ANALYTICAL REDUNDANCY OF ELECTRONIC SYSTEMS

A FAILURE DETERMINATION & COMPENSATION SYSTEM

GO SERVARE, Inc.

"Autonomous Command & Integrated Electronic Monitoring"

September 18, 2019

AGENDA

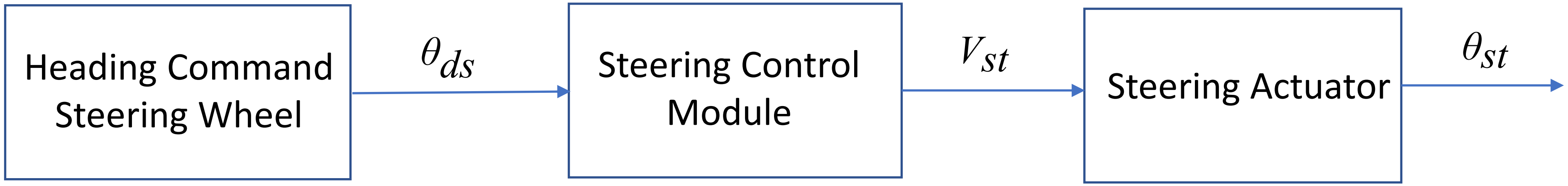
- Introduction
- The Technology
- Application to Demonstration Vehicle
- Vehicle Demonstration
- Patent Position
- Next Steps

Introduction

Autonomous vehicles will require redundancy in their control mechanisms. This is a low cost analytical redundancy methodology that can be integrated into autonomous vehicle control systems. This system first monitors various vehicle control systems, identifying component or system failures, impending failures and time to failure. It then uses this information to warn the occupants of the failure while at the same time take action to compensate for the failure ensuring that a safe vehicle operating condition is maintained.

Example of Technology Applied to Steering System

First Look at a Basic Steer by Wire System



Wheels are pointed in a direction determined by the steering wheel
Output of steering actuator results in a steering angle that is is proportional to steering wheel angle

That is: $\theta_{ds} \propto \theta_{st}$

$$\theta_{ds} = K_a \theta_{st}$$

Where:

$\theta_{ds} =$ Desired steering angle

$V_{st} =$ Signal to steering actuator from steering control module

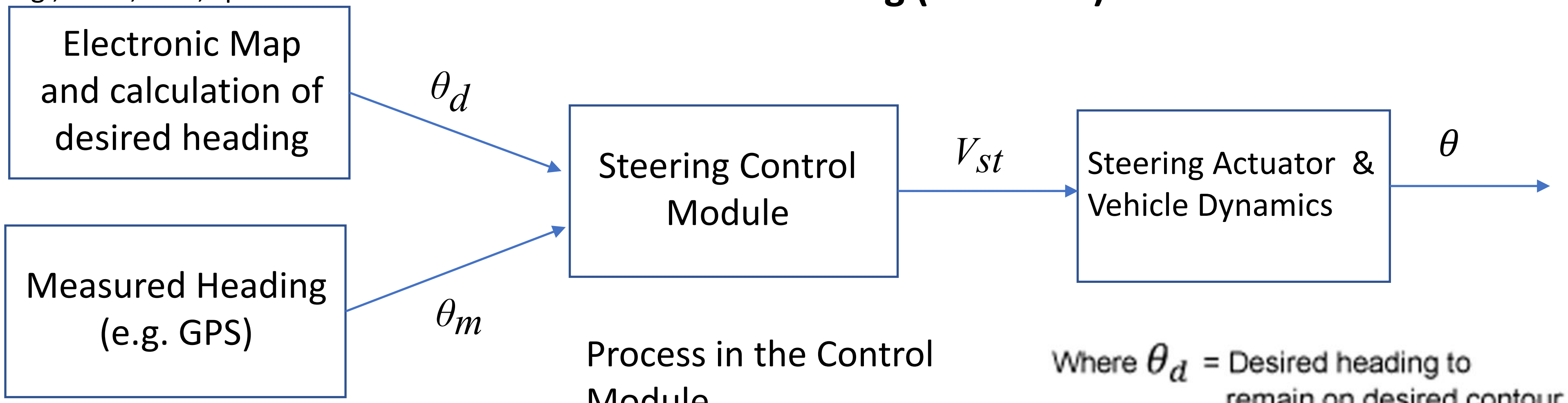
$\theta_{st} =$ Vehicle steering angle

$K_a =$ Steering actuator calibration

Steering Example With Possible Sensor Error/Failure

Should include other device, e.g., radar, lidar, speed sensor

Automatic Steering (no driver)



