UAS Flight Planning & Operational Safety & Risk Decision Intelligence™

Safety Management International Collaboration Group

May 8, 2018
Toronto

www.periculumlabs.com
Periculum Labs

- Periculum Labs builds advanced tools & API’s to optimize UAS Flight Operations for autonomous vehicles now and in the future across all Phases of Flight enhancing Safety, Situational Awareness and Decision Intelligence as industries move to safe, secure, real time dynamic operations

- Our scenario risk and utility based methodologies, taxonomies, Phase of Flight models, algorithms and decision intelligence are able to incorporate and support in a dynamic quantifiable fashion global interoperable performance standards and regulations for integrating unmanned and evolving autonomous operations from rural to densely urbanized ecosystems
SCENARIO BASED RISK ASSESSMENT METHODOLOGY AND TOOLS IN BUILDING SAFETY CASES
Role of Data in UAS Integration into the Airspace

• Planned growth of commercial UAS operations raises questions
  – What is an acceptable level of risk for commercial operations?
  – What policies and regulations are needed to achieve this level of safety?
  – What level of performance and reliability are required to satisfy critical functional requirements

• Satisfactory answers to these questions depend on the availability of large data sets
Data Sets for Integration of UAS into the Airspace

- Types of data sets
  - Simulations of flight operations and safety system performance
  - Component/subsystem testing
  - Flight testing under controlled conditions with high performance sensor and data acquisition systems
  - Operational data for commercial applications

- Current availability of flight data is dependent on level of interactions with manned aircraft and exposure of population on ground in crash scenarios
  - Data sets for Visual Line of Sight (VLOS) operations (e.g. Part 107 in the U.S.) are growing
  - Data sets for Beyond Visual Line of Sight (BVLOS) operations (e.g. Waivers in the U.S.) are sparse

- Large fraction of economic potential of commercial UAS operations and the key safety issues are associated with BVLOS
Data Requirements for Safety Risk Assessment

• Major contributors to overall safety risk for UAS operations are low probability/high consequence accident sequences
• Initiating events for accident sequences often associated with component failures e.g. batteries, system failures e.g. Command and Control link loss and human error e.g. incorrect flight planning
• Probabilities estimates for these events are uncertain because the data sets are small and granularity (dependencies) is low
• Risk reduction depends on the capability of safety systems to prevent the initiating event or to mitigate the consequences
• For BVLOS operations, data sets for safety class systems, e.g. Detect, Sense and Avoid are currently too sparse to demonstrate acceptable performance and reliability levels for key accident sequences
UAS Safety and Risk Methodologies are broken out into 2 Operational types of systems

• Two types of systems
  – **Type 1**: Existing systems with large operational data sets
    • Most accidents and their precursors have been observed
    • Focus on operational procedures, training, maintenance, etc.
  – **Type 2**: New systems or systems with major modifications
    • Little or no applicable operational data
    • Focus on CONOPS, technologies, regulations and functional requirements

**Introduction of UAS changes the NAS from a Type 1 to a Type 2 system**

**Standard operational safety methods and tools (Type 1) are of little value for a Type 2 problem**
Swiss Cheese Model of Type 1 Accidents

- Swiss Cheese Model was proposed by John Reason.
- Reason’s research is concerned primarily with human error and organizational failures in Type 1 systems.
- Model doesn’t (nor is it intended to) address Type 2 issues
  - Number and details of accidents
  - Range of accident consequences
  - The number and types of slices (barriers)
  - ‘Size of the holes” and how holes in slices are related
  - Barriers and holes associated with performance of safety technologies
- To address these issues we need to use risk analysis
Safety Questions for Type 2 Systems

• What accidents are possible?
• How do these accidents occur?
  – How do they start?
  – What events allow the accident to progress?
• How likely is a particular accident? How often does it happen?
• If a particular accident does occur, how bad is it?
  – What are the types of unwanted outcomes?
  – Do multiple types of losses occur in the same accident?
  – What is the range of loss and what magnitude is expected?
• Do we need safety systems to reduce the impact of accidents?
  – Where in the accident sequence does a safety system intervene?
  – How effective is it in reducing the impact of an accident?
A Closer Look at Missions, Mission Scenarios and Accident Sequences

