***California Polytechnic, Pomona***

**Self Driving Tour Vehicle**

*System Requirements Specification*

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# 1.0 Scope and System Definition

The scope of this project is to develop a driverless vehicle that shall provide transportation of passengers throughout the Cal Poly Pomona campus. The intended user audience are those individuals who are visiting the campus and likely for the first time. The vehicle shall provide transpiration for these induvial from a given origination to any one or more destinations. The scope of this project is to develop a vehicle that combines commercial off the shelf (COTS) equipment and as needed custom design mechanical and electrical hardware and low and high level software. This project will involve professors and students from various departments and colleges such as the College of Engineering and the College of Science. The scope of this document is to capture a set of preliminary top system level requirements with a one tier level of dependency requirements.

The Document is composed as follows:

1. Scope
2. Requirements
   1. System
   2. Mechanical
   3. Electrical
   4. Embedded Sensor Software
   5. Autonomous Behavior Software
   6. User Interface Management
   7. Safety
3. Testing and Development
   1. Facilities
   2. Location
   3. System and Subsystem
   4. Environment

# 2.0 Requirements

## **2.1 System Requirements**

The system requirements provide traceability from the subsystem requirements while also providing an overall integration between the various design entities. The system includes the vehicle subsystems as well as the use case parameters.

* + 1. The system shall provide an interface for the average user to interact with the Golf cart and access all of its available functionalities, such as selecting a destination from any origin on the Cal Poly Pomona Campus.
    2. The system shall provide an interface for the operator to observe, diagnose and remotely control the vehicle during its execution.
    3. The system shall develop routes from the origin selected destination for the vehicle to travel.
    4. The vehicle shall perform its operations in an autonomous manner with a few exceptions, such as emergency override.
    5. The vehicle shall transport one or more passengers without the necessity of any driver interaction to travel on selected routes.
    6. The vehicle shall have three modes of operation: Autonomous, Semi-Autonomous, Emergency manual, Service mode
    7. The vehicle shall support operator control / override in an emergency manual mode or semi-autonomous mode and then resume autonomous mode.
    8. The vehicle shall provide a service mode where no autonomous functions are enabled.
    9. The vehicle routes shall be on campus sidewalks.
    10. The system shall avoid all obstacles that would impede transport.
    11. The vehicle shall detect stationary obstacles to avoid.
    12. The vehicle shall avoid moving obstacles within a range of tbd speed limit and within a range of *tbd* meters that would potentially impede transport.
    13. The vehicle shall use multiple sensors types that are unrelated in data acquisition method to detect obstacles.
    14. The obstacle size shall be no larger than *tbd*.
    15. The vehicle shall stop in a manner safe for the passengers.
    16. The vehicle routes shall not contain routes that exist on public standard streets other than being limited to crosswalks.
    17. The vehicle shall detect if the route is?
    18. In the event of a route block preventing the intended route to be completed, the vehicle must reroute using forward direction with the exception of moving in reverse to reroute.
    19. The vehicle shall not exceed *tbd* MPH.
    20. The vehicle shall be a COTS battery powered type “Golf Cart”.
    21. The processing of the vehicle shall be on board.
    22. The primary processing unit(s) shall be on COTS level hardware.
    23. The vehicle shall have knowledge of its location and orientation at all times.
    24. That vehicle shall transport at least one or more passengers.
    25. The user interface shall be readable in daylight (daylight readable) and night readable
    26. The vehicle shall provide a service mode to observe internal state data for testing and analysis
    27. The vehicle shall operate in moisture prone environments
    28. The vehicle shall withstand storage in moisture (condensing) environments.
    29. The vehicle shall operate in temperatures up to 50 degrees C.
    30. The vehicle shall withstand storage in temperatures up to 65 degrees C.

## **Mechanical System Requirements**

*(The following mechanical requirements are mechanical top level derived 1st tier)*

* + 1. The mechanical system shall enable the vehicle to autonomously control the steering.
    2. The mechanical system shall enable the vehicle to stop (brake) autonomously.
    3. The mechanical system shall support forward and reverse motion autonomously.
    4. The mechanical system shall provide full steering control to the user as required by operation mode.
    5. The mechanical system shall provide full braking control to the user as required by operation mode.
    6. The mechanical system shall provide full acceleration control to the user as required by operation mode.
    7. The mechanical system shall provide mounts for all sensors that do not impede motion, but are easily removable
    8. The mechanical system shall provide mounts for user interfaces per passenger that are easily removable.
    9. The mechanical system shall provide moisture resistant enclosures for all added electronic assemblies to those that do not already provide sufficient enclosure.
    10. The mechanical system shall provide any cooling necessary to maintain operational requirements.

## **Electrical System Requirements**

*(The following electrical requirements are top level derived 1st tier)*

* + 1. The electrical system shall enable the vehicle to autonomously control the steering.
    2. The electrical system shall enable the vehicle to stop (brake) autonomously.
    3. The electrical system shall support forward and reverse motion autonomously.
    4. The electrical system shall provide interface for full steering control to the user as required by operation mode.
    5. The electrical system shall provide interface between the user full braking control to the user as required by operation mode.
    6. The electrical system shall provide full acceleration control to the user as required by operation mode.
    7. The electrical system shall provide redundancy for related types of sensors to capture vehicle internal state awareness.
    8. The electrical system shall provide redundancy for unrelated types of sensors to capture vehicle internal state awareness.
    9. The electrical system shall provide redundancy for related types of sensors to capture vehicle situational awareness.
    10. The electrical system shall provide redundancy for unrelated types of sensors to capture vehicle situational awareness.
    11. The electrical system shall interface to *a majority* of the existing vehicle.
    12. The electrical system shall provide all step down power for onboard processing and sensors.
    13. The electrical system shall support an operational time of tbd hours.
    14. The electrical system shall support a standby time of tbd hours.
    15. The electrical system shall provide filtering from transient power on each regulated supply with a RMS ripple of *tbd%*  per supply
    16. The electrical system shall provide a 20% derating of required power draw of max measured/calculated consumption.
    17. The electrical system shall interface all processing using modular COTS physical bus(es) structure(s).
    18. The electrical system shall provide physical layer bus interfaces not subject to transient response
    19. The electrical system shall provide physical layer bus interfaces not subject to DC noise
    20. The electrical system shall adhere to all system environmental requirements.

