# Unmanned Aircraft Systems (drones)

AI 109

Richard Kelley

# Quiz Friday

- Look at https://richardkelley.io/AI109_slides/week-12/rlhf.pdf
- Know what a **base model** is.
- Know why a base model shouldn't be used by itself.
- Know the 3 steps used to create InstructGPT
  - **Supervised fine-tuning** (a kind of **imitation learning**)
  - **Reward modeling**
  - **Reinforcement learning from human feedback.**
- Be able to explain how ethical "preferences" can be embedded in an AI using the 3 steps of InstructGPT.

# Some Nomenclature for Today

- Terms that are mostly interchangeable:
  - Drone
    - Originally a term for an aircraft without a pilot, used for target practice.
  - UAV
    - Unmanned aerial vehicle
  - UAS
    - Unmanned aircraft system
- “Unmanned” vs. “uncrewed”
  - Tendency has been to move to the latter.
  - Some people care very much.

# It’s hard to predict how technology will develop…

2007

2024

these two events are linked, but Steve Jobs likely never predicted that the iPhone would lead to Ukrainian combat robots

# Technologies evolve together in surprising ways

- At any given time, several “distinct” technologies are evolving separately.
- Well-defined cultures emerge around these technologies.
- Sometimes these technologies converge and lead to surprising results.

# How do we learn about new technologies?

- Tech Press
- Trade Shows
- One of the biggest trade shows is CES
- Some things from CES in the past
  - VCRs (1970)
  - The Atari (1977)
  - CD Players (1981)
  - Nintendo Entertainment System (1985)
  - Tetris (1988), John Madden Football (1991)
  - DVDs (1998)
  - Xbox (2005)

https://en.wikipedia.org/wiki/Consumer_Electronics_Show

# CES 2010: The Parrot AR.Drone

- Quadcopter
- Sold as a toy
  - Designed to be controlled by an iPhone
  - Supposed to be used with “augmented reality” (AR)

# AR.Drone in 2010

## CES 2010 – PARROT'S AR DRONE QUADRICOPTER

6 January 2010 Shiny CES 2010, Gadgets, iPhone

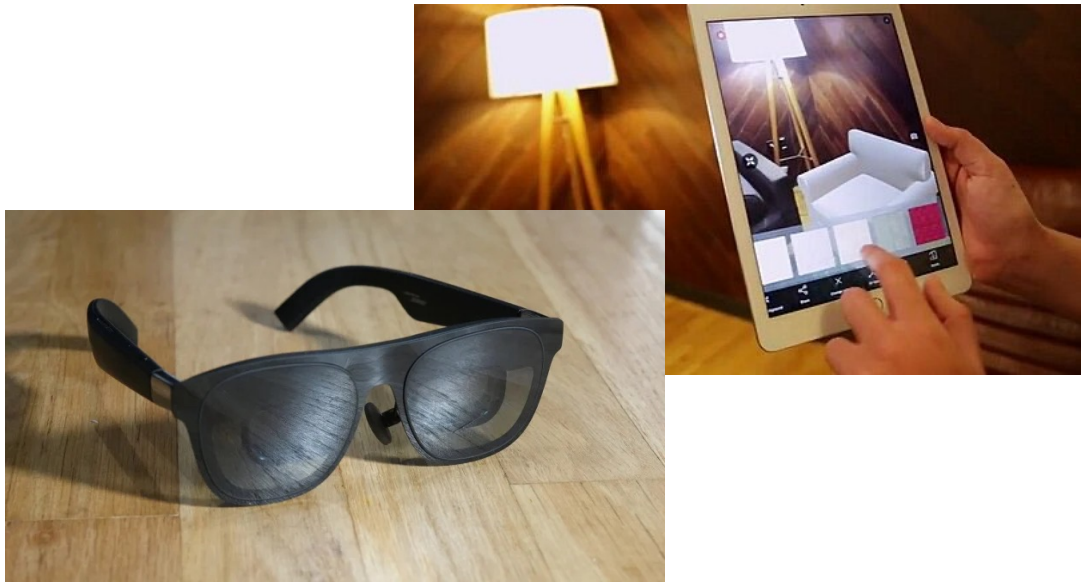
Talk about hitting the sweet spot! Parrot, who we mainly know for wireless accessories, has just been demoing a gadget that is 1, controlled by an iPhone, 2, uses Augmented Reality and 3 is loads of fun.