Process in the Control Module

$$\epsilon = \theta_d - \theta_m$$

$$V_{st} = K_p\,\epsilon + K_I \int \epsilon\, dt$$

Standard control theory

Where θ_d = Desired heading to remain on desired contour

θ_m = Measured heading

θ = Actual vehicle heading

V_{st} = Input signal to actuator

Steering Example

Looking at the potential failure of one element of the system – the Actual Heading determination device (GPS)

θ_m = *measured heading* Which may have an error

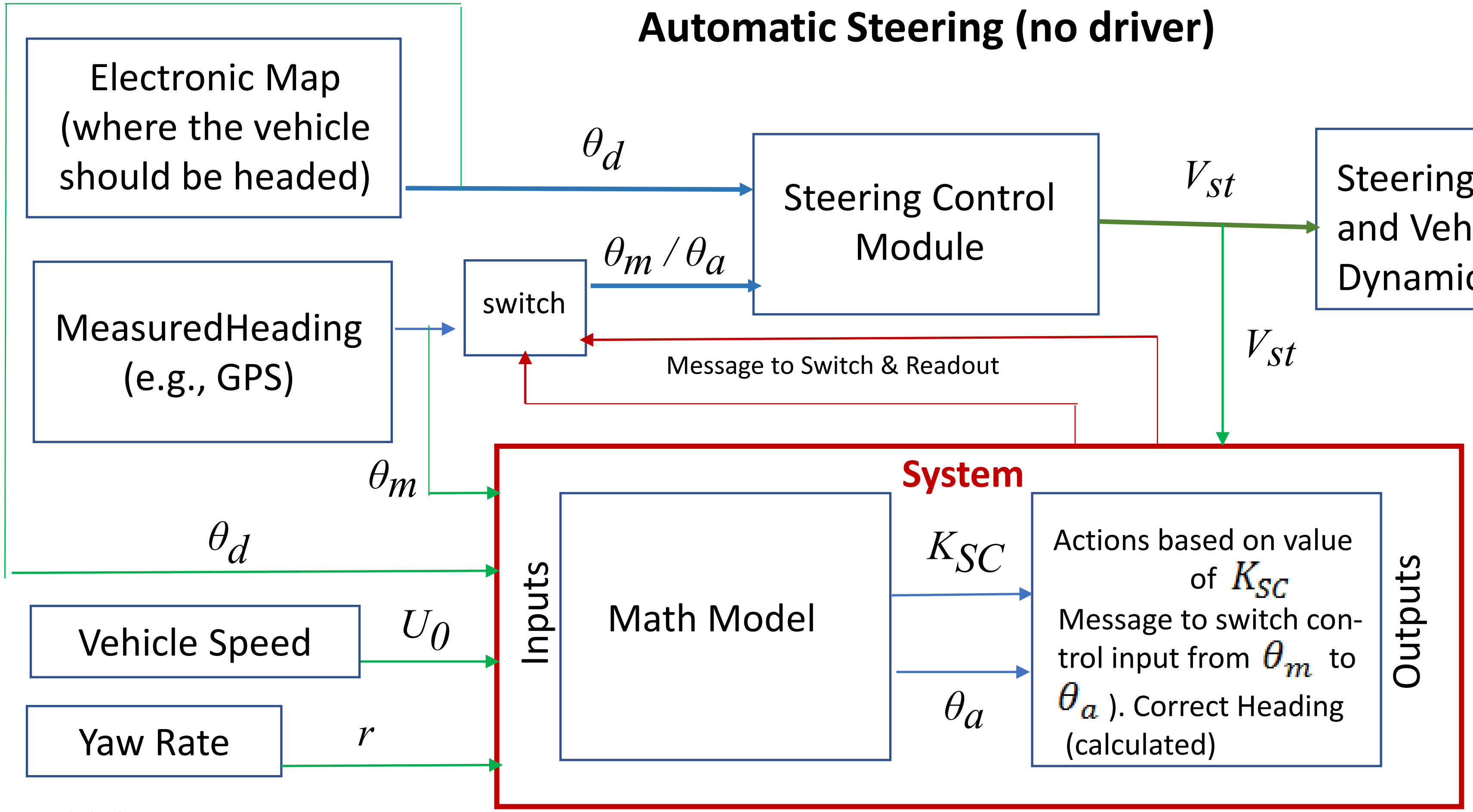
$\theta_m = K_s\,\theta$ Where: θ = *actual heading*

