PERICULUM LABS

UAS Flight Planning & Operational **Safety & Risk Decision Intelligence**™

Safety Management International Collaboration Group

May 8, 2018

Toronto

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

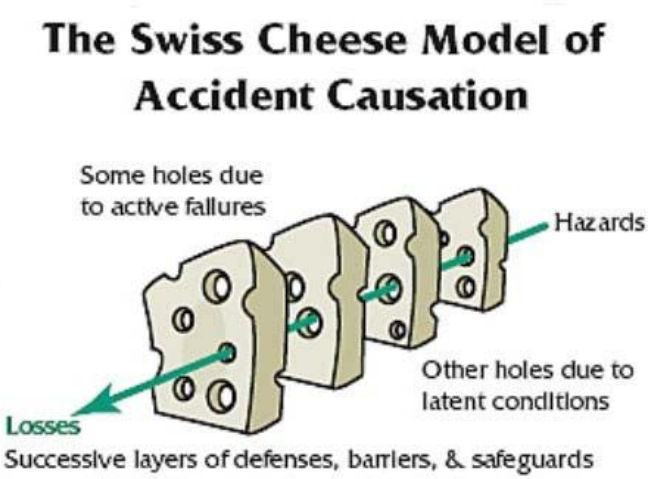
- Major contributors to overall safety risk for UAS operations are low probability/high consequence accident sequences
- Initiating events for accident sequences often associated with component failures e.g. batteries, system failures e.g. Command and Control link loss and human error e.g. incorrect 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

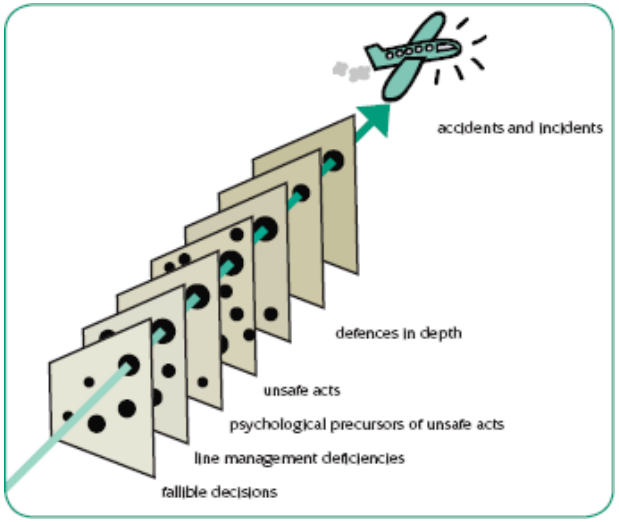
UAS Safety and Risk Methodologies are broken out into 2 Operational types of systems

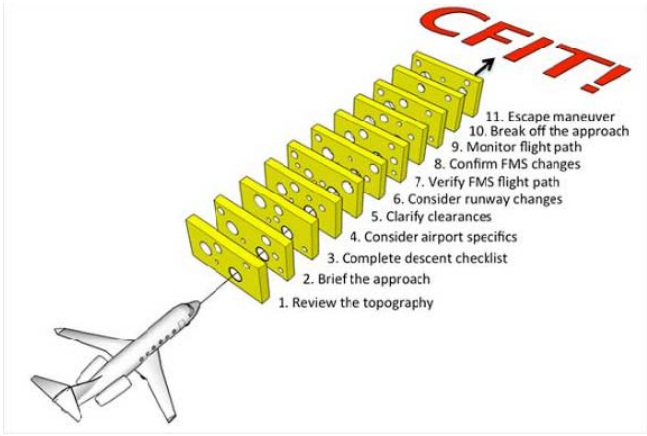
- Two types of systems
  - Type 1: Existing systems with large operational data sets
    - Most accidents and their precursors have been observed
    - Focus on operational procedures, training, maintenance, etc.
  - *Type 2*: New systems or systems with major modifications
    - Little or no applicable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

