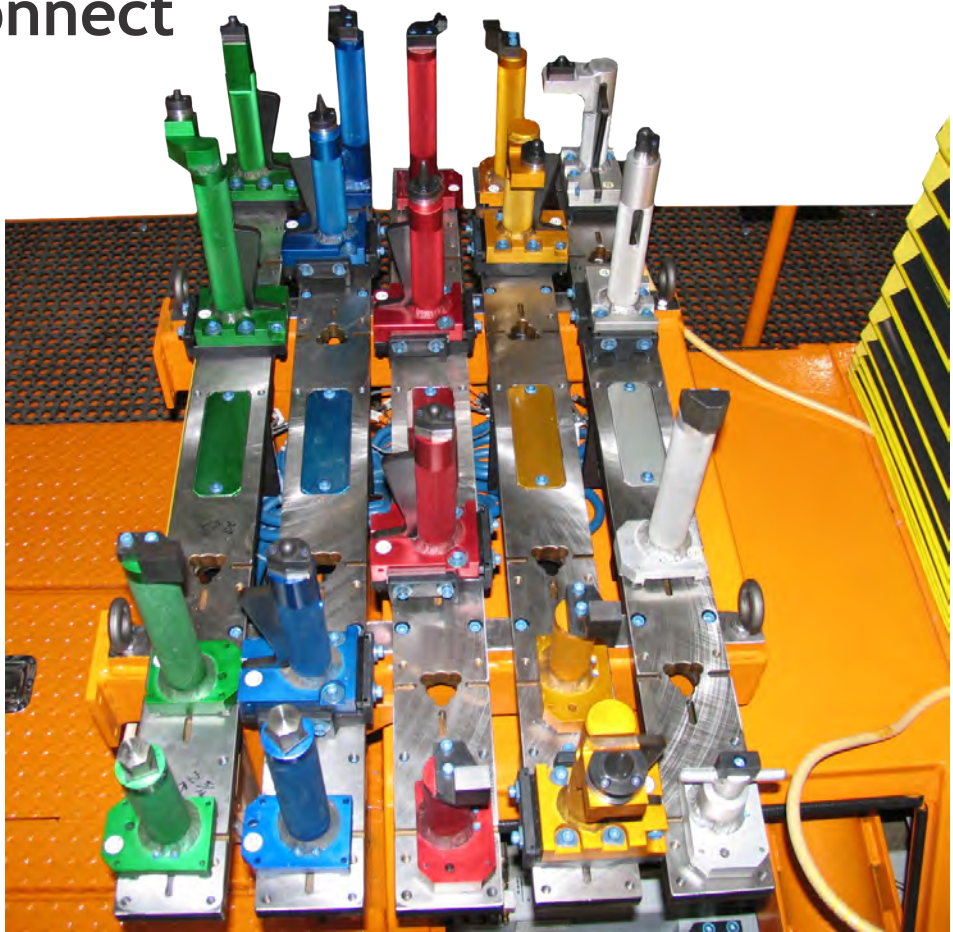
- Configurable Lift stroke: 56 in / 1.4m – 3 stage
Lift Stroke Max: 50 in / 1.27 m ; Min: 32 in / .82m
- Lift speed: 4 in / 10.2 cm per second
- Lift capacity: 4,000 lbs / 1,815 kg
with large offset load capacity
- Minimum - Collapsed Work Height:
33 in / 83.82 cm @ 56 in / 1.4 m stroke
25 in / 63.5 cm @ 32 in / .82 m Stroke
- Electrical requirements: 480 V,
3 ph, 60 Hz. Servo driven lift motor
with safety brake and encoder feedback
- Footprint (X-Y) 40.5" / 1,029mm x 19" / 482mm



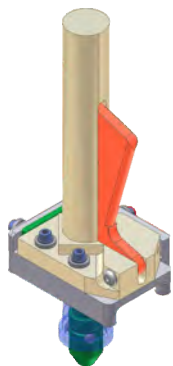
Fori's Low Profile (LP) Standard Lift is of a proven robust design to accommodate the severe off-center loads required of daily Chassis Decking Operations in Vehicle Assembly Plants.