K_s Is the ratio of the measured heading to the actual heading

For the case where: $K_s = \frac{\theta_m}{\theta} = 1$ there is no error

The goal of this technology is to determine K_s in real time (the failure indicating mechanism) and to compensate for the error to give the correct θ_{st} (in this case to maintain the desired/safe heading).

Steering Example With Sensor Error



K_{SC} is time variable and will approach 1 as the system makes corrections

System Inputs (available on vehicle CAN bus) θ_d θ_m U_o r

System Outputs: Compensated heading display of error msg.

GO SERVARE, Inc.
"Autonomous Command & Integrated Electronic Monitoring"

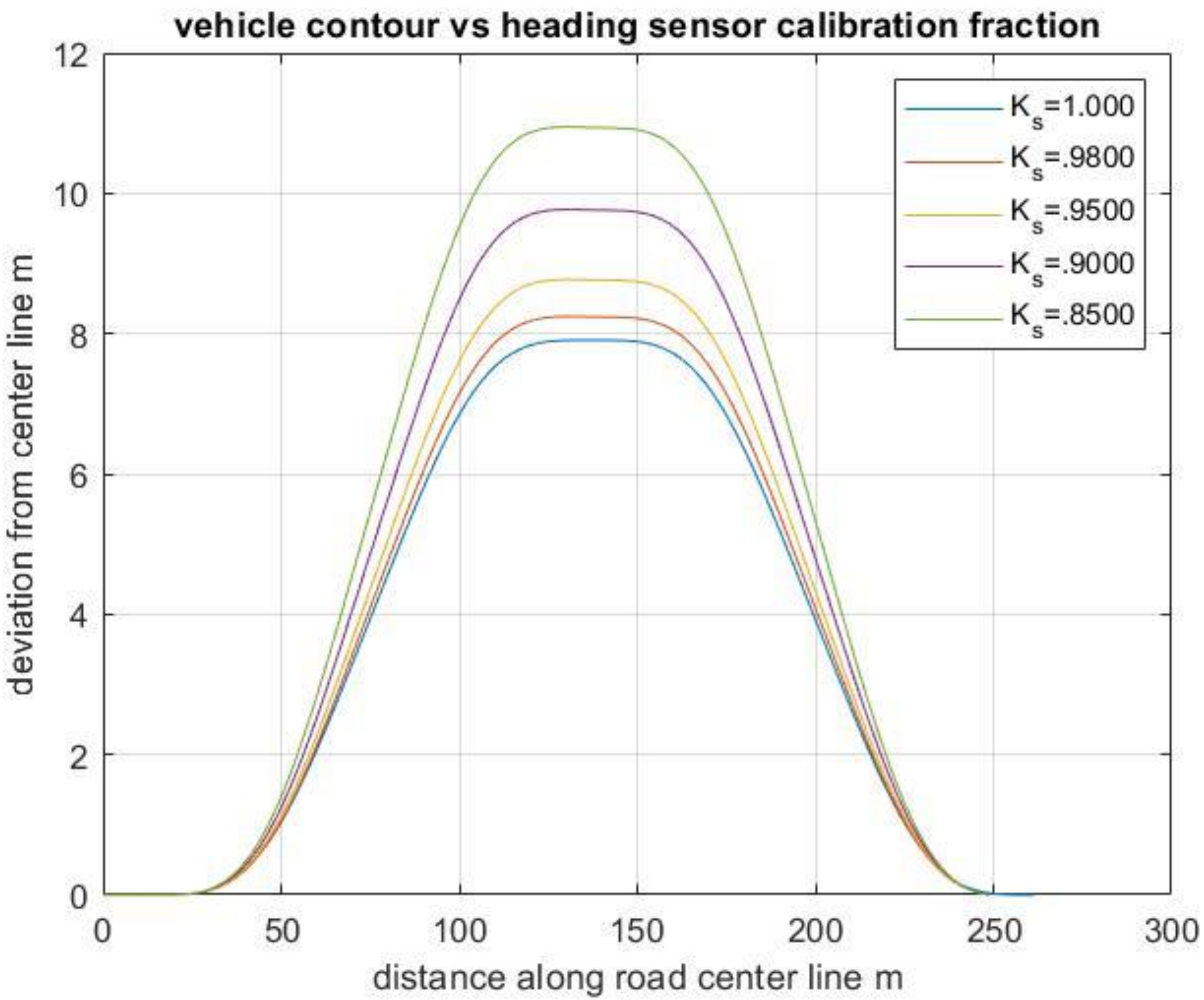
Steering Example Simulation

Demonstration

Lincoln MKZ at Mcity

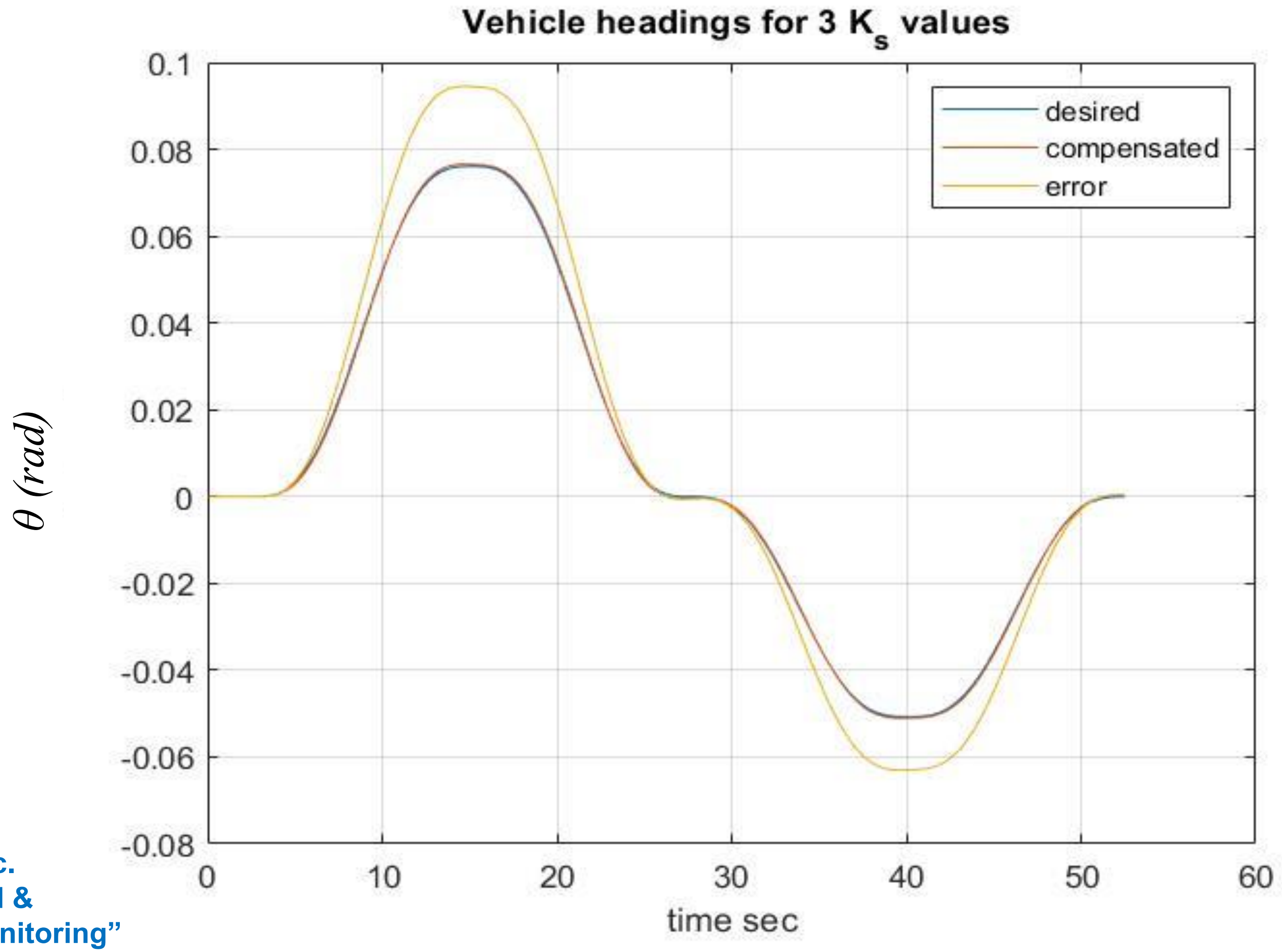
Note that when $K_S = 1$ there is No error and thus this is the path that the vehicle should be taking when there is no error in the system.

