HOW WE AUTOMATE

“Our only objective was to create a solution that allows for this type of intense off-road testing that could take our vehicles to the most extreme limits of their engineering while ensuring the safety of all involved.”

Dave Payne
MANAGER OF VEHICLE DEVELOPMENT OPERATIONS
FORD MOTOR COMPANY

Automate Any Vehicle Type, Including:

- CARS
- SUVS
- VANS
- MILITARY VEHICLES
- CONSTRUCTION VEHICLES
- PICKUP TRUCKS
- LARGE TRUCKS
- AGRICULTURAL VEHICLES
- MINING VEHICLES
Sensors

Sensors collect environmental info and relay it to the on-board VCU to give awareness to the automation system. Compatible with the Mobileye® camera system.

Control Unit

ASI’s patented VCU computer is the brain in the vehicle. It communicates with the sensors and controls the vehicle. It also relays info between the vehicle, server, and Mobius.

Actuators

Universal actuators are placed in the vehicle to communicate with the VCU so that vehicle operations can be controlled safely and accurately. In by-wire vehicles no actuators are needed, as the VCU integrates with vehicle controls directly.
Mobius Command & Control

**PROXIMITY MONITOR**
When multiple vehicles are on a track at the same time, Proximity Choreographer monitors their location, direction and speed. If paths may cross, it directs vehicles to react appropriately to avoid collisions.

**SAFE AREA LOCKOUT**
These areas exist around autonomous vehicles and can be designated around human controlled vehicles on a track. Unmanned vehicles will stop if they approach any designated safe areas.

**E-STOP**
If unmanned vehicles leave the safety area or lose signal, the e-stop override immediately applies the brake.

**MULTI VEHICLE OPERATION**
Enjoy greater productivity and economies of scale as a single operator controls multiple unmanned vehicles interacting in the same area or at dispersed locations.

**A.I.**
Improve productivity with embedded artificial intelligence modules that automatically task vehicles, generate maps and paths, and more.

**SIMPLE SITE SETUP**
Quickly generate custom maps, designate lanes and roadways, set safety perimeters, and create drivable areas with Map Builder.

Experience the simple, clean Mobius interface that leverages advanced design and development techniques and incorporates user testing results from industry professionals.

**LIVE TELEMETRY**
View real-time gauges and meters that display a vehicle’s current speed, gear, RPM, fuel level, & more...

**MANUAL MODE**
Easily switch between autonomous mode and manual mode to control the vehicle manually when needed.
**Event Planning**

Execute actions at a specific point in a path. Functions include: acceleration, deceleration, stop, wait, lane change, variable force braking, roll over, and more...

**Path Builder**

Creates a drivable path that can be customized to match testing needs and course routes.

**Vehicle Tasking**

Vehicles can be tasked to run routes as many times as needed. No need to switch drivers out due to hazardous road conditions, fatigue, and driver breaks.
Robotic Automation Benefits

**Variability Between Human Drivers vs. ASI’s High Precision Robotic Kit**

This data was taken from real proving ground durability tests and highlight the variability between human drivers and the variability between ASI robot drivers.

Four vehicles of the same model were subject to a standard durability test cycle. Two of the vehicles were driven by two different drivers. The other two vehicles were driven by two different ASI robot drivers. Each vehicle was fitted with an accelerometer measuring force in a single axis. The charts to the left plot the measurements made on the four trials at that same point.

**Accuracy**

The Frequency Response and Histogram charts at left highlight the reduced variability between robot drivers when compared to similar data from human drivers. Robot drivers allow for much more consistent application of your drive cycles to your prototype vehicles.

**Repeatability**

Tests being repeated more consistently by robotic drivers mean the integrity of that data increases due less variability in the results.

**Productivity**

In results from proving grounds that were conducting tests performed by ASI robotic kits, they were able to complete a series of tests in about half the time that it would take human drivers to complete that same series of tests. With robotic drivers, there is no need for regulated brakes or switching drivers out.

**Safety & Stamina**

The ASI automation kit is rugged enough to withstand any harsh durability test, and repeat it over and over again without any need to stop. A robotic automated durability test vehicle can run for as long as its fuel tank will allow.

Robotic drivers can be used in tests that are not suitable for humans.

**Value**

Enjoy greater productivity and economies of scale as single operators can control multiple unmanned vehicles.