Options - Plug & Play System / Quick Change Disconnect

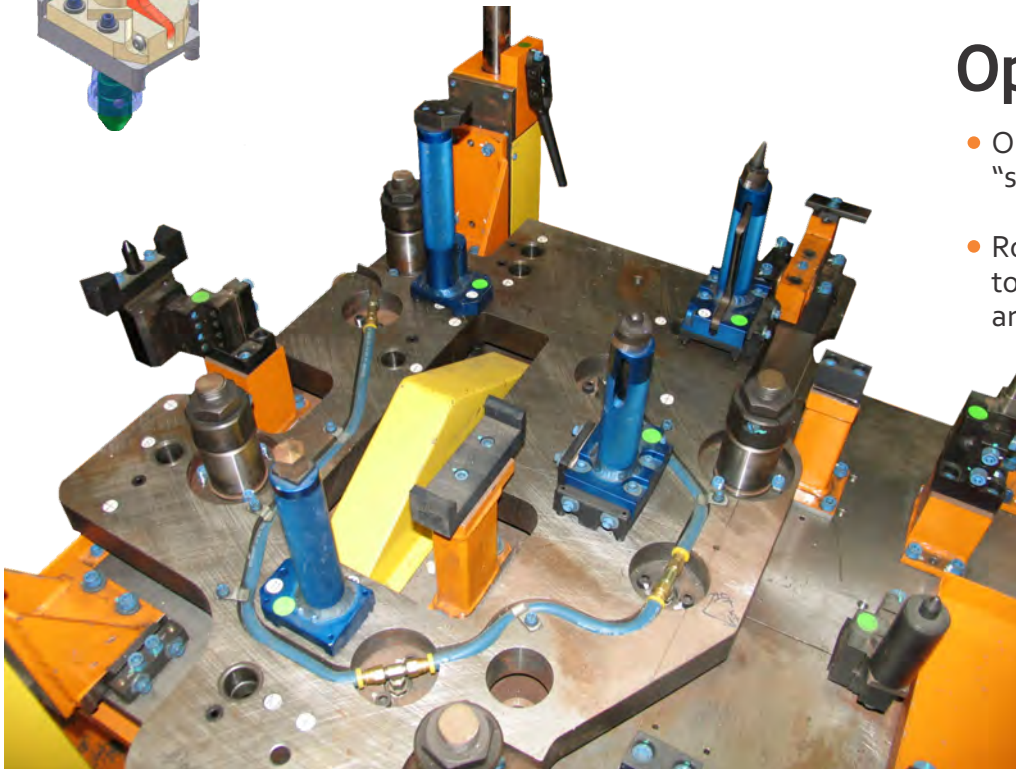
- Multiple engine, cradle & transmissions on the same tooling plate
- Eliminates multiple flip details
- Certified Accurate within +/- 0.13 mm
- Simplifies the tooling plate model
- Change over process for the operator with lite weight details
- Locking storage tray ensures that only the correct details can be accessed
- Designed for flex plant expansion & for future products with minimal tooling plate modifications



Color & Number Coded with Dowel Pins to Simplify Use



Patent Pending Quick Disconnect tooling detail



Details in Position on the Tooling Plate

Options

- Optional vision system that can "see" the details and verify that
- Robotic load and unload of all tooling plate details all components are in the correct positions

RGV Chassis Marriage System



RGV chassis marriage system for a new Van Plant in Saltillo Mexico. This project includes the participation of Fori USA, Fori Korea and Fori Mexico. The project was engineered in Fori USA and was based on Fori Standard RGV marriage system. The manufacturing and assembly of the system was developed between

Fori USA, Fori Mexico and Fori Korea. The integration of the track, controls, and the first RGV was handled at Fori USA with customer buy off at Fori USA. Fori Mexico built to print the balance of (8) RGVs, integrating the Carts' control panel and front/rear lifters which were manufactured by Fori Korea.

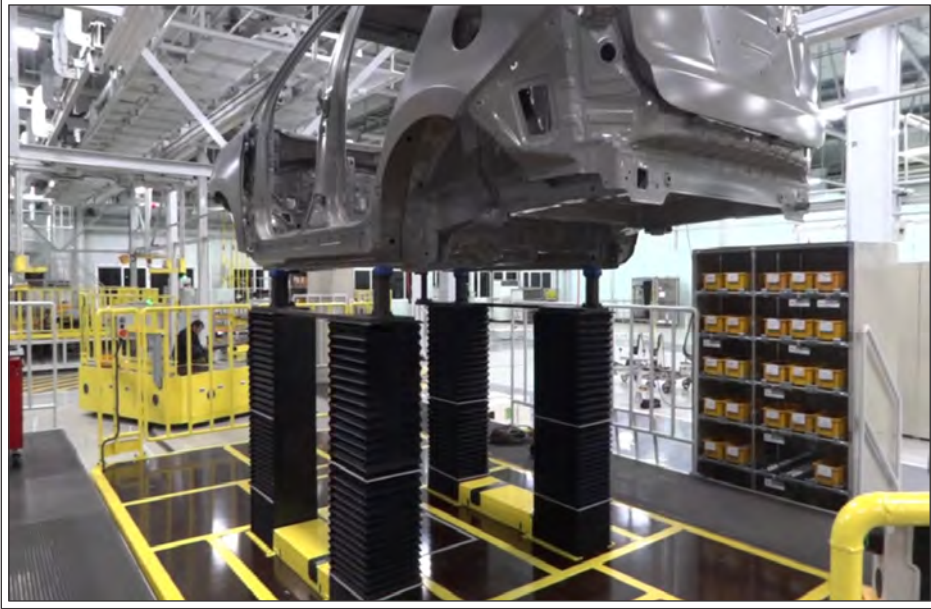
Air-Bearing Based Chassis Marriage - AirGV



Air-bearing based chassis marriage system (Air Guided Vehicle / Air GV). The marriage system included a pair of electro-hydraulic scissor lifts moving in tandem for front & rear assemblies at 2 jph. The front, center & rear tooling assemblies are

all mounted on a common base plate so that they all lift and lower together. The Air GV moves with minimal push-pull effort and is operated by only 1-2 operators while moving from the loading area to the decking area.