The values of $K_S \neq 1$ are simulated errors in the system which cause the vehicle to deviate from the proper path.



Steering Example With Sensor Error and Accurate Calculated Compensation of θ

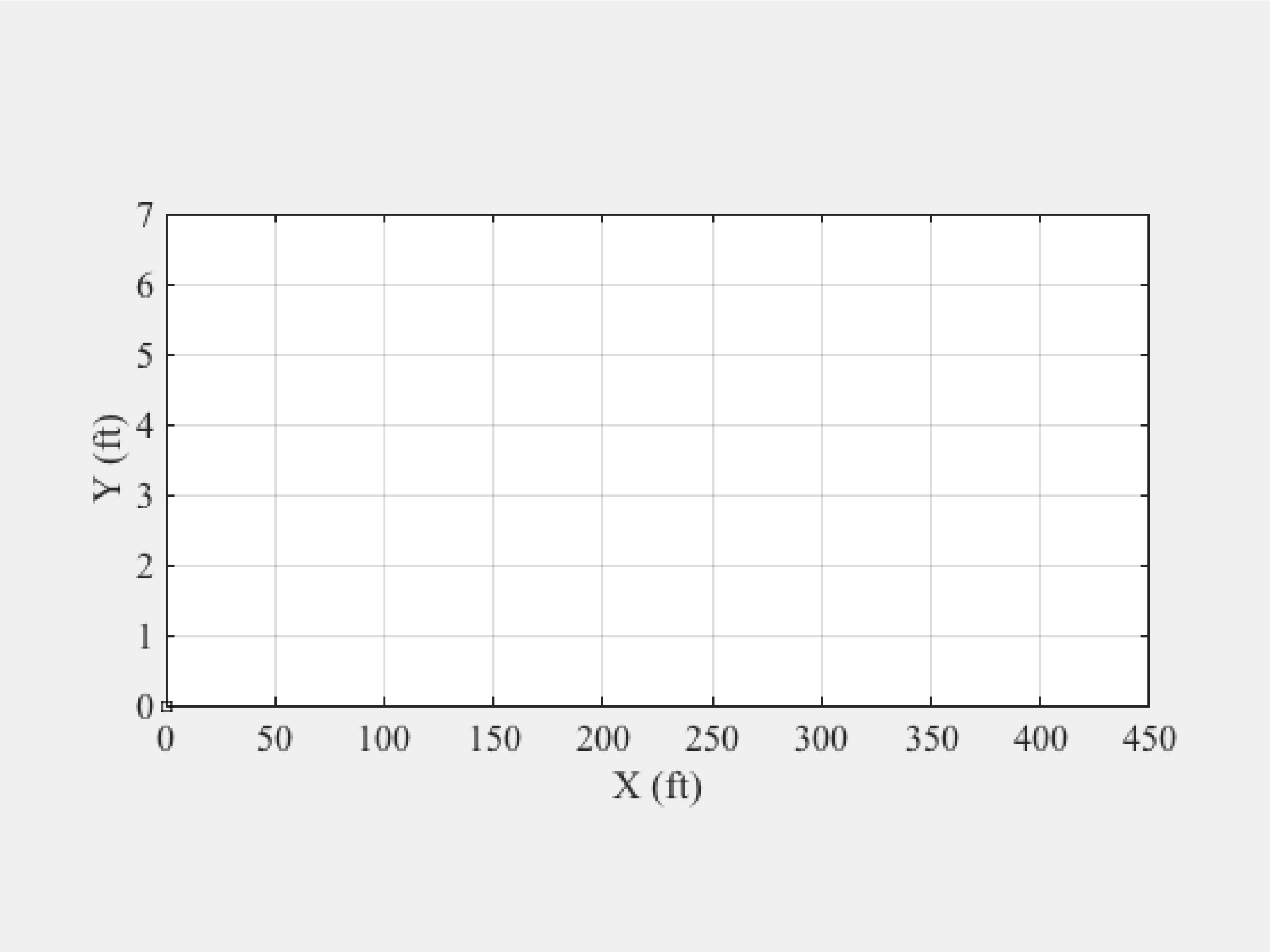
Demonstration



GO SERVARE, Inc.
“Autonomous Command &
Integrated Electronic Monitoring”