A robotic automation kit costs much less than trained durability drivers operating the same vehicle.
# Automate Any Durability Test

<table>
<thead>
<tr>
<th>Supported Test Feature Types:</th>
<th>Supported Testing Types:</th>
<th>Robotic Accelerated Structural Durability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chuck holes</td>
<td>Durability / Mileage accumulation</td>
<td>Suspension</td>
</tr>
<tr>
<td>Jounce holes</td>
<td>Chassis development</td>
<td>Damping</td>
</tr>
<tr>
<td>Drop slabs of varying heights</td>
<td>Severe maneuvers</td>
<td>Mountings</td>
</tr>
<tr>
<td>Acceleration bumps for drive line shock</td>
<td>Stability roll over tests</td>
<td>Components</td>
</tr>
<tr>
<td>Twist ditch</td>
<td>Braking systems (ABS/Regenerative) – on wet surfaces</td>
<td>Bodies and structures</td>
</tr>
<tr>
<td>Pavé</td>
<td>General durability</td>
<td>Accessories</td>
</tr>
<tr>
<td>Cobblestone</td>
<td>Repeated brake test</td>
<td></td>
</tr>
<tr>
<td>Belgian block</td>
<td>Lane changes</td>
<td></td>
</tr>
<tr>
<td>Resonance road</td>
<td>Pothole braking</td>
<td></td>
</tr>
<tr>
<td>Corrugations</td>
<td>Any other standard durability test</td>
<td></td>
</tr>
<tr>
<td>Potholes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water splash and wading troughs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compacted Rubble</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loose rubble</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potholes and ruts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mud</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wading pool and trough</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rough grassy field</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Supported Test Feature Types:**

- Chuck holes
- Jounce holes
- Drop slabs of varying heights
- Acceleration bumps for drive line shock
- Twist ditch
- Pavé
- Cobblestone
- Belgian block
- Resonance road
- Corrugations
- Potholes
- Water splash and wading troughs
- Compacted Rubble
- Loose rubble
- Potholes and ruts
- Mud
- Wading pool and trough
- Rough grassy field
- Most other severe misuse surfaces

**Supported Testing Types:**

- Durability / Mileage accumulation
- Chassis development
- Severe maneuvers
- Stability roll over tests
- Braking systems (ABS/Regenerative) – on wet surfaces
- General durability
- Repeated brake test
- Lane changes
- Pothole braking
- Any other standard durability test

**Robotic Accelerated Structural Durability:**

- Suspension
- Damping
- Mountings
- Components
- Bodies and structures
- Accessories
Vehicle Control Unit

Function
The VCU manages vehicle network connections. POE switch for cameras that powers and networks a camera system. OEM Signal Interface connects to vehicle via CAN Bus and OBD Port (sends OEM data such as speed, RPM, engine temp., etc. back to Mobius command & control base station).

Specs
- OPERATIONAL TEMP. RANGE: -40°C to +55°C (-40°F to +130°F)
- WEATHER PROOFING: Weather sealed to IP67, usable in moderate rain, snow and light dust
- DIGITAL I/O: Quadrature x1 (5 V) Digital In x8 (5-30 V) Analog In x3 (0-5 V)
- COMMS INTERFACE: Ethernet 1x (10/100) CAN x3 Serial x3 (RS-232)
- PROCESSOR: iMX6 QuadCore 1GH2 ARM 9
- RAM: 2 GB DDR3
- STORAGE: micro SD x2
- BOOT FLASH: 128 Mbit
- NAND FLASH: 2 GB
- WEIGHT: 2.3 kg (5 lb)

Mounting
INSTALL FEATURES
The VCU is placed within a steal carrier box that is secured via the seat belt. This allows the user to easily transfer kit components from one vehicle to another.
Ignition By-Pass & E-Stop

Function

**Ignition By-Pass** allows the Vehicle Automation Kit to be powered independent of the vehicle. It also provides a layer of safety and security. Turning the key to the "off" position powers off the kit and cannot be powered on without the key in the "on" position.

**E-stop** immediately halts all vehicle operations as an emergency safety override. Available in both on-board and remote switches.

**Auto/Manual Switch** provides the ability to toggle the vehicle between automated and manual control. Autonomous-capable vehicles may be driven in manual mode even with kit installed.
The Steering Robot actuator provides more accurate and repeatable steering than a human driver by applying powerful and precise speed and torque.