AGV Chassis Marriage Systems

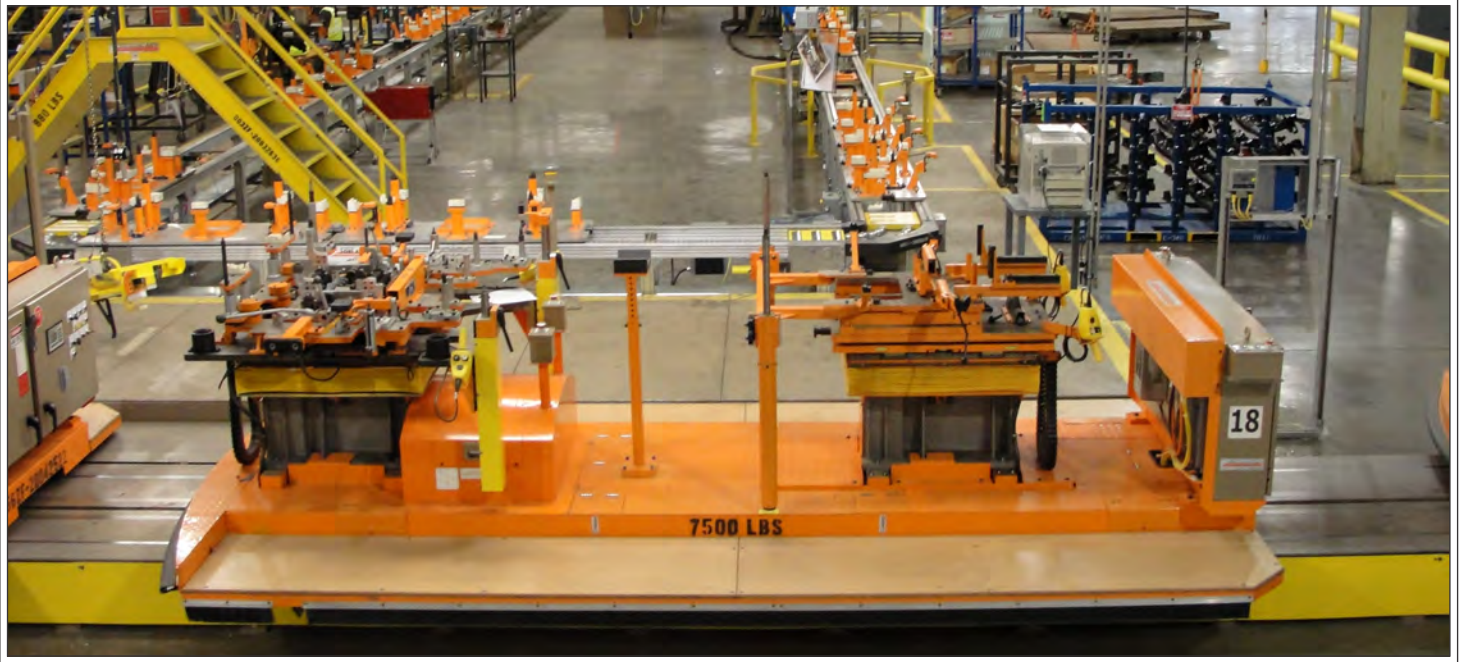


The AGV Chassis Marriage system utilized an induction powered rail guided vehicle. The induction system has a 440 volt 3 phase 60 hertz input and a 24/600 dc volt output. The cart is used to transfer the vehicle through the entire assembly process, underbody assembly, and chassis marriage, trim and final. The AGV has a patent pending dual lifter system for the cart. These lifters have a capability of 2.4 tons. They are used to raise the body assembly into various positions for assembly and transferring processes. The system also has two transfers one to move the car body from the RGV to the marriage station and one to unload the completed assembly at the end of the process.

Automated Guided Vehicle (AGV) to be incorporated into the chassis marriage systems in the automobile assembly processes. This AGV runs on a 48 volt battery powered system which can be charged at various floor contact quick charging stations during regular operation. The motors for lift, drive and steering functions are AC Asynchronous motors. The AGV has a maximum speed of 45m/min. with a stopping accuracy of ± 10 mm. It can be operated manually with a side to (crab walk) function. All drives communicate with the on board PLC via Ethernet / CAN-Open communication. The controls package is 100% PLC based. The AGV utilizes a patented Fori guide sensor to track the embedded magnetic guide. It has RFID capability. This product uses two FORI patented electric mechanical lifts with a load capacity of 4,000 lbs including tool plates. This platform was developed to be very flexible. Different drive steers, motor controllers PLC platforms and multiple tooling plates can be adapted per customer requirements. They can take full advantage of limited floor space and non-traditional traffic patterns.