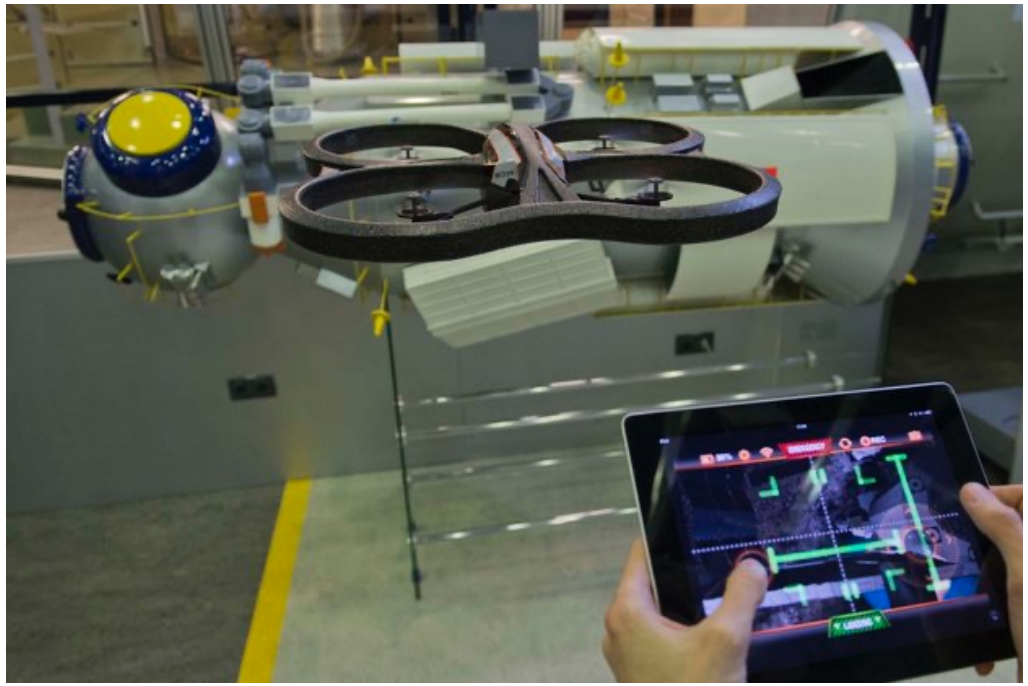
The AR Drone Quadricopter (that's a four propeller helicopter to you and me) is a very cool device that is sure to be one of the year's hottest gadgets. It is controlled by either an iPhone or an iPod touch and boasts two cameras – one for controlling the device and another which streams images back to the iPhone/touch. Basically if you tilt the phone then the Quadricopter tilts, raise the iPhone and the copter rises etc.

https://www.techdigest.tv/2010/01/ces_2010_-_parr.html

# Augmented Reality and Virtual Reality

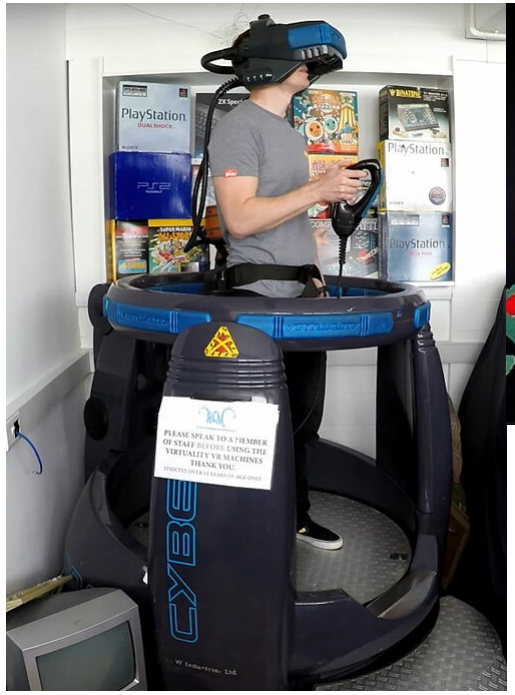
- Augmented Reality
  - Graphical world rendered on top of the real world