• For **Type 1** systems, PRA is done with fault trees, event trees and master logic diagrams
  – Emphasis is on reliability of equipment and deviations from procedures (human error)
  – Equipment failures, human error and external events generate risk
• For **Type 2** systems the details of the system, external environment and CONOPS are not yet well-defined
  – There are large number of *possibilities* that need to be considered before focusing on individual accident sequences
• Begin by considering the range of operations to be performed – for UAS in the NAS this is the set of missions (VLOS/BVLOS/ full autonomy)
• For a particular mission consider possible flight scenarios (use cases)
  – Model the scenarios using a Phase of Flight (PoF) model
• Insert the accident sequences into the PoF model
• *This is a scenario-based approach to risk assessment*
Why Use Risk?

The Regulatory Gap

- Existing global regulations focus on VLOS missions
- Growth of the UAS economy will be primarily in BVLOS missions
- The safety case for BVLOS missions is a work in progress

- There is a emerging global consensus on a mission risk-based approach (scenarios) to accelerate the introduction of BVLOS operations
- There is no overall agreement on what this means
UAS BVLOS CLUSTER TEST BED
OPERATIONAL DATA VALIDATION

The need to collect, assess, simulate and fly missions scenarios to validate the test data and share appropriate data with regulatory authorities to accelerate safe BVLOS policies and regulations
National UAS BVLOS Cluster Ted Bed Project
Architecture

Web-based User Interface

- Transport Canada
- Government Planner
- NavCanada
- UAS Service Provider
- UAS System Provider

Users

Outputs

- BVLOS Use Cases for Planning & Development
- Validated BVLOS Best Practices, Policies & Regulations
- Validated UTM Functional Requirements for BVLOS
- Safety Case for BVLOS in the NAS

BVLOS Mission CONOPS

BVLOS Technologies

NAS Environment

Regulations & Best Practices

BVLOS Mission Authorization Requirements

BVLOS Business Cases

BVLOS Functional Requirements for Service or Technology

BVLOS Business Cases

RISK LABS

- Operator Private Lab
  - Mission scenarios
  - Initiating events
  - Accident sequences
  - Other proprietary information
- Other Private Lab
  - D&A technologies
  - Safety system concepts
- Shared Project Lab
  - Mission templates
  - Generic accident sequences
  - Risk acceptance criteria

TESTBED

- Simulation
  - Mission scenarios
  - UAS/manned aircraft interactions
  - Command & Control Links
- Subsystem Testing
  - D&A systems
- Mission Testing
  - Prototype missions
  - Obstacle avoidance
  - Autonomy

Now Data Factory

Failure & Performance Data

GIS Data
BVLOS Test Bed Hierarchy of Scenarios

- Scenarios used to make the safety case for integration of UAS into the NAS
- Scenarios designed to allow operators to explore the mission envelope and build practical and profitable businesses within regulatory constraints
- Scenarios intended to facilitate test and evaluation of operational and safety systems using the national BVLOS Testbed.
Data Interactions within the Testbed

Canadian BVLOS Community

Transport Canada

Operators

Technologists

BVLOS Mission Taxonomy

Spanning Set Mission Scenarios

Commercial Mission Scenarios

Test & Evaluation Mission Scenarios

Simulation

Subsystem Testing

Flight Testing

GCS Interfaces

DSA Systems

UTM Systems

Community Data Requests

Member - only Data Needs

Proprietary Data Sets

Community Data Sets
Data Flow in the Test Bed System

- BVLOS UAS Missions
- NAS Environment
- BVLOS Technologies
- Regulations & Best Practices
- System & Risk Tools
- Simulation Tools
- Component & Subsystem Testing
- Flight Testing
DATA DRIVEN DECISION MAKING

PL DECISION INTELLIGENCE™

PERICULUM LABS IS A WORLD CLASS TEAM OF RISK AND DECISION ANALYSIS EXPERTS, AI AND BUSINESS TRANSFORMATION SPECIALISTS WHO HAVE DEVELOPED PL DECISION INTELLIGENCE™ (PL DI), A PLATFORM FOR AUGMENTED DECISION MAKING INVOLVING COMPLEX HIGHER ORDER HUMAN REASONING. PL-DI HAS BROAD APPLICABILITY AND TRANSFORMATIONAL POTENTIAL IN MANY VERTICAL MARKETS.
PL Decision Intelligence Capabilities

SETTING THE STAGE: THE AUTOMATION SPECTRUM
Robotic and Cognitive Automation (R&CA) replicates human actions and judgement at tremendous speed, scale and quality, and lower cost.