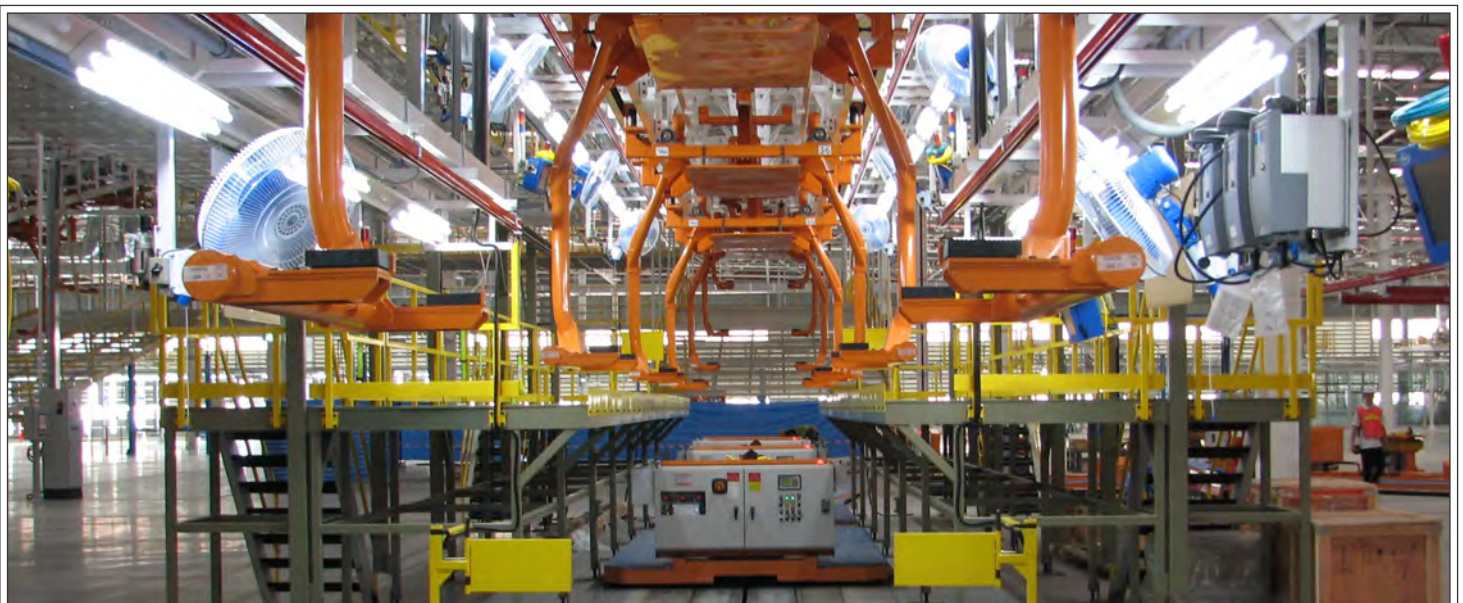


Chassis Marriage with Integrated Module Assembly



Engine decking system with integrated front and rear suspension build assembly lines, linked by Fori's twin strand conveyor. The pallets travel to build stations along the conveyor loop. The pallets are held at each build station by cushioned anti-backup stops until build for that station is complete, and then they are released back on the continuously moving conveyor to travel to the next station. The front module assembly line also incorporates accumulating stops, pallet diverters, and lift and rotate stations to allow both sides of the pallet to be worked on. These conveyor systems streamline the assembly process while feeding the engine decking system.

The completed front suspension with the engine pallet is loaded onto the chassis marriage carts by an elevator that transfers the completed pallet to the cart using extending conveyors. Once on the chassis marriage decking cart is completed prior to decking. The 21 carts travel around the marriage loop at variable speeds and through several build stations. When the cart reaches the decking area Fori's patented electric lifts lift the completed chassis to the vehicle body where it is then fastened. The empty engine pallets are offloaded by an elevator where they re-enter the front suspension build conveyor.



Chassis Marriage Automated Guided Vehicles



Custom tooling plates accommodated the five different frame styles.

The Chassis Marriage system was based on a flexible, magnetic bar methodology. Previously, the standard was Rail Guided Vehicles (RGVs) with in floor or above floor track utilizing a bus rail for power and communication.

Utilizing a 48V Lithium Ion powered system and wireless for communication has enabled Fori to reduce infrastructure costs and increase flexibility.

One of the most important features of the Chassis Marriage AGV was the utilization of Lithium Ion



batteries. Lithium Ion allows for much high charge and discharge current and a much longer life in comparison to lead acid options. The vehicles utilized an opportunity charging scheme in assembly stations, ensuring uninterrupted production.