# Augmented Reality and Virtual Reality

- Virtual Reality (VR)
  - You see a rendered graphical world
  - You don’t see the real world.



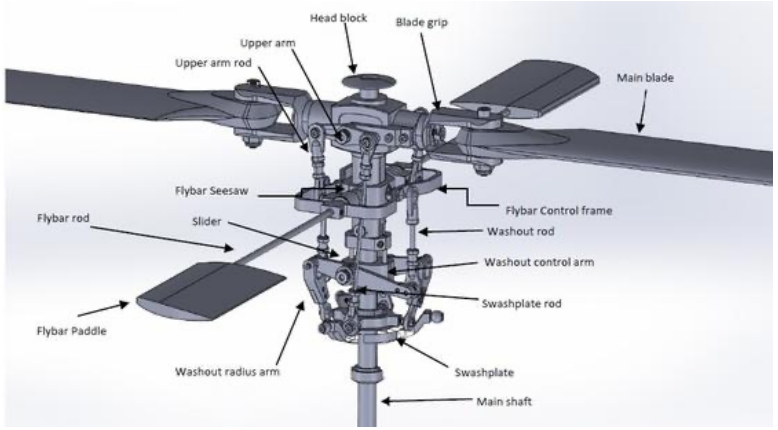

A VR system from 1991 with the game Dactyl Nightmare

# How do drones work?

- Drones move by spinning propellers.
- Spinning propellers create **forces** and **torques**.
- A **force** is a “push”
  - A spinning propeller creates **lift**.
- A **torque** is a “twist”
  - The propeller pushes air down and makes it “twist” a bit.
  - This causes the drone to twist in the other direction.

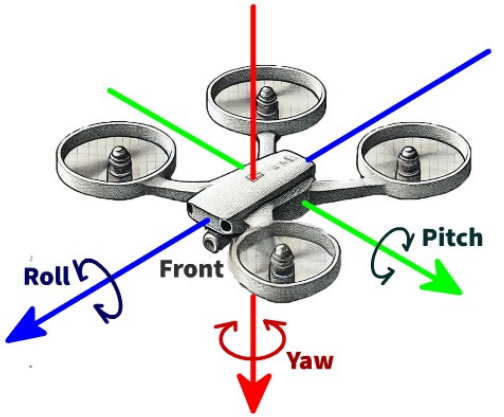
# How do drones work?

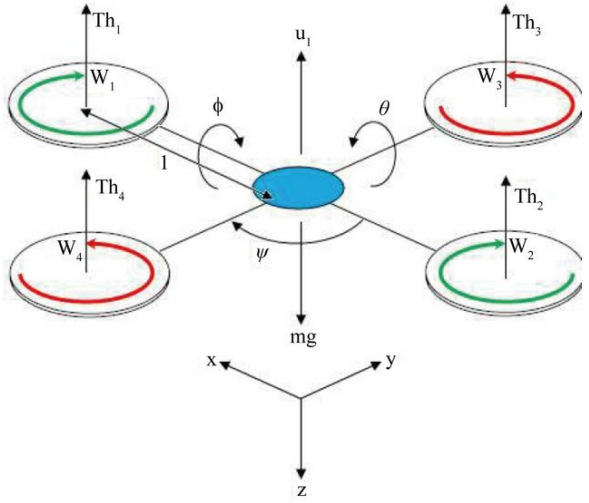
- Why do they have 4 propellers?
- Do the propellers move?
  - In a normal helicopter, yes.
  - This is really complicated (mechanically), but computationally simple.
  - In a multicopter, the blades are fixed.




