



# AUTONOMY DEVELOPMENT PROCESS

Francis X Govers III

**AVLS Autonomy Team**

# Bell V-247



# Autonomy Under Development

- Precision Landing
- Waypoint Navigation (flight planning)
- 6-DOF Landings (on Boats)
- Unimproved Landings
- IFR / National Airspace
- Contingency Operations
- MUM-T
- DVE/ Night Operations
- GPS Denied
- See and Avoid (following up on NASA SIO)
- Formation Flying
- Aerial Refueling
- Sling Loads



# Autonomy Functions Under Development

Operation	Nominal	Degraded/ Contingency	GPS Denied	Night/DVE/Wx
Precision Landing				
Waypoints				
Landing on Boats				
Unimproved Landings				
Search				
MUM-T				
See and Avoid				
Formation				
Aerial Refueling				
Sling Loads				

# Landing on Boats

## Process:

- **GPAS Ground Based Augmentation guidance +**
- **Optical Tracking +**
- **Lidar / Doppler Drift / Relative Navigation**

## Research Gaps

- **All weather operations**
- **Contingency**

## Strategies

- **“crawl-walk-run” approach**
  - Stationary landing
  - Stationary landing with 3d Information
  - Landing on trailer
  - Landing on moving trailer + envelop expansion
  - Landing on moving trailer with simulated wave data
  - Landing on boat

# Off Field Landings

## Process:

- Vision (LIDAR, Radar, Video) based survey
- SWEEP – plan takeoff before you land, escape routes
- Direct observation technique – active guidance to touchdown

## Research Gaps

- **Edge Cases**
  - Water, bogs, snow, sand, etc
  - DVE – Degraded Visual Environments
  - Machine learning for classification of obstacles

## Strategies

- **“crawl-walk-run” approach**
  - High Survey
  - Low Survey
  - Approach and Land

# Autonomous Aerial Refueling

## Process

- Formation Flying using DGPS
- Sensor-based tracking
- Transitions

## Research Gaps

- Reliability, Repeatability, Reliability

## Strategies

- Following NASA AAR efforts with F-18
- X-47
- British AAR experiments
- Partnering with experienced players

# GPS Denied Navigation

## Process:

- **Combination of seven navigation techniques**
- **Many date back to the '70's "pre-GPS"**
- **Includes SLAM, Terrain, visual odometry, fixtaking, SOO**

## Research Gaps

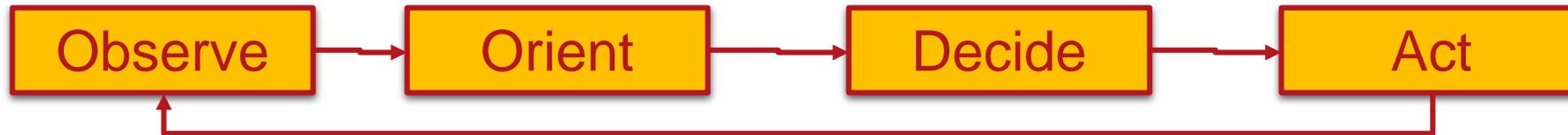
- **Signals of Opportunity**
- **Daylight Star Tracker**
- **Over Water**

## Strategies

- **Kalman Filter**
- **Adaptive Navigation Performance**
- **No "one size fits all" approach**



# V-247 | OODA Loop



Sensors &  
Sensor processing:  
Radar  
GPS, IMU  
Ir, LIDAR, EW  
IFF, ADS-B in  
Link 16 SA  
Engine, props, fuel  
Airspeed, altitude, etc.

Place all data in a  
common reference  
frame  
-Relative to the UAV  
-Lat/long/altitude  
-UTM  
-Why is this data  
relevant to this UAV?

Given all data and  
relevant information,  
what needs to be done  
about it?  
Determine course of  
action (COA) based on  
analysis of alternatives

Issue the necessary  
commands to the  
systems to execute the  
decision

Radar return 1.2 miles 32.123 deg  
ADS-B report lat xx lon yy  
GPS current position lat zz, long aa

Friendly Aircraft 1.2  
miles away same  
altitude  
Range decreasing  
bearing steady

Collision course  
Avoidance maneuver  
necessary  
Change altitude + 1000'

Send CWA notice to operator  
Engine to climb power  
Pitch up 5 degrees

# Autonomy Development: WHY?



## WHY?

- Risk Reduction for Unmanned Systems
  - Test on different Platforms
  - Simulator, SIL, 407, Truck, Dragon UAV, 412
- All future Bell autonomous and optionally pilot vehicles need it
- Comply with customer mandated FACE and MOSA requirements

# Bell 407 Test Vehicle



# Aircraft Agnostic Autonomy Pallet Flight Director Display & Precision Landing

The screenshot displays a comprehensive software interface for aircraft autonomy. At the top, a toolbar contains various navigation and control icons. The main area is a satellite map showing a mission path with green and purple waypoints. A central aircraft icon is labeled 'T#: 1087' and is surrounded by red circular markers with distance values (e.g., 0.50NM, 0.37NM, 0.27NM, 0.54NM). A 'Mission Planning' panel on the left lists parameters: Launch (1087), Approach, Flight, Ctg A, and Ctg B, with an 'Upload' button. Below the map, a 'Glass Cockpit' panel shows speed (268.6 kt), altitude (6560 ft), and other flight metrics. A 'Flight Info' panel at the bottom center displays 'MotherGoose T#: 1087 V247' and various engine and system status indicators. On the right, a 'Video Window' provides a first-person view from the cockpit, showing the pilot's perspective and a large cyan circular overlay. At the bottom right, a 'Stream' panel shows the address '239.23.212.200' and a 'SET' button.

# Crawl – Walk - Run

- Testing started with simulation to develop control loops
- Added sensors and systems in a stimulation environment
- Flight testing with manned open-loop helicopter (Bell 407)
- Flight testing with scale demonstrator (Dragon UAV)
- Flight testing with full size aircraft Fly By Wire a/c (Bell 412 or 429)
- Production Prototype