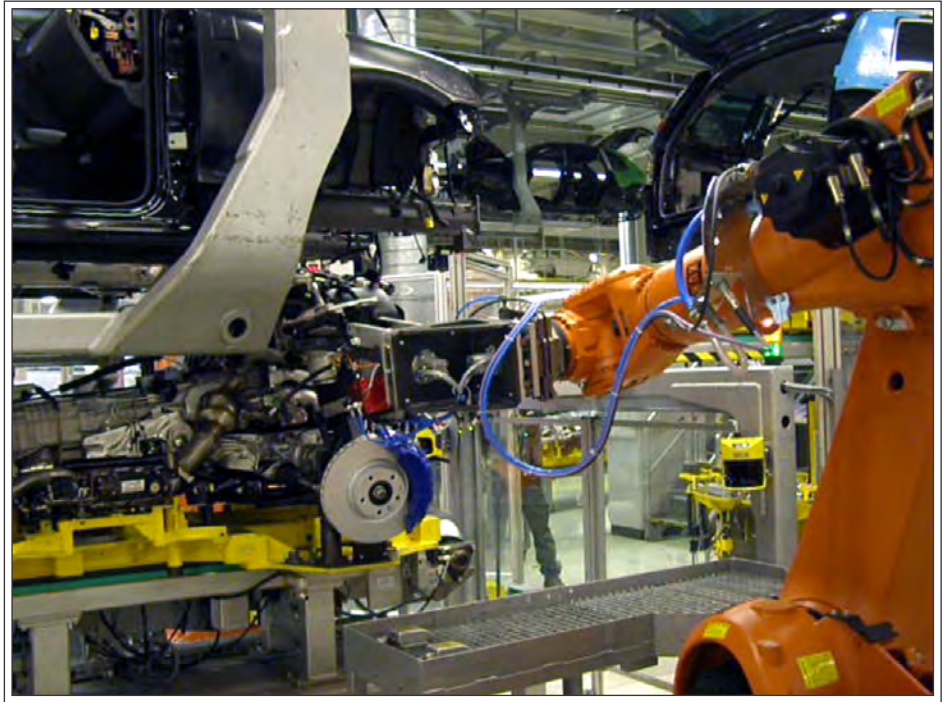
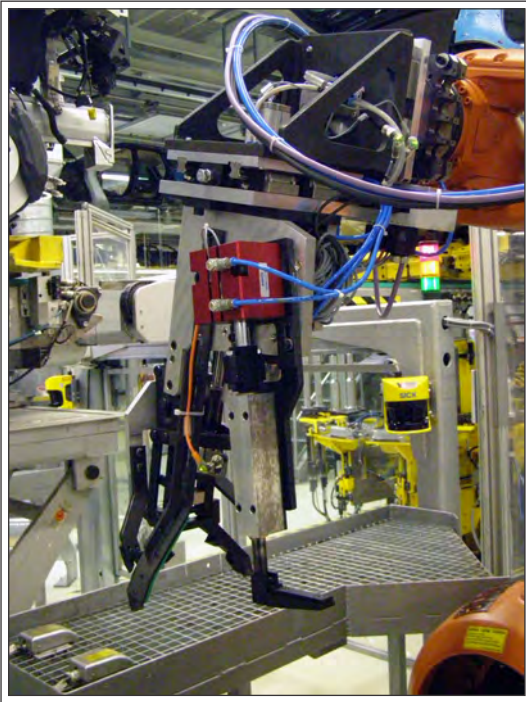
The Omni-directional AGVs utilized a continuous magnetic bar guidance method, which is highly accurate and reliable. Accuracy achieved was +/- 10 mm, moving at speed up to 50m/min. The final differentiating feature against our competition was the 100% PLC based system, providing an open architecture.



The six Lithium Ion Battery Powered AGVs are capable of transporting 6,000 lbs. / 2,721 kg. at speeds up to 18"/ 457 mm per sec. Chassis Marriage AGVs. Fori provided a station with one set of lifts in order to reduce the vehicle power consumption and overall system cost. By utilizing magnetic bar guidance versus

the previous rail guided methodologies, installation cost and time was decreased substantially. Magnetic bar guidance is not only the most reliable guidance method, but also lends itself to increased flexibility by simplifying the time and install associated with making changes to the path.