# How do drones work?

- Blades spin in opposite directions
  - Cancel out torque.



# At the same time…

- Open-source drones were coming into the world.
- 3D Robotics was founded in 2009.
- Grew out of an online forum for hobbyists.

3DR

# Open Source

- Companies historically treated their software as an important secret.
- Software is **compiled** into a **binary** and the binary is what goes to customers.
- It's hard to go in the other direction: from compiled binary to **source code**.
- In the 1990s, a movement started to promote the idea of sharing the source code directly with other people. The movement settled on the term "open source"
  - Caught on in some areas (operating systems, databases)
  - Less so in others (video games, word processors, spreadsheets)

# Open-source Robotics

- Around the same time, interest grew in building open-source software for robots.
- Willow Garage started in 2006 when Scott Hassan (who helped build the original Google search engine) decided he wanted a robot that ran open-source code.
- This led to the **PR2** robot and the open-source **Robot Operating System** (**ROS**)


ROS

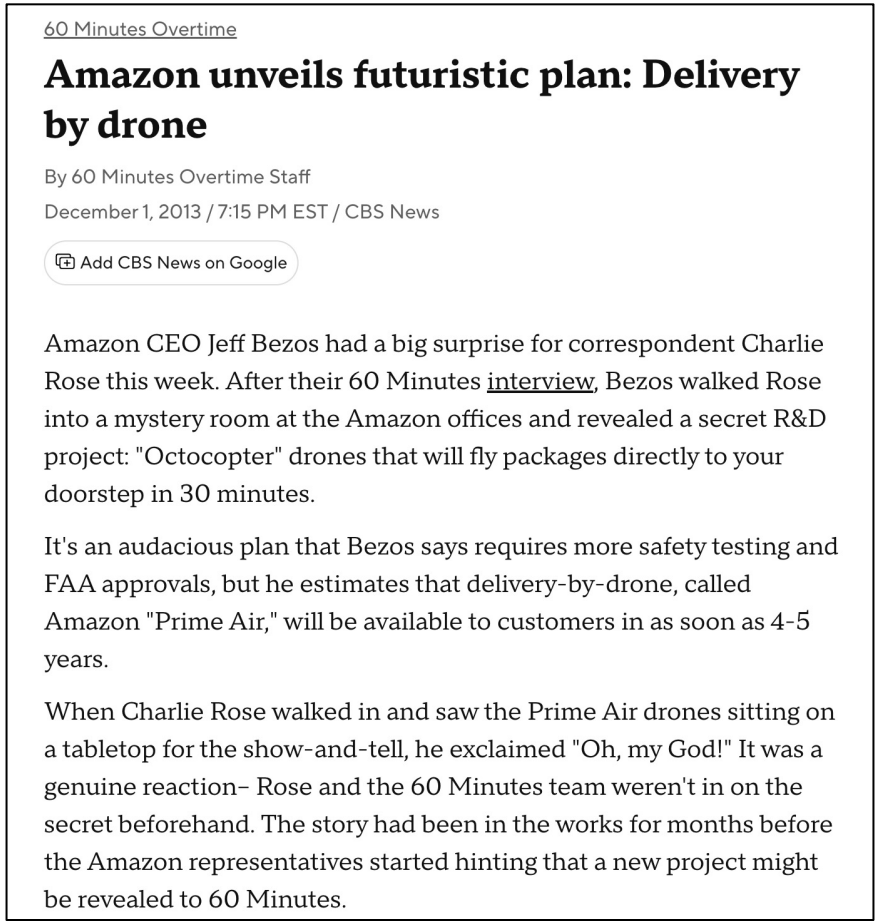
# On the other side of the world…

- In 2006, Frank Wang founds Shenzhen Da-Jiang Innovations Sciences and Technologies Ltd.
  - Better known as **DJI**
- Allegedly, DJI starts designing drones in 2006, but their first commercial platform is the Phantom 1 in January 2013.