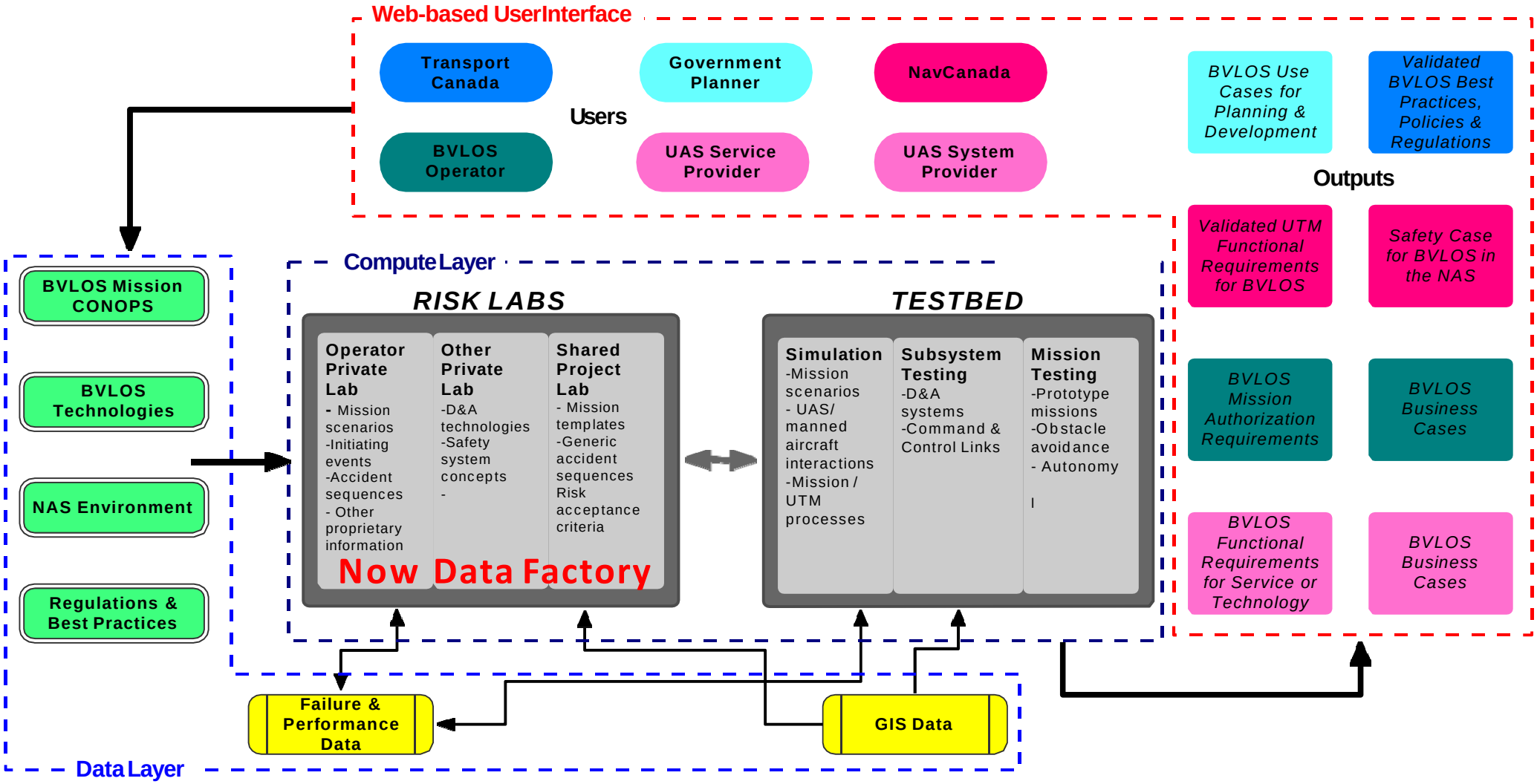
- Existing global regulations focus on VLOS missions
- Growth of the UAS economy will be primarily in BVLOS missions
- The safety case for BVLOS missions is a work in progress