Robotic Chassis Marriage



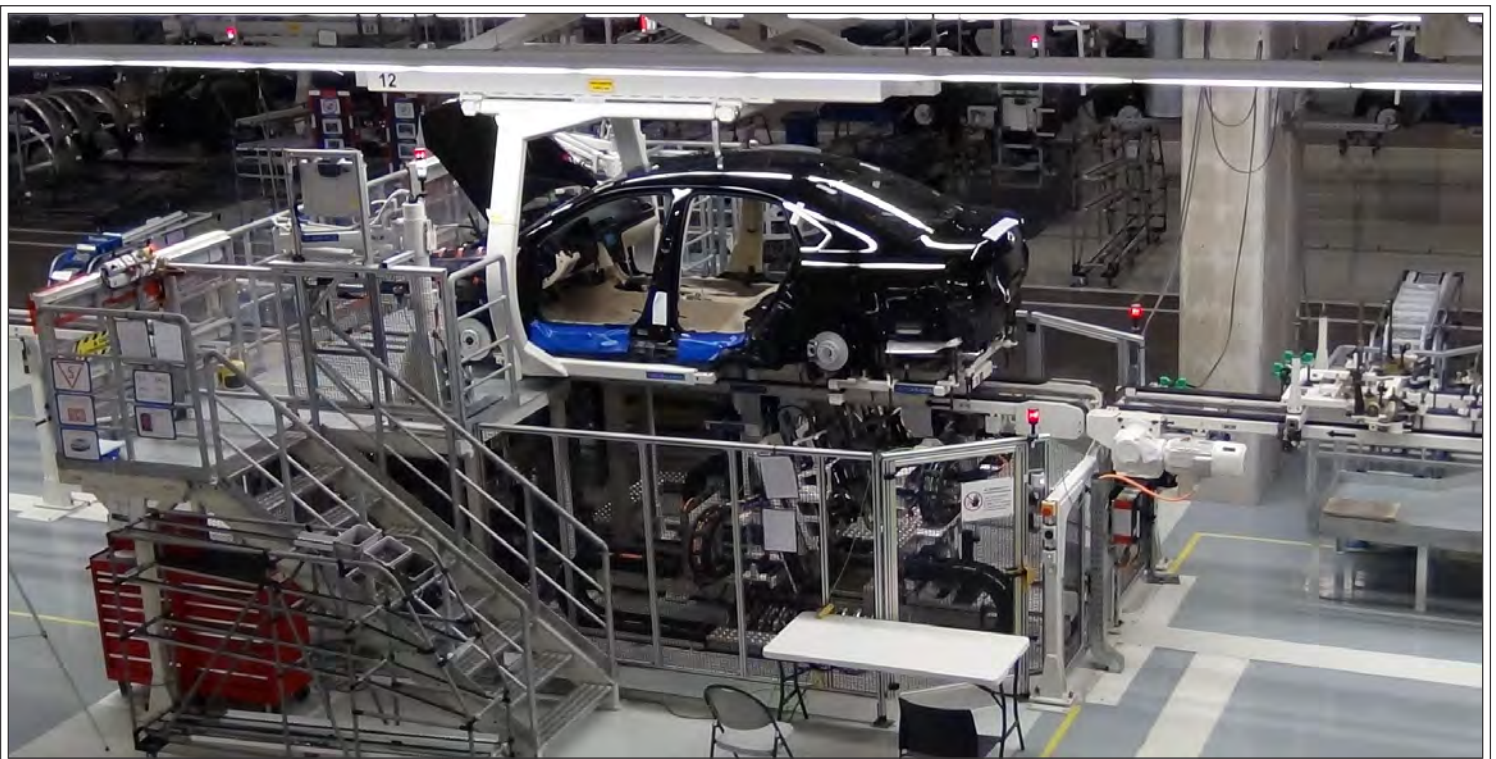
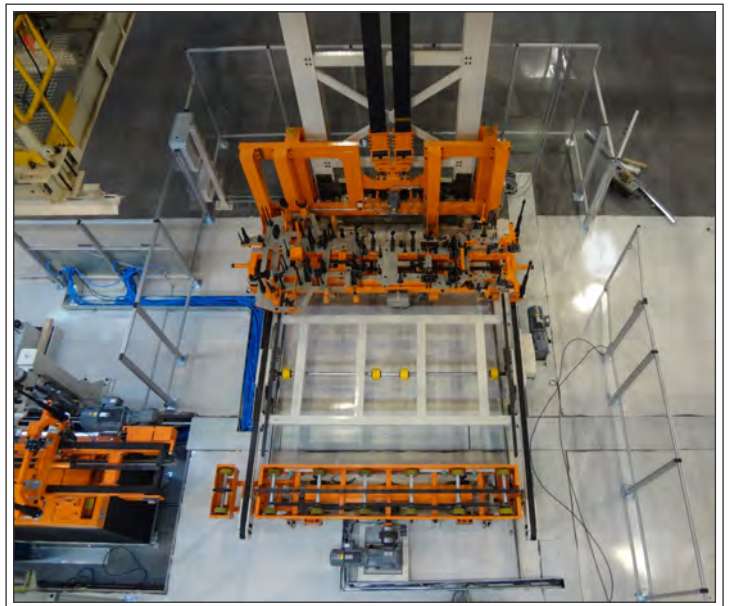
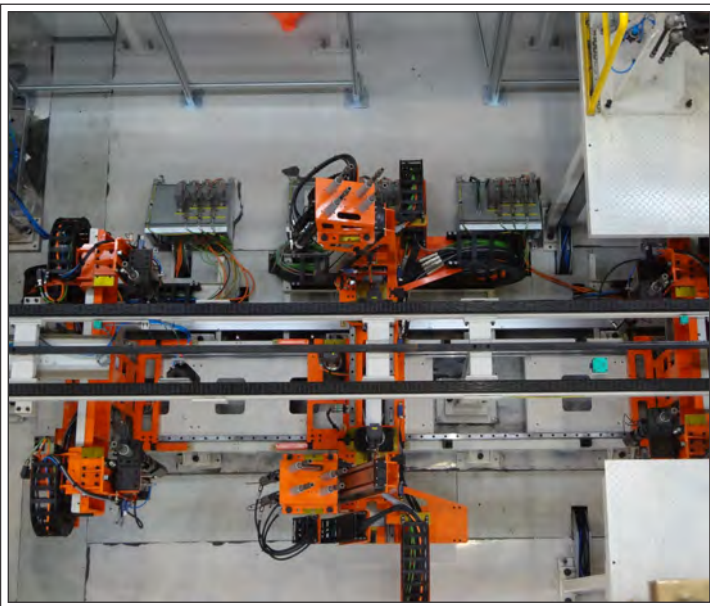
Robotic suspension fastening. Two robots are used to lift and fasten the chassis to the vehicle body. This system was designed and installed by Fori Germany for a Volkswagen Bratislava plant.