# 2013

- A few big things happened in 2013:
  - DJI releases the phantom 1.
  - The US Government decides to create a set of “FAA drone test sites”
  - Amazon announces a drone delivery program

# Amazon’s Drone Program



60 Minutes Overtime

## Amazon unveils futuristic plan: Delivery by drone

By 60 Minutes Overtime Staff

December 1, 2013 / 7:15 PM EST / CBS News

Add CBS News on Google

Amazon CEO Jeff Bezos had a big surprise for correspondent Charlie Rose this week. After their 60 Minutes interview, Bezos walked Rose into a mystery room at the Amazon offices and revealed a secret R&D project: "Octocopter" drones that will fly packages directly to your doorstep in 30 minutes.

It's an audacious plan that Bezos says requires more safety testing and FAA approvals, but he estimates that delivery-by-drone, called Amazon "Prime Air," will be available to customers in as soon as 4-5 years.

When Charlie Rose walked in and saw the Prime Air drones sitting on a tabletop for the show-and-tell, he exclaimed "Oh, my God!" It was a genuine reaction– Rose and the 60 Minutes team weren't in on the secret beforehand. The story had been in the works for months before the Amazon representatives started hinting that a new project might be revealed to 60 Minutes.

https://www.cbsnews.com/news/amazon-unveils-futuristic-plan-delivery-by-drone/

# FAA Drone Test Sites

## FAA selects 6 sites to test drone capability, including one airport

BY TAYLOR SOPER on Dec 30, 2013 at 9:25 am

Share

The Federal Aviation Administration today announced six sites where research will be conducted to test the legitimacy of drones sharing space in the sky with commercial airlines.

Today's announcement comes after the FAA spent 10 months cutting down a list of 25 potential locations to the final six. Each testing ground will be used to research various aspects of the drones, from safety to climate issues.

This is all part of the government's initial steps to allow for the integration of unmanned aircraft into U.S. airspace. A 74-page Federal Aviation Administration report, released in November, laid out a roadmap for UAVs based on the mandates of the FAA Modernization and Reform Act of 2012.

https://www.geekwire.com/2013/faa-drones/

# Others Catch On

- Google creates “Project Wing” in 2014.
  - Hires MIT Aeronautics Professor Nick Roy to design drone.
  - 1st attempt fails - design was too complicated.
- In 2016 a startup called Flirtey makes the first commercial drone delivery.

TECH

**7-Eleven beats Google and Amazon to the first regular commercial drone delivery service in the U.S.**

PUBLISHED TUE, DEC 20 2016•3:25 PM EST | UPDATED WED, DEC 21 2016•11:28 AM EST

recode | April Glaser

[7-Eleven beats Google and Amazon to the first regular commercial drone delivery service in the U.S.]

# 2014 National Championship Air Races

- The first year that the National Championship Air Races had a “drone” category.
- More drones, more jobs for Northern Nevada
  - Economic development stories end up being important for the development of new technologies.
- By January 2015 it’s clear drones are going to be a “thing”