ACTUAL ANIMATION From Demonstration DATA

Lincoln MKZ at Mcity

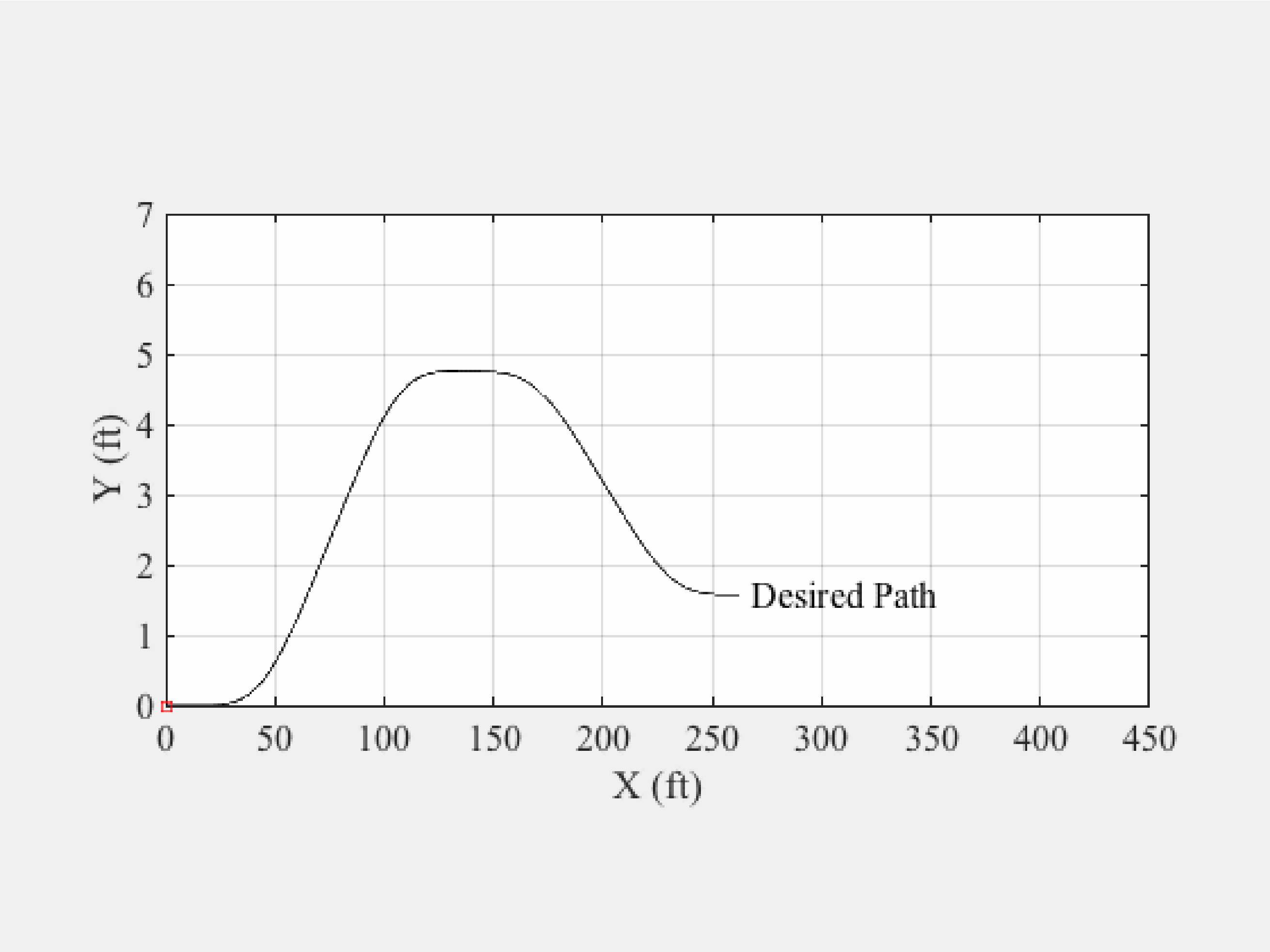


Vehicle desired Path
Perfect Sensor

GO SERVARE, Inc.
"Autonomous Command &
Integrated Electronic Monitoring"