<table>
<thead>
<tr>
<th>Robotics</th>
<th>Cognitive Automation</th>
<th>Artificial Intelligence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>“Mimics Human Actions”</strong></td>
<td><strong>“Mimics/Augments Quantitative Human Judgment”</strong></td>
<td><strong>“Augments Human Intelligence”</strong></td>
</tr>
<tr>
<td>- Used for rules based processes</td>
<td>- Used for judgement based processes</td>
<td>- Used for making predictive decisions</td>
</tr>
<tr>
<td>- Enables</td>
<td>- Has machine learning capability</td>
<td>- Has dynamic self-adaptable and managing capabilities</td>
</tr>
<tr>
<td>- Faster processing time</td>
<td>- Capabilities include natural language processing, natural language generation, machine learning, cognitive analytics, sensing</td>
<td></td>
</tr>
<tr>
<td>- Higher volumes</td>
<td>- Reduced errors</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Turing Test Definition - “A test for intelligence in a computer, requiring that a human being should be unable to distinguish the machine from another human being by using the replies to questions put to both”</td>
</tr>
</tbody>
</table>

Sample Vendors

- Blue Prism
- UiPath
- Redwood
- Automation Anywhere
- Pure DI
- Google DeepMind
- Salesforce
Pure Decision Intelligence

- **PURE DI** algorithms value, assess and optimize commercial strategic, planning and operational processes. **PURE DI** manages assets in environments of high risk and uncertainty. **PURE DI** incorporates “imperfect data” (incomplete or inconsistent) data to produce quantitative and qualitative decision intelligence.
Fused Decision Intelligence

DI Fusion provides AI companies and enterprise adopters with new tools to build applications faster. We fuse higher level logical thinking (Pure DI) with Artificial Neural Networks (ANNs), Evolutionary Computing Methods such as Genetic Algorithms (GAs) and Agent-based methods (ABMs). Applications developed using DI Fusion fall within the realm of Cognitive Automation and for ANNs and Agent-based tools fall within the category of Augment Human Intelligence.
UAS Enterprise Business & Operations Decision Value

Making BVLOS Missions Safe and Profitable – PL Decision Intelligence

Pre Flight Planning Decision Intelligence
MissionBuilder™

Enterprise Strategic Planning Decisions
Market Decision Analysis
Competitive Decision Analysis
Business Decision Analysis
Regulatory Decision Analysis
Technology Decision Analysis
Investor Decision Analysis
Monetization Decision Analysis
M&A Decision Analysis

Lower Premiums
Insurance

Operational Safety, Risk & Utility
Pre Flight Plan

Fleet/Operations Post Flight Analysis
Pilot/Operator & Payload Operator
Ground Maintenance
Operations Center
Dispatch & Logistics Center
Maintenance
Engineering – Design & Test
Finance
Sales & Marketing

In Flight Operational Constraints Decisions
RealFlight™

In Flight Operations Real Time
Dynamic Constraints

Pay as You Operate
Insurance

Emergency or Optimised
Operational Insurance

In Flight Operational
Constraints Decisions
RealFlight™

Pilot/Operator & Systems
Decision Support
Alerts/Notifications/Rules
and PL DI “Higher Order
Expert Emulated Reasoning”
Engine

www.periculumlabs.com
PL UAS Decision Apps/API’s Roadmap

- MissionBuilder
- Flight Risk Screener
- Flight Planning
- Pre Flight Operations
- RealFlight
- Flight Operations
- Weather Risk Manager
- Flight Operations
- Flight Planning
- Mission Risk Screener