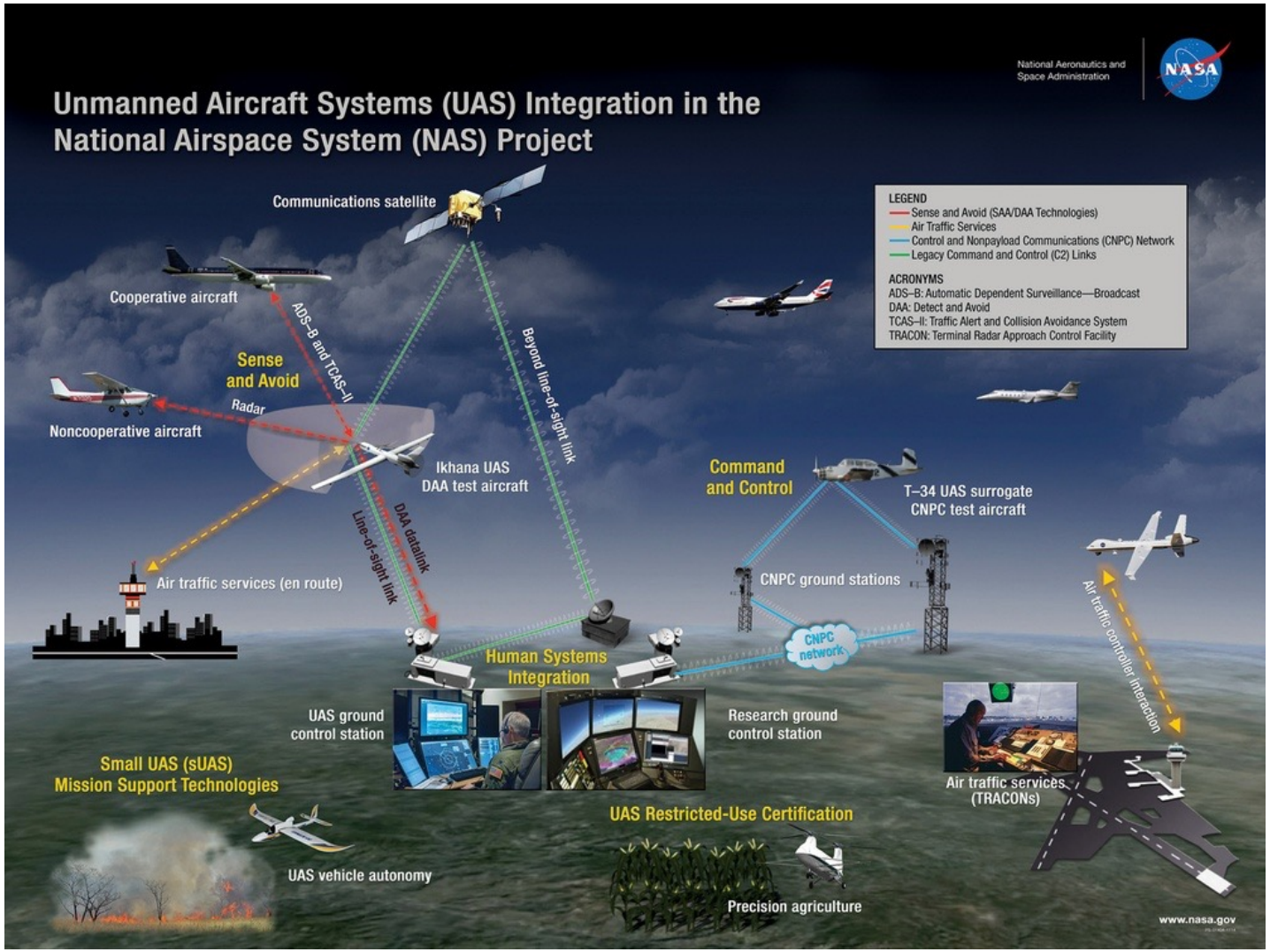
# How many drones can you fly at once?

What’s the limiting factor? What problems do you have to solve?

# Several, it turns out…

- **Command and Control** (C2)
  - How do you send commands to a drone?
  - What commands do you send?
- Aircraft **Certification**
  - Proving to the government that aircraft are safe.
- **Human factors** (Human-machine interaction)
  - This is a combination of psychology and engineering.
- **Sense and avoid**
  - How do you make a drone able to fly on its own without crashing?
- **Airspace Management**
  - Should drones talk to air traffic control?