**Steering Robot Assembly**

<table>
<thead>
<tr>
<th>Function</th>
<th>Specs</th>
<th>Mounting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MAX SPEED</td>
<td>Easily unmounted from the vehicle steering wheel without losing calibration.</td>
</tr>
<tr>
<td></td>
<td>1000º/sec @ 12 V</td>
<td>*Adapters available to fit any size wheel</td>
</tr>
<tr>
<td></td>
<td>2000º/sec @ 24 V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TORQUE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60 N.m. max @ 500º/sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15 N.m. continuous 1000º/sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CURRENT DRAW</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 Amp mean</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60 Amp peak</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SUPPLY VOLTAGE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9–36 V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>WEIGHT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.6 kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(19 lb)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>WHEEL DIAMETER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>365–415 mm (14.4–16.3 in)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>*Adapters available to fit any size wheel</td>
<td></td>
</tr>
</tbody>
</table>
**Actuation Assembly**

**Function**

- **Actuator Boards** each control an individual actuator: throttle, brake, automatic transmission, redundant brake. Typically sits on the floor in front passenger or back seat.

- **Bell Crank Assembly** allows remote location actuation and simple variable length calibration. Easily adapts to different vehicle types.

- **Shifting Assembly** can be configured for rotary shifter, steering column shifter, or console shifter. Each is adjustable based on software and hardware configurations.

**Specs**

<table>
<thead>
<tr>
<th></th>
<th>WEIGHT</th>
<th>STROKE</th>
<th>SPEED</th>
<th>FORCE</th>
<th>CURRENT DRAW (AT FULL LOCK)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>THROTTLE ACTUATOR</strong></td>
<td>1.1 kg</td>
<td>7.6 cm</td>
<td>7.6 cm/sec</td>
<td>13.6 kg</td>
<td>18 Amp (stall)</td>
</tr>
<tr>
<td></td>
<td>(2.5 lb)</td>
<td>(3 in)</td>
<td>(3 in/sec)</td>
<td>(30 lb)</td>
<td></td>
</tr>
<tr>
<td><strong>TRANSMISSION ACTUATOR</strong></td>
<td>1.1 kg</td>
<td>7.6 cm</td>
<td>7.6 cm/sec</td>
<td>13.6 kg</td>
<td>18 Amp (stall)</td>
</tr>
<tr>
<td></td>
<td>(2.5 lb)</td>
<td>(3 in)</td>
<td>(3 in/sec)</td>
<td>(30 lb)</td>
<td></td>
</tr>
<tr>
<td><strong>BRAKE ACTUATOR</strong></td>
<td>1.8 kg</td>
<td>10.2 cm</td>
<td>17 cm/sec</td>
<td>225 kg</td>
<td>26.8 Amp (stall)</td>
</tr>
<tr>
<td></td>
<td>(4 lb)</td>
<td>(4 in)</td>
<td>(6.7 in/sec)</td>
<td>(500 lb)</td>
<td></td>
</tr>
<tr>
<td><strong>REDUNDANT BRAKE ACTUATOR</strong></td>
<td>1.4 kg</td>
<td>5.1 cm</td>
<td>0.5 cm/sec</td>
<td>275 kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3 lb)</td>
<td>(2 in)</td>
<td>(0.2 in/sec)</td>
<td>(600 lb)</td>
<td></td>
</tr>
<tr>
<td><strong>CONTROL BOARD</strong></td>
<td>1.4 kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3 lb)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BELL CRANK</strong></td>
<td>9.1 kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(20 lb)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SHIFTER</strong></td>
<td>0.2–2.3 kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.5–5 lb)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Universal roof unit can be applied to most vehicles through bracket clips or suction cup mounts. The roof rack can be customized to fit a variety of components such as radio, GPS, camera, beacon lights, sirens, and others.

## Positioning

**POSITIONING**
- GPS, GLONASS, & RTK
- 220 channels
- 1PPS (pulse per sec) output
- L1/L2/L2C signal support
- CAN 2.0B & RS-232 support

## Comms

**HIGH FREQUENCY RADIO**
- Fixed Outdoor Wireless
- 2.4GHz Frequency
- 100Mbps Bandwidth
- Point to Multi-point

Various frequencies available depending on your network needs.

## Camera

Network Camera
105º degree view
The Rajant BreadCrumb ME4 node is a rugged, wireless device that forms a mesh network when used with other BreadCrumb systems and is reliable in extreme weather conditions. The BreadCrumb ME4 also exceeds both wireless data-transfer and security standards.

