ELEC 3224 — Introduction

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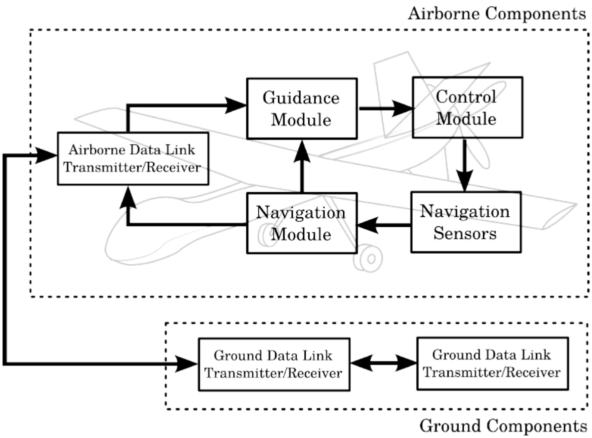
Introduction

- The objectives of this module are:
- Introduction of the concept of GNC (Guidance Navigation and Control).
- Analysis of subsystems and then overall system integration.
- The applications covered will not be confined to one sector as the general principles stretch over aerospace vehicles, including aircraft and UAVs (Unmanned Air Vehicles), autonomous ground vehicles, Autonomous surface vessels, AUVs (Autonomous Underwater vehicles).

Introduction

- This is a subject area where the 'current state of the art' is fast moving, driven by developments in senors and actuators, cheap and very powerful architecture for implementation and driven by ever increasing requirements.
- All of the current books have a research focus and so there is no recommended text. The notes will suffice.
- This module will be examined by an examination paper worth 100% of the marks.
- The exam paper will have a free choice of answer 3 questions out of 5, each of which carries equal marks.
- Next, a general introduction to (aspects of) the subject area is given.

Introduction — A General Schematic



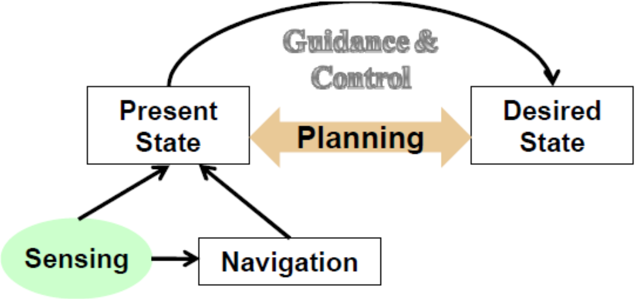
Introduction — focus on Autonomous Ground Vehicles (AGV)

- An autonomous ground vehicle is a vehicle that navigates and drives entirely on its own with no human driver and no remote control.
- Uses a variety of sensors to carry out the task it has been assigned.
- What is the mission of the autonomous vehicle?
- Farming, transportation, surveillance, etc.
- How does the vehicle accomplish the mission?

Introduction

- What is the Present State?
- By sensing (and hence sensors)
- What is the Desired State?
- By planning a route or path
- How does the vehicle get from the present state to the desired state?
- By use of a Guidance, Navigation & Control (GNC) System.

Introduction — GNC Schematic



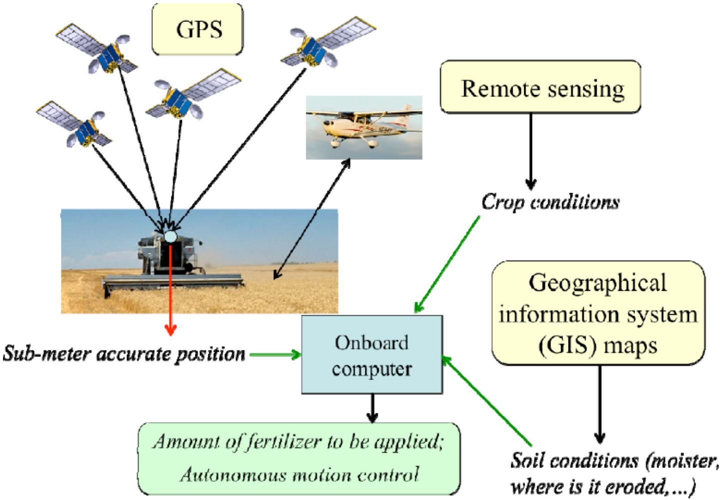
Introduction

- Guiding an intelligent vehicle requires global perception, local perception and vehicle control.
- **Global perception** — identifies the vehicle position relative to an available global map and the path the vehicle is to track.
- The vehicle **has to know** its position and direction wrt the real world and a series of positions to reach its destination.
- **Environmental dynamics** mean that a **global perception system alone** is **not enough** to maneuver the vehicle to move its destination.