# Several, it turns out…

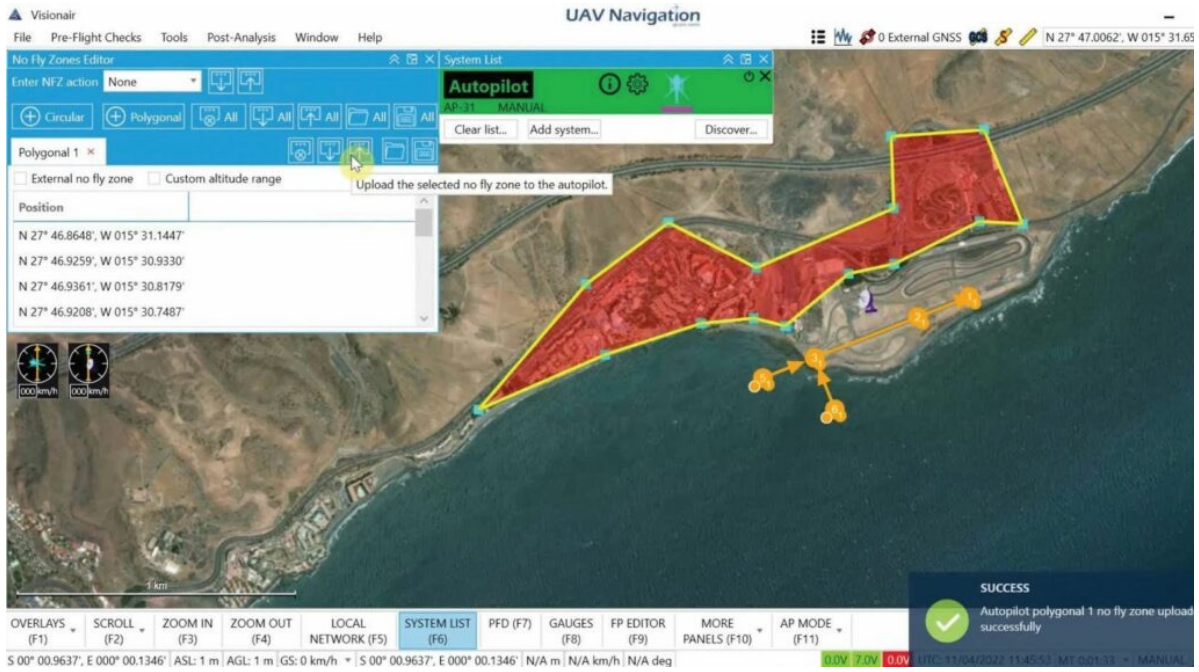


# Command and Control

- How the human operates the drone.
- Ranges from a laptop to a “virtual cockpit”

# Sense and Avoid

- Even in a large virtual cockpit, it’s hard to control a drone.
  - Latency
  - Amount of information.
  - Way that information is presented.
- Autonomous operation requires a drone to move safely on its own.
- May require coordination with other aircraft.



Test sites for evaluating sense and avoid and C2 technologies.

