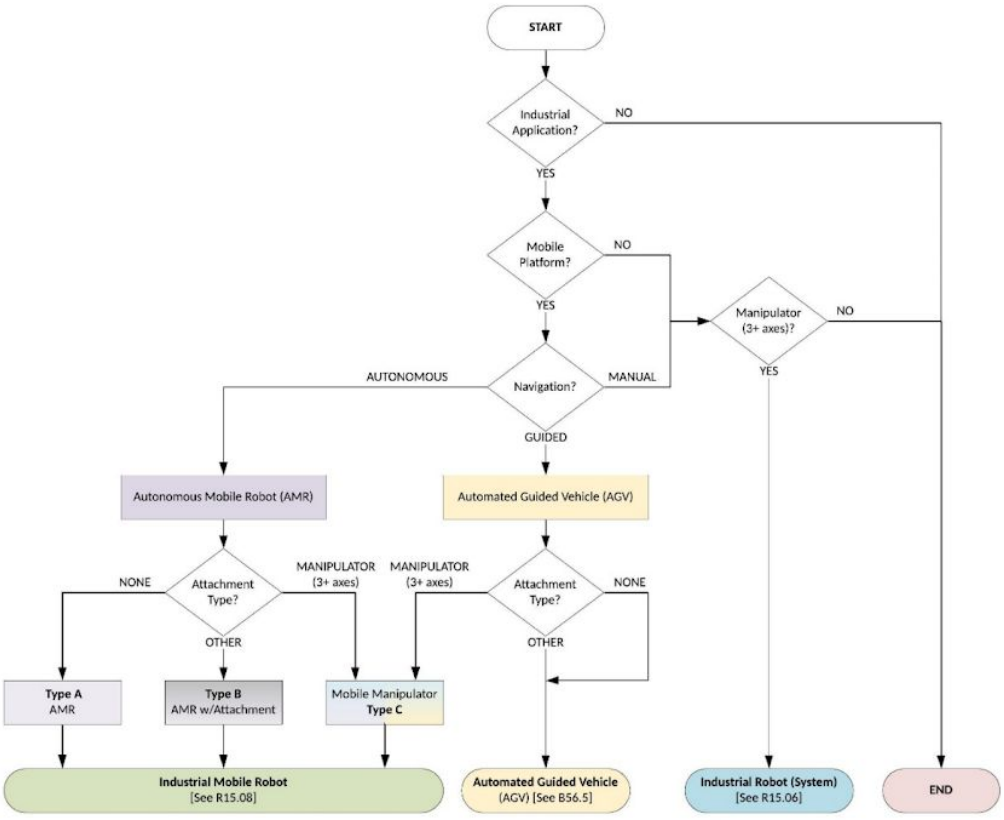
Q from Ross: Charlie...I just received an industry inquiry on OSHA regs as it relates to the Burro. We discussed this last summer and you believed no reg/law was directly applicable. Latest news/thinking? Thanks!

In short:

1. No OSHA regulation currently applies directly to Burro or vehicles like it in agriculture
2. Safety is a top priority; we ensure that we are following ANSI and ISO standards (where applicable) applied to similar machines (autonomous guided vehicles) in indoor spaces.
3. A new ANSI standard due for publication in 2020 directly covers vehicles like Burro; we will be compliant and are also on the standard-writing committee.

In long:

1. There are two standards for mobile robots that exist today; a third standard will soon be published that keeps up with the rapidly evolving technology. Note that standards sometimes form the basis for regulation.[1]
    a. ANSI/ITSDF B56.5-2019 B56.5:
        i. This standard defines the safety requirements relating to the elements of design, operation, and maintenance of powered mobile vehicles (manned or automated). It is not necessarily applicable for Burros, although we have taken steps to comply.
    b. Beyond B56.5, there are two standards that apply depending on the type of mobile robots:
        i. Automatic Guided Vehicles (AGV) - follow tape in warehouses (not what Burro is)
            1. ANSI/RIA R15.06-2012: American National Standard for Industrial Robots and Robot Systems- Safety Requirements (revision of ANSI/RIA R15.06-1999) applies to these machines.[2] Not directly applicable to Burro.
        ii. Autonomous Mobile Robots (AMR) - navigate autonomously, performing tasks like path planning and obstacle handling (what Burro is)
            1. ANSI/RIA ANSI standard (R15.08, Preview) covers these and will come out in 2020.[3] **Burro is at launch, a Type-A AMR (chart below)[4]**



[1] https://mobilerobotguide.com/wp-content/uploads/2019/06/AMR-Regulatory_June14.pdf
[2] https://mobilerobotguide.com/2019/06/14/regulatory-issues-affecting-autonomous-mobile-robots/
[3] https://www.safetyandhealthmagazine.com/articles/16866-industrial-standards-for-robotic-machinery
[4] https://www.robotics.org/userAssets/riaUploads/file/AMR19_Michael_Gerstenberger.pdf - page 16 and 17

c. **OSHA has no explicit standard covering AMRs** and instead refers to the ANSI/RIA standard.

2. With framework above, Burro Commercial Gen 1 complies with relevant portions of B56.5 2019 (which is not written for off road vehicles but rather for warehouse trucks, but still illustrates best practices), and with the published portions of R15.08 (which is not fully published yet). In short, we are embracing a number of redundancies to ensure a safe self-driving system, and continuously assessing our performance to ensure it meets standards. Specifically:
    a. The commercial robots we are building for Spring delivery have:
        i. Six cameras on either side of the vehicle providing wide field-of-view coverage.
        ii. Visual and audio indicators to alert bystanders to imminent and current vehicle motion.
        iii. Clear and simple button interface, including Emergency stop buttons on both ends of the robot so that it can be stopped from either side.
        iv. Full robot-width bumper bars as a fail-safe last resort, which trigger the robot to stop if depressed, are mounted approximately 1.5 feet ahead of the wheels to keep obstacles out of harm's way, and if triggered, these must be cleared by an operator manually before operation can resume.
    b. Our autonomy software suite detects objects in real time and categorizes them as **traversable** and **non-traversable**:
        i. We use a trained AI algorithm to recognize traversable ground on which the robot is free to operate. We are therefore able to account for standard traversable terrain (grass, gravel, weeds, tarmac etc.) that the robot may frequently encounter, while simultaneously ensuring the robot always stops for obstruction.
        ii. We have a second perception layer that can explicitly detect and categorize objects for the purposes of safety.
    c. Finally, the robot travels at most at 4.5MPH when following people, and typically at 1.8-2 miles per hour (about 1 meter/second). In the presence of non-traversable obstacles ahead of it, it slows to around 0.5 meter/second. At these speeds, the robot has ample time to react to/stop for obstacles that appear, barring the scenario when someone deliberately jumps in front of the robot at which point he/she will hit the bumper bars triggering a stop.

    The scenario we have to avoid is making contact with anything and we are building a system that behaves accordingly.