- ***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

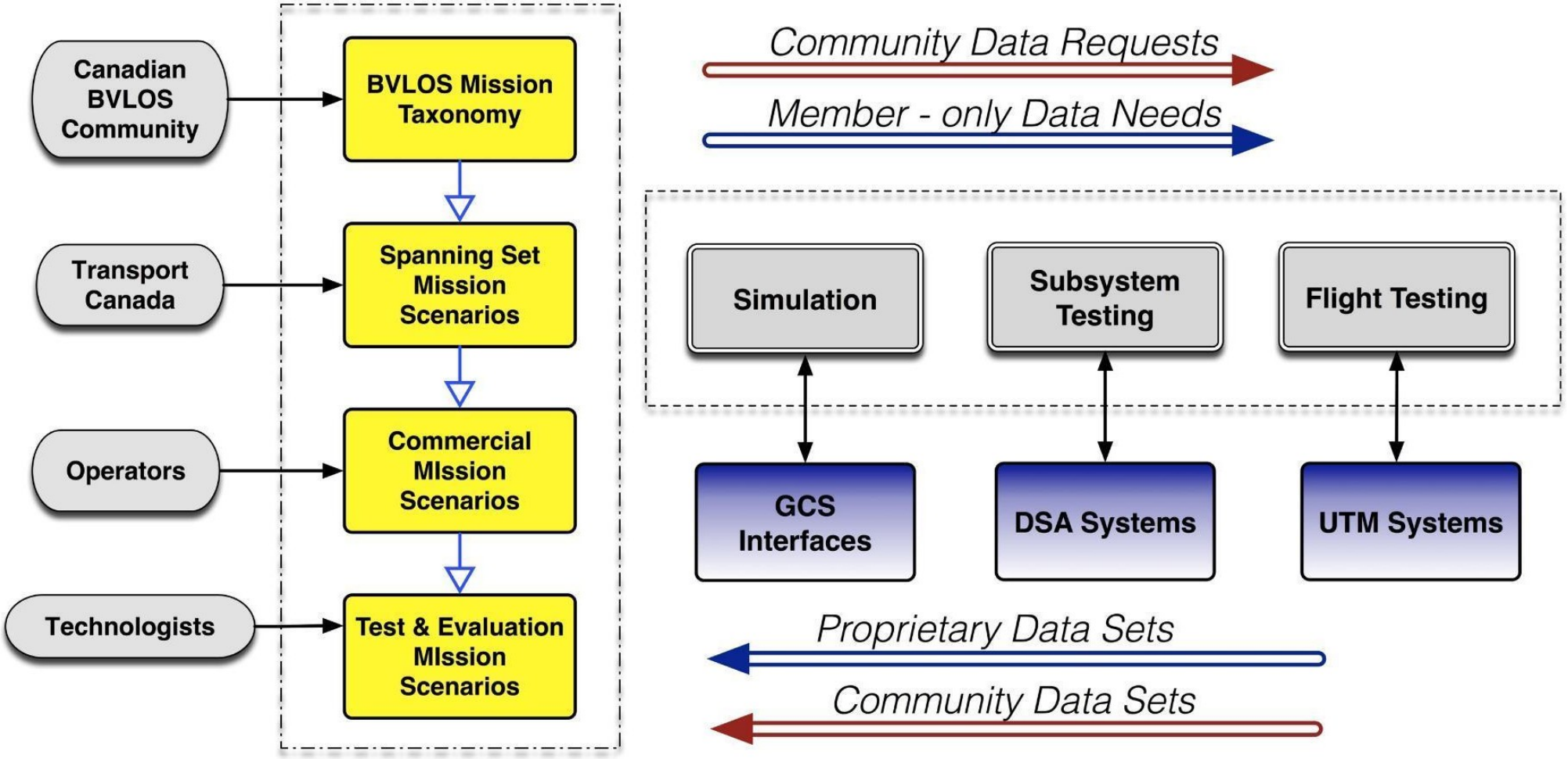
National UAS BVLOS Cluster Ted Bed Project Architecture