# Drone Delivery

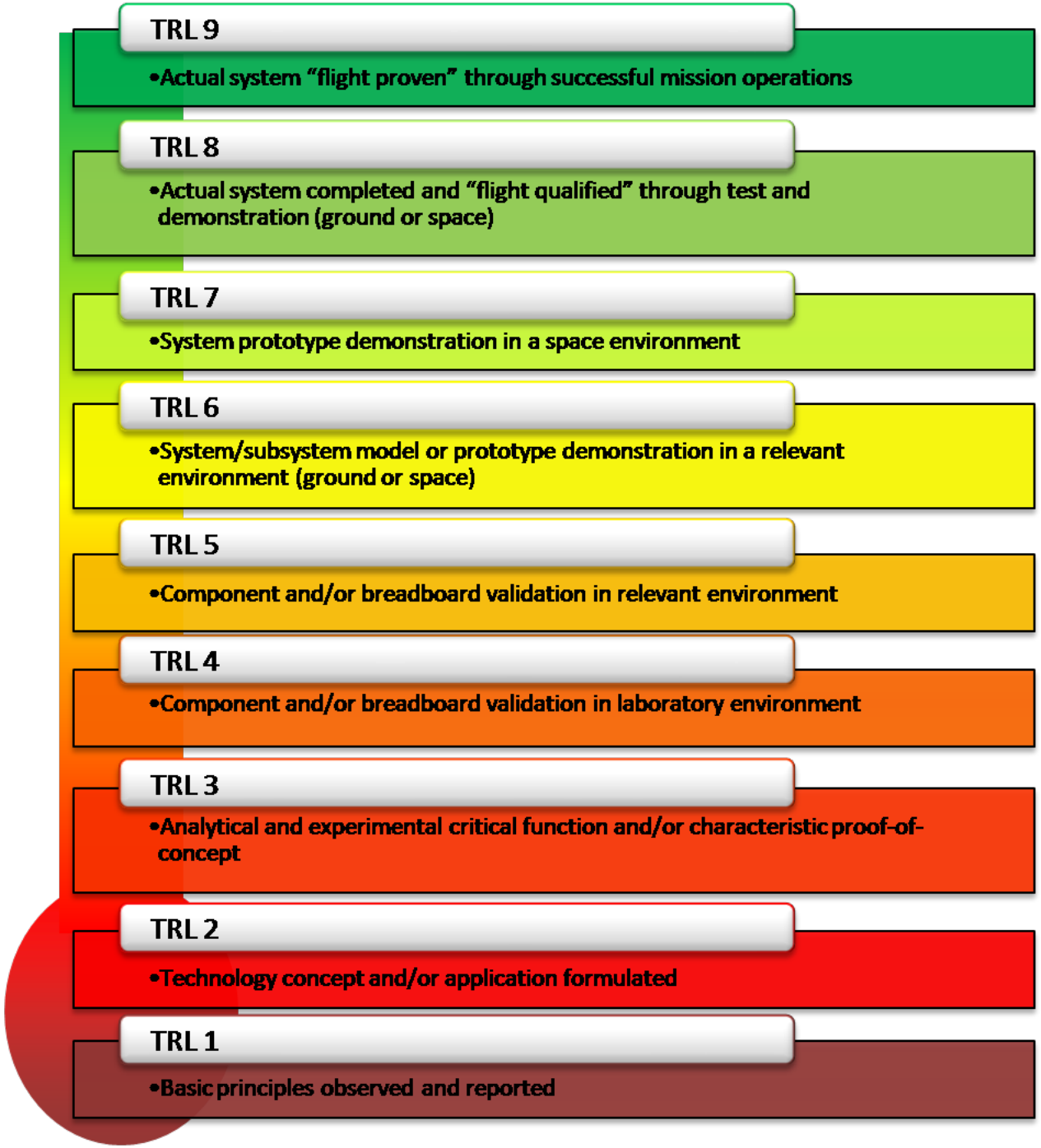
- Example: Google Wing delivery drone.

# NASA UAS Traffic Management (UTM) Project

- In 2015, NASA started designing a prototype air traffic control system for drones.
- Such a system has to be **autonomous**. Why?
- Are there potential social problems created by an autonomous air traffic control system?

# NASA UTM

- Prototype system evolved from concept to a ready-to-deploy system.
- Levels of development are captured by **technology readiness levels**.
  - NASA has one set of TRL definitions, military has another set.
- Pick a technology of your choice and ask “what’s its TRL?”



# NASA UTM

- Ended up testing in urban areas in 2019, with aim to hand technology off to FAA.
- Testing was done by NASA in Reno, Nevada.
- What's holding drones back? Why aren't they everywhere?

# Where are drones today?

- Drone delivery is still limited in the US.
- Big in China.
- The battlefield.
  - Ongoing debate about whether or not this is ethical.
  - There are degrees and different angles to the question.


# Where will drones be in the future?

- Drone delivery will become a thing that we just use.
- Eventually drone taxis will be available and cheap.
  - Currently being tested in Dubai.
- Everywhere on the battlefield.