**Recommended Radio**

**Model:** ME4—2450R; ME4 with (1) 2.4GHz, 2x2 MIMO, 300 Mbps and (1) 5Ghz, 2x2 MIMO, 300 Mbps transceivers.

### Wireless Specs

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Throughput</th>
<th>Max Physical Layer Data Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2.4GHz</strong></td>
<td><strong>54Mbps</strong></td>
<td><strong>300Mbps</strong></td>
</tr>
<tr>
<td><strong>5GHz</strong></td>
<td>N/A</td>
<td><strong>300Mbps</strong></td>
</tr>
</tbody>
</table>

**Max RF Transmit Power**: 29 dBm ± 2 dB

### Security Specs

Multiple cryptographic options, including NSA Suite algorithms (implementation not certified).

Separately configurable data and MAC address encryption via AES256-GCM, AES192-GCM, AES128-GCM, AES256-CTR, AES192-CTR, AES128-CTR, XSalsa20, XSalsa20/12, and XSalsa20/8.

Configurable per-hop, per-packet authentication between BreadCrumbs via AES256-GMAC, AES192-GMAC, AES128-GMAC, HMAC-SHA512, HMAC-SHA384, HMAC-SHA256, HMAC-SHA224, and HMAC-SHA1.

Supports IEEE 802.11i: AES-CCMP and TKIP encryption; WPA-Personal/Enterprise; WPA2-Personal/Enterprise, 802.1x: 64/128-bit WEP. Access Control Lists; Compatible with Layer-2 and Layer-3 client/server and peer-to-peer security solutions; Compatible with Harris SecNet 54 encryption.

### Physical Specs

**Startup Temperature**: 0° C to 80° C (32 F to 176 F)

**Operating Temperature**: -20° C to 80° C (-4 F to 176 F)

**Storage Temperature**: -40° C to 80° C (-40 F to 176 F)

**Enclosure**: Designed for IP67 (6: Dust-tight, 7: waterproof)

**Certification**: FCC Part 15 (USA)

ICES-003 and Rss-210 (Canada)

CE mark (European Economic Area, Switzerland and Turkey)
The Trimble BX982 is a sensible and durable GPS unit that meets ASI’s utility and convenience standards and is the only GPS unit that ASI recommends. Key features include:

- Two 220 channel Maxwell 6 chips for multi-constellation GNSS support.
- Dual antenna inputs for precise heading calculation
- Centimeter level position accuracy
- Convenience of Ethernet connectivity

### Technical Specs
Position antenna based on 220 Channel Maxwell 6 chip:
- Navigation outputs – ASCII: NMEA-0183 GSV, AVR, HDT, GGA, GSA, VTG, GST
- BeiDou: B1, B2
- SBAS: Simul. L1 C/A, L5
- RS232 ports (x3)

### Environmental Specs
Operating Temp: -40° C to 70° C (-40° F to 158° F)
Storage Temp: -55° C to 85° C (-67° F to 185° F)
Vibration: MIL810F, tailored; Random 6.2 gRMS operating; Random 8 gRMS survival
Mechanical Shock: MEL810D; +/- 40 g operating; +/- 75 g survival
IP Rating: IP67 (6: Dust-tight, 7: waterproof)

### Performance Specs
Velocity Accuracy, Horizontal: 0.007 m/sec
Acceleration: 11g

### Positioning Specs
RTK (<50km): Accuracy = 0.015 m + 1 ppm Vertical
About ASI

Our Mission

“To help organizations reach their potential through innovative robotic solutions.”

Autonomous Solutions, Inc. is a world leader in vendor independent vehicle automation systems. From our headquarters and 100 acre proving ground in northern Utah (below), we serve clients in the mining, agriculture, automotive, government, and manufacturing industries with remote control, teleoperation, and fully automated solutions.

ASI's vehicle automation products can be found in companies and government agencies throughout the world, including: CNH Industrial, SHARP, Anglo American, Rio Tinto, Ford Motor Company, Fiat Chrysler Automobiles, Luke Air Force Base, and the Los Angeles Police Department.

Recent Awards

2015
Inc. 5000 list
An annual ranking of the fastest-growing private companies in America

2017, 2016, 2015, & 2014
Robotics Business Review 50
A list of the 50 most influential public and private companies in the global robotics industry.

2013
Automotive Testing Technology International
“Hardware Innovation of the Year” shared with Ford Motor company for our robotic durability testing program.

15+ Patents

15+ patents have been awarded to ASI over nearly two decades of industry leadership including patents covering key features of our proving ground automation suite:

Robotic Path Planning
Robotic Command & Control
**Sales & Support**

**Sales Staff**
Contact our sales staff for quotes, to schedule a demo, or for any additional information.

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**Installation & Training**
ASI offers initial installation and training to get your equipment up and running.

**Support**
Our dedicated and knowledgeable support staff are here to help.

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