Fori Germany designed and installed an inductive power AGV system for the Porsche Osnabrück plant in Germany. The system consists of an AGV track, seven (7) AGV's equipped with Wampfler IPT induction systems and a hydraulic lift. At the marriage station the loaded AGV is lifted to the suspended vehicle body and the chassis is fastened to the body at 12 jph.

Pallet Style Chassis Marriage

- Eighty Five (85) electronically controlled tightening spindles.
- One (1) Fully automatic chassis marriage fastening station
- Control system for conveyors
- Nutrunner torque & RFID tracking system
- Line side tooling system with hoists, trays, utilities and tables
- Thirteen (13) Fori twin strand conveyors with an elevator and lowerator
- Thirty Three (33) AGV front module assembly carts
- Eighteen (18) Chassis marriage PA Stations
- Ten (10) Chassis marriage operation stations
- Overhead front pallet loading system, super pallet return conveyor, front / middle / rear sub-pallet storage line and transfer pallet load / unload



Pallet Style Chassis Marriage



Fori China completed the design, build and installation of a chassis marriage system for system installed in Shanghai China. This system was built with Fori's global design Team. Fori Korea supplied the design and build for the following components: system layout, tooling, EC & NR manipulators and the electrical design. Fori USA designed the DL1

lifter and aided in mechanical assembly. Fori China then took the components and built and installed the front module conveyor, five (5) silent conveyors, control panels and electrical installation and integration. This system demonstrates Fori's global resources and collaboration including their ability to design systems on a global level.

Cab Pick and Cab Deck Chassis Marriage

The Cab Pick and Cab Deck systems were supplied to support a truck assembly process. The three systems were used to support the three different lines of trucks.

Each system consisted of a standalone structure, overhead rail system, overhead four point cable lift, custom end effector and a main control panel. The system included a PLC controlled primary system and backup system in the case of a catastrophic failure. The operators were responsible for manipulating the cab with a

Wireless control pendant. Each of the systems provided a custom designed end effector to handle the different cab styles and weights. The system is meant to increase safety of transfer for completed cab assemblies. The custom end effector ensures a rigid transfer and improves reliability of transfer and decreases potential for product damage during transfer.

The full rate production for the Cab Pick and Cab Deck system is 35 jobs per hour. Production began in the first quarter of 2016.



Electro-Mechanical Systems

- Powered cart that rides at floor level and is mechanically guided
- Moving line or stop station process
- 360° operator access
- Operators can ride on or walk along with cart
- Carts can be equipped with ergonomic lifter or rotate mechanism to manipulate work piece to optimal ergonomic position
- Programmable speed, stopping position and operator work heights
- Operator safety ensured with utilization of sensors
- Cart positioning and spacing monitored through code rail feedback
- Two (2) electrification options:
 - Contact style bus rail
 - Non-contact style induction power
- Variable track configurations can include multiple intersecting lanes and off-line spurs
- Carts can accommodate loads up to 8,000 lbs / 3629 kg
- Traffic control
- Part present error proofing
- Pallet identification
- Hi-lo access on both sides of track



The Fori carts have several options as to how they are powered and moved along the plant floor. From magnetic strip to chain towed Fori's carts are designed to fit each need.

Chassis Marriage System Options

Operator Gantry Fastening Station



The final engine secure can be performed on a line-side-limo. This system moves the operator into position on a platform in front of the vehicle all the while the platform in moving down the line with the vehicle. When completed the operator and platform return the home position for the next vehicle and the cycle begins again. Multiple models can be fastened using a single gantry station with no retooling.

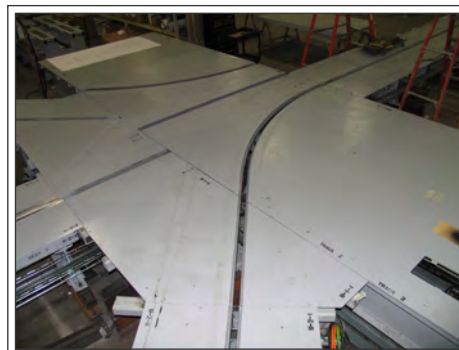
Auto & Multi-Fasten Systems

The Auto-Fasten system uses robots to turn spindles that in turn fasten the chassis to the vehicle.

