CASCADE Case Study: Scan a Bridge

• Single-operator aerial inspection of the Clifton Suspension Bridge

• Thermal data, workflow and business case
Operational Challenges: Safety and Agility
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• Highly complex environment

• Risk mitigations
  • Exploit road closures for events and planned maintenance
  • Railway rarely used
  • Bridge Trust and Bristol City Council supportive
  • Tether?
Complexity

• Mitigation: use off-the-shelf small (<7kg) multirotor
  • DJI * or AscTec Falcon8
  • Limited on-board complexity

• Congested, complex environment
  • Mostly VLOS, some EVLOS

• Category A or B operation
  • Depends how you judge the complexity
Research Challenges

• Major goal: single person (E)VLOS operation in complex* environment
  • “Crew – usually minimum of two. One pilot in command, and one observer/camera operator. Other missions may require more crew; spotters, engineers, aides and so on.” – Network Rail
  • * Means we will not sterilise the area... but maybe it’s quiet and partly controllable

• Approach: on-ground autonomy to mitigate environment complexity
  • Mission design for safety
    • Includes Remote Pilot location, spotting, contingencies, and robust mission execution
  • Autonomous execution monitoring by Remote Pilot Station
    • Concept: autonomous RPA Observer for EVLOS
  • Simple – low workload – Remote Pilot interface
    • Pause / Go / Abort
Mission Design

• Inputs
  • CAD model of target structure
  • Routes of uncontrolled users through region of interest
  • Platform and sensor parameters

• Output: robust sequence of segments
  • *E.g.* a behaviour tree
  • Each has safety preconditions
    • Battery > X%; Zone Z clear; UAV at W; Remote Pilot at location Y
    • System integrity confirmed
  • Whole mission proven safe
    • Contingencies pre-planned
Nuggets

MAIN STREAM
• Mission modelling and design methods
• Statistical basis for acceptance trials criteria
• SUA platform integration and safety case
• Autonomous Remote Pilot Station

EXTRA SCOPE (PhDs? Creep?)
• Autonomous RPA Observer
• Flight design and operations with safety tether
• Ballistic characteristics of standard platforms
• Smartphone-based black box
  • “Internet of Drones”
Demonstration Milestones

• Following nuclear industry’s “lab / white / red” concept

• Thorough statistical analysis
  • Acceptance criterion = X hours of problem-free operation
  • “Problem” here means an unhandled circumstance
    • Manual intervention?

• Quick & dirty demo in Aug 2018

• Lab
  • Simulation → HWIL sim → HW at flying site
  • Simulated disturbances, failures and passers-by

• White
  • Real site, but with closures, and trained participants interacting
  • Include simulated failures

• Red
  • Real site, real day
Collaborations

**Internal**
- Cranfield: formal mission spec
- Manchester: mission & safety
- Southampton: visual tracking
- Imperial: drones & tethers

**External**
- UK Collaboratorium for Research on Infrastructure and Cities (UKCRIC):
  - Value added and payload
- Clifton Suspension Bridge Trust
  - A bridge!
- Assuring Autonomy (?)
Next Steps

• “Quick and dirty” concept experiment
  • August 2018

• Refinement of scope
  • Payload: UKCRIC
  • Tech: CASCADE

• Possible aligned PhDs
  • Sept 2018/19 start

• Target: August 2020

• What’s not in scope?
  • Turbulence & poor weather
  • Precision proximity control
  • Multi-platform operations
  • Autonomous flight control
  • Dynamic mission re-planning
  • 5G connectivity