ACTUAL ANIMATION From Demonstration DATA

Lincoln MKZ at Mcity

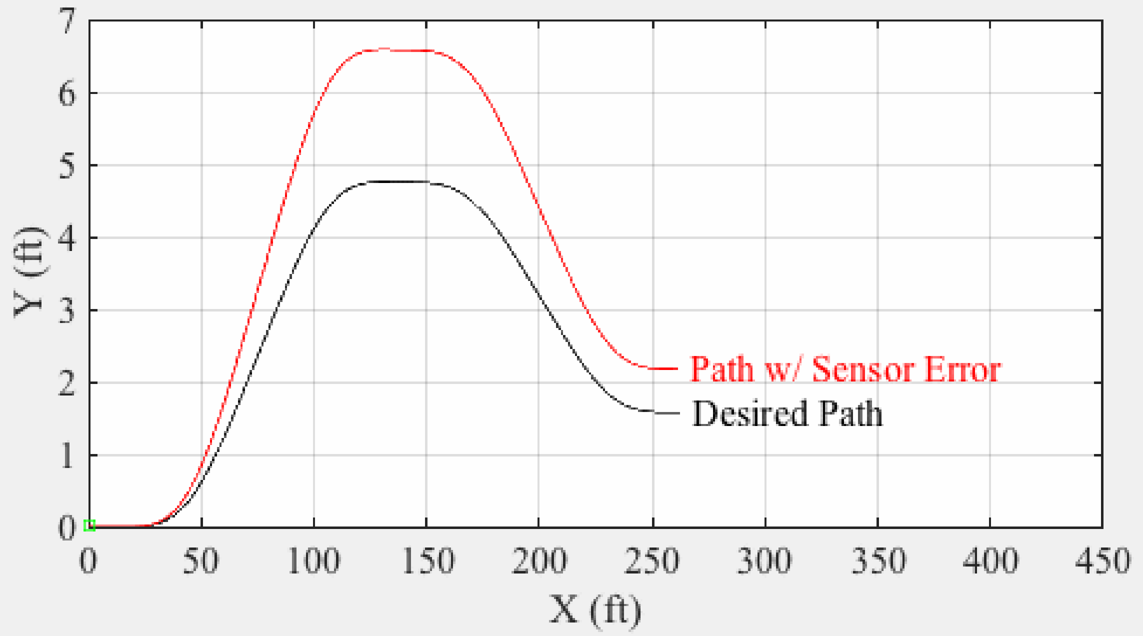


Vehicle desired Path
Perfect Sensor

Vehicle Path deviation with failed Sensor

ACTUAL ANIMATION From Demonstration DATA

Lincoln MKZ at Mcity



Vehicle desired Path Perfect Sensor

Vehicle Path deviation with failed Sensor

Vehicle Path with failed Sensor corrected by Go Servare

GO SERVARE, Inc.
"Autonomous Command & Integrated Electronic Monitoring"

Intellectual Property

1. **62/605,429 Autonomous Vehicle Failure Detection System, OTT File: 2018-332**
   The technology has demonstrated via simulation, that it can detect and uniquely identify failures in components or subsystems of vehicular electronic systems. This technology, which is euphemistically termed a Failure Detection System (FDS), clearly detects/identifies component/subsystem failures that are 1) complete/catastrophic failures, 2) intermittent failures and 3) failures resulting from the gradual degradation in the performance of a component.
   Filing: PCT, May 2018
   Inventor: William Ribbens

2. **62/602,876, Error Detection and Evaluation of Lidar/Radar Surveillance Systems for Vehicles, OTT File 2019-037**
   The invention provides a means of precisely and accurately determining such errors in LIDAR/RADAR surveillance systems for vehicles. The invention has the capability of early detection of errors and in the case of gradual degradation in accuracy of the LIDAR/RADAR.
   Filing: PCT, August 2018
   Inventor: William Ribbens

Thank You