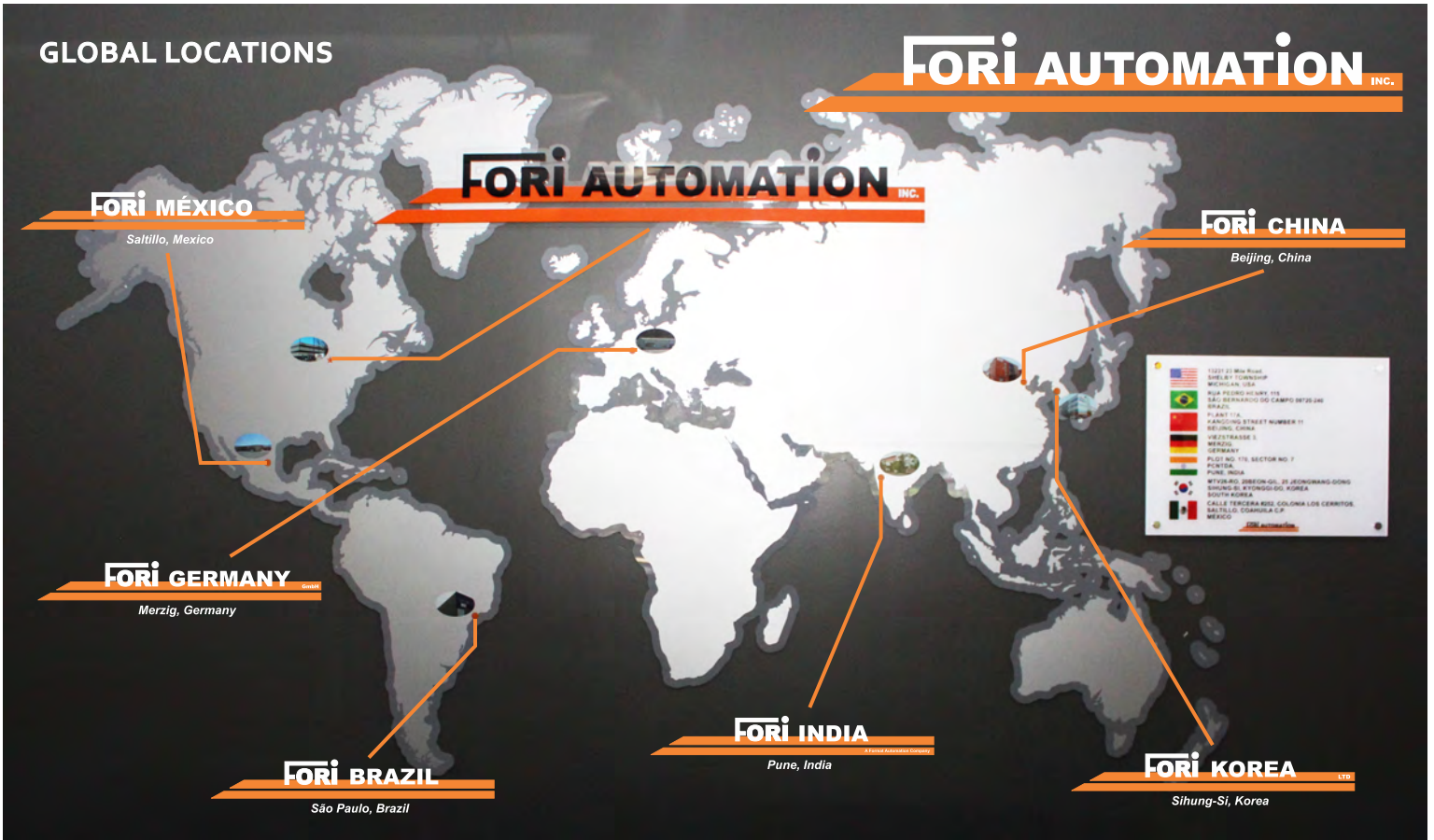
The Multi-Fasten station fastens all of the spindles simultaneously while moving at line rate.



Track Switches



Track switches and lane diverters allow multiple lanes to be accessed which reduces the overall equipment footprint.



Fori Automation Inc.
Global Headquarters
Shelby Twp., MI, USA 48315
Phone: 586-247-2336
Fax: 586-266-6773

Fori Automation China
Beijing, BDA, 100176 China
Phone: 86-10-6780-2940
Fax: 86-10-6780-2945
email: sales@foriauto.com

Fori Korea Ltd.
Sihung-Si, Korea
Phone: 82-31-496-3400
Fax: 82-31-431-528

Fori Automation India
Pune, India
Phone: +91-20-66140925/26

Fori Automation do Brasil
São Paulo, Brazil
Phone: 55-11-4124-7624
Fax: 55-11-4337-3172

Fori Automation GmbH
Merzig Germany
Phone: + 49 (0) 6861-7009-0
Fax: + 49 (0) 6861-7009-310

Fori Automation de México
Saltillo, Coahuila, Mexico
Phone: 52-844-416-8918



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