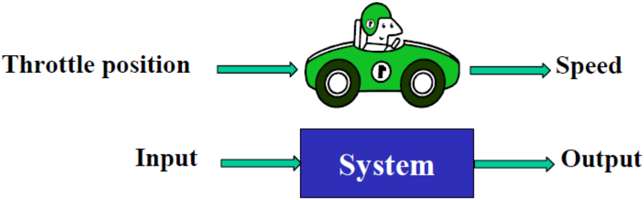
Introduction

- **Local perception** — real-time sensing system required to perceive the vehicles surroundings
- Obstacle avoidance — static and dynamic — requires localisation accuracy – higher to detect small objects and needs coherent image scanned data.
- **Vehicle control system** — integrates information from global and local perception systems and then determines an appropriate action from the vehicle.

Precision Agriculture Example



Open-loop Control



How much input is needed to get the desired output?

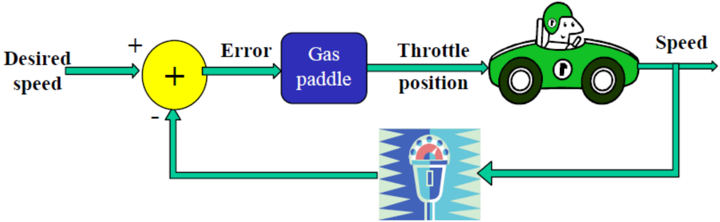
Input ⟷ **Output**

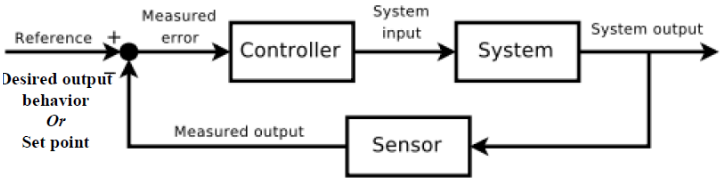
Calibration

Problems with open loop control:
Calibration results are invalid when environment/system changes

Slopes, vehicle mass, wind, tire pressure,
gas quality, road surface, engine wear, ...