## Embedded Software System Requirements

*(The following embedded software requirements are top level derived 1st tier)*

* + 1. The embedded software system shall enable the vehicle to autonomously control the steering.
    2. The embedded software system shall enable the vehicle to stop (brake) autonomously.
    3. The embedded software system shall support forward and reverse motion autonomously.
    4. The embedded software system shall provide interface for full steering control to the user as required by operation mode.
    5. The embedded software system shall provide interface between the user full braking control to the user as required by operation mode.
    6. The embedded software system shall provide full acceleration control to the user as required by operation mode.
    7. The embedded software system shall provide data fusion from all sensors that capture vehicle internal state awareness.
    8. The embedded software shall provide internal sensor data for autonomous processing
    9. The embedded software shall provide real-time support with a deterministic response time of *tbd* ms *(ISR – maybe RTOS)*
    10. The embedded software system shall interface to the behavior software for user interface processing.
    11. The embedded software system shall provide an open transport layer protocol structure.
    12. The embedded software will ensure a command velocity from the behavior software with an initial overshoot less than 15%
    13. The embedded software will ensure a command velocity from the behavior software with a steady state ripple no greater than 2%
    14. The embedded software will ensure a steering rate from the behavior software with an error *2*%
    15. The embedded software shall accelerate/decelerate within a 2% error of the commanded value from the behavior software.

## **Autonomous Behavior Software System Requirements**

*(The following embedded software requirements are top level derived 1st tier)*

* + 1. The behavior software system shall perform autonomous control the steering.
    2. The behavior software system shall perform autonomous vehicle to stopping (braking).
    3. The behavior software system shall perform autonomous vehicle attitude / direction control.
    4. The behavior software system shall provide support for full steering control to the user as required by operation mode.
    5. The behavior software system shall provide interface between the user full braking control to the user as required by operation mode.
    6. The behavior software system shall provide full acceleration control to the user as required by operation mode.
    7. The behavior software system shall provide data fusion from all sensors that capture vehicle internal state awareness.
    8. The behavior software shall receive internal sensor data for autonomous processing
    9. The behavior software shall perform sensor fusion from all sensors that capture vehicle situational sensor data for autonomous processing.
    10. The behavior software shall provide real-time support with a deterministic response time of *tbd* ms *(RTOS)*
    11. The behavior software system shall interface to the user interface for processing.
    12. The behavior software system shall provide an open transport layer protocol structure.
    13. The behavior software system shall implement the route/reroute planning.
    14. The behavior software system shall implement the points of interest (POI) way-points into the route planning.
    15. The behavior software system shall implement the modes of operation.
    16. The behavior software system shall issue emergency behavior for sudden stops.
    17. The behavior software system shall be simulated prior to deployment using near similar target processing with the development environment.
    18. The behavior software system shall maintain its location along the route calculated.
    19. The behavior software system shall calculate the acceleration and deceleration command data to the embedded system.

## **User Interface Software System Requirements**

*(The following embedded software requirements are top level derived 1st tier)*

* + 1. The user interface software system shall enable autonomous control the steering.
    2. The user interface software system shall indicate autonomous vehicle to stopping (braking).
    3. The user interface software system shall support autonomous vehicle attitude / direction control.
    4. The user interface software system shall instruct support for full steering control to the user as required by operation mode.
    5. The user interface software system shall instruct interface between the user full braking control to the user as required by operation mode.
    6. The user interface software system shall support provide full acceleration control to the user as required by operation mode.
    7. The user interface software system shall display data fusion from all sensors that capture vehicle internal state awareness during service operation.
    8. The user interface software system shall display data fusion from all sensors that capture vehicle situational awareness during service operation
    9. The user interface software system shall interface provide operational control for the user.
    10. The user interface software system shall provide an open HMI display structure.
    11. The user interface software system shall request the points of interest (POI) way-points from the user(s).
    12. The user interface software system shall use moving mapping function during route travel indicating the current vehicle position.
    13. The user interface software system shall provide zoom in zoom out features of the map.
    14. The user interface software system shall display the route/reroute computed.
    15. The user interface software system shall provide POI information at the POI as the passengers’ travel.
    16. The user interface software system shall support all modes of operation.
    17. The user interface software system shall be simulated prior to deployment using near similar target processing with the development environment.
    18. The user interface software system shall support multiple modalities of user requests. *(visual, aural)*
    19. The user interface software system shall support multiple modalities of to instruct the user. *(visual, aural)*
    20. The user interface software system shall support multiple displays for user interaction.
    21. The user interface software system shall respond to environmental conditions to ensure sufficient display brightness.

Top Level System Architecture

*(in work – pending SRR)*

## Safety Requirements

*We will figure these out a bit later???*

# 3.0 Development and Testing Environment