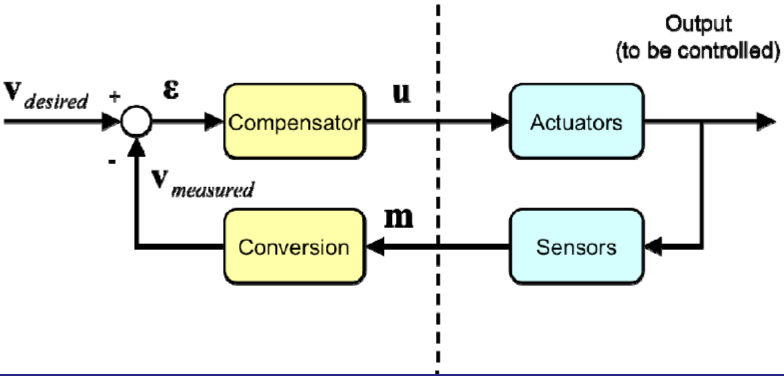
Closed-loop Control





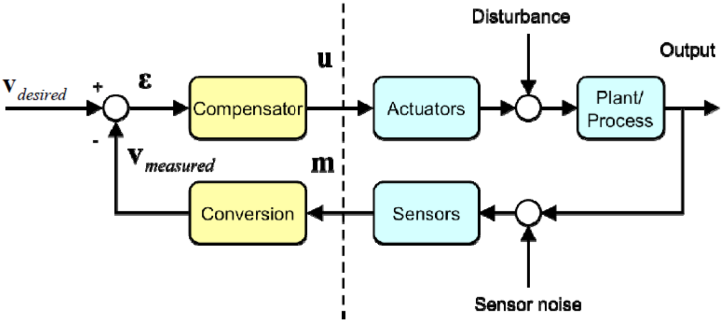
Closed-loop Control — 'Ideal' Case

In general



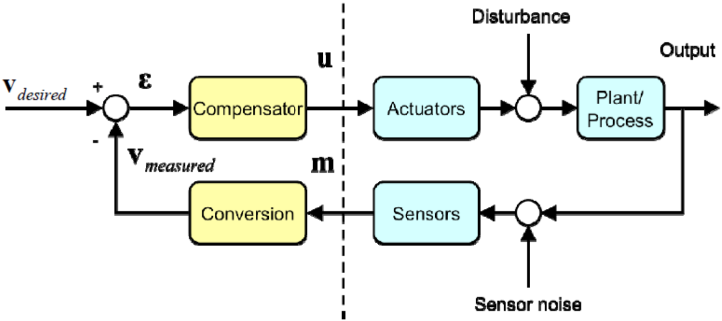
Closed-loop Control — 'Real' Case

However, in reality

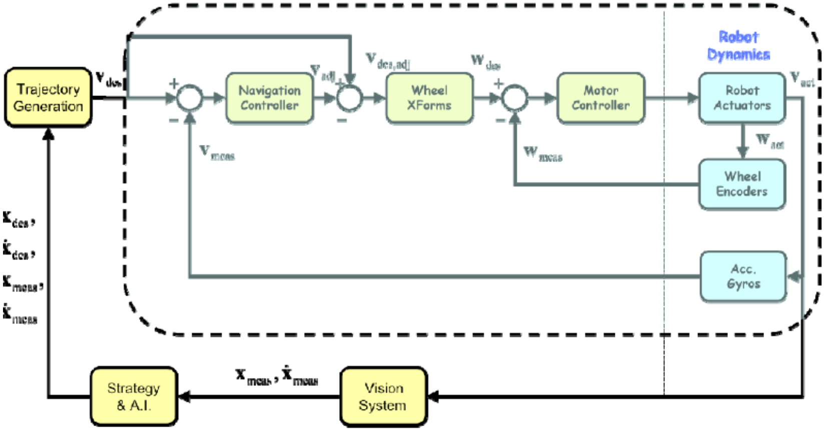


Closed-loop Control — 'Real' Case

However, in reality

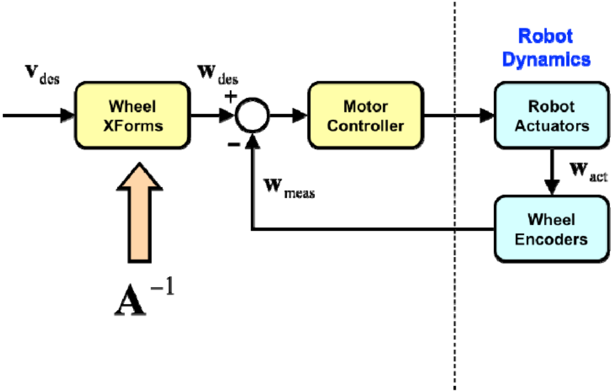


Autonomous Vehicle Navigation & Control Loop



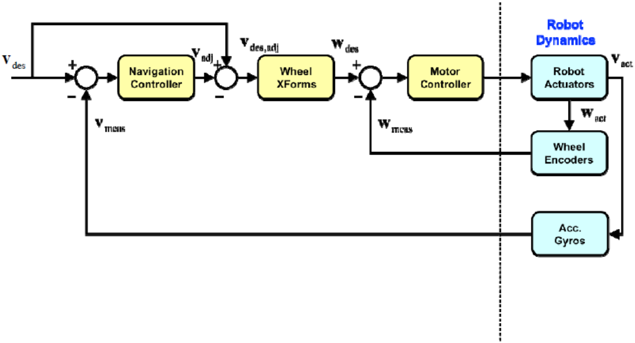
Note: x = position

Controller Inner Loop

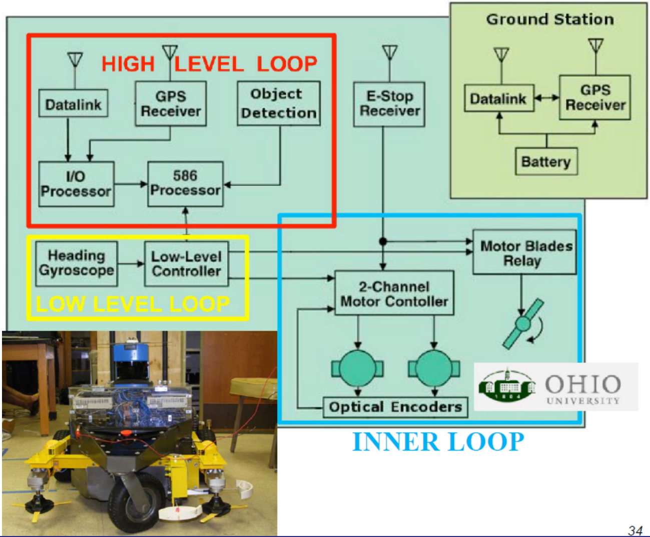


Note: A^{-1} = Transformation matrix from v to w

Controller Middle Loop



An overall design (Ohio State University)



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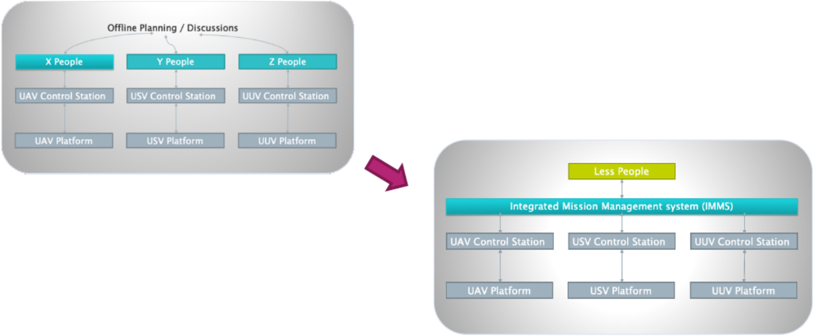
- How to go from large number of people running separate platforms to a more integrated system requiring less people e.g:



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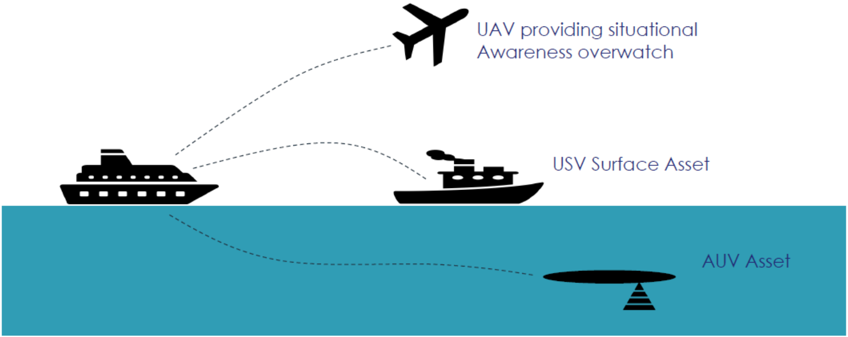
The Use Case / Scenario

- Conduct a seabed survey of a defined area (Goal)



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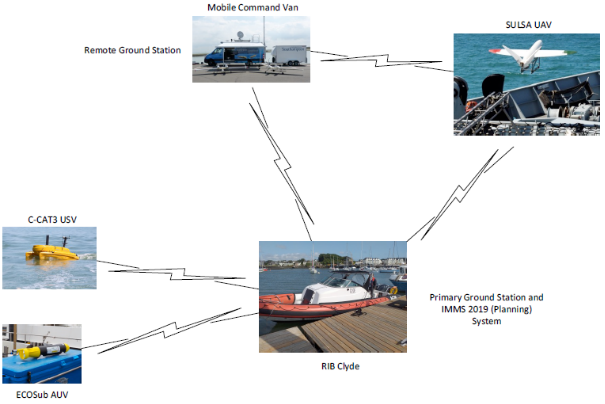
What does this involve?



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Trials

- Week 7th October 2019
- Turnchapel Wharf, Plymouth is base.
- Trials in Cawsand Bay. UAV based out of Hooe Lake Campsite
- Provisional Plan of Week:

DAY 1 Monday October 7th	AM PM	Travel from Southampton/Reading Initial Platform Setup and Briefing
DAY 2 Tuesday October 8th		Single Platform IMMS Trials
DAY 3 Wednesday October 9th		Mixed Platform IMMS Trials
DAY 4 Thursday October 10th		Integrated Platforms Demonstration
DAY 5 Friday October 11th	AM PM	Trials Review Meeting Travel back to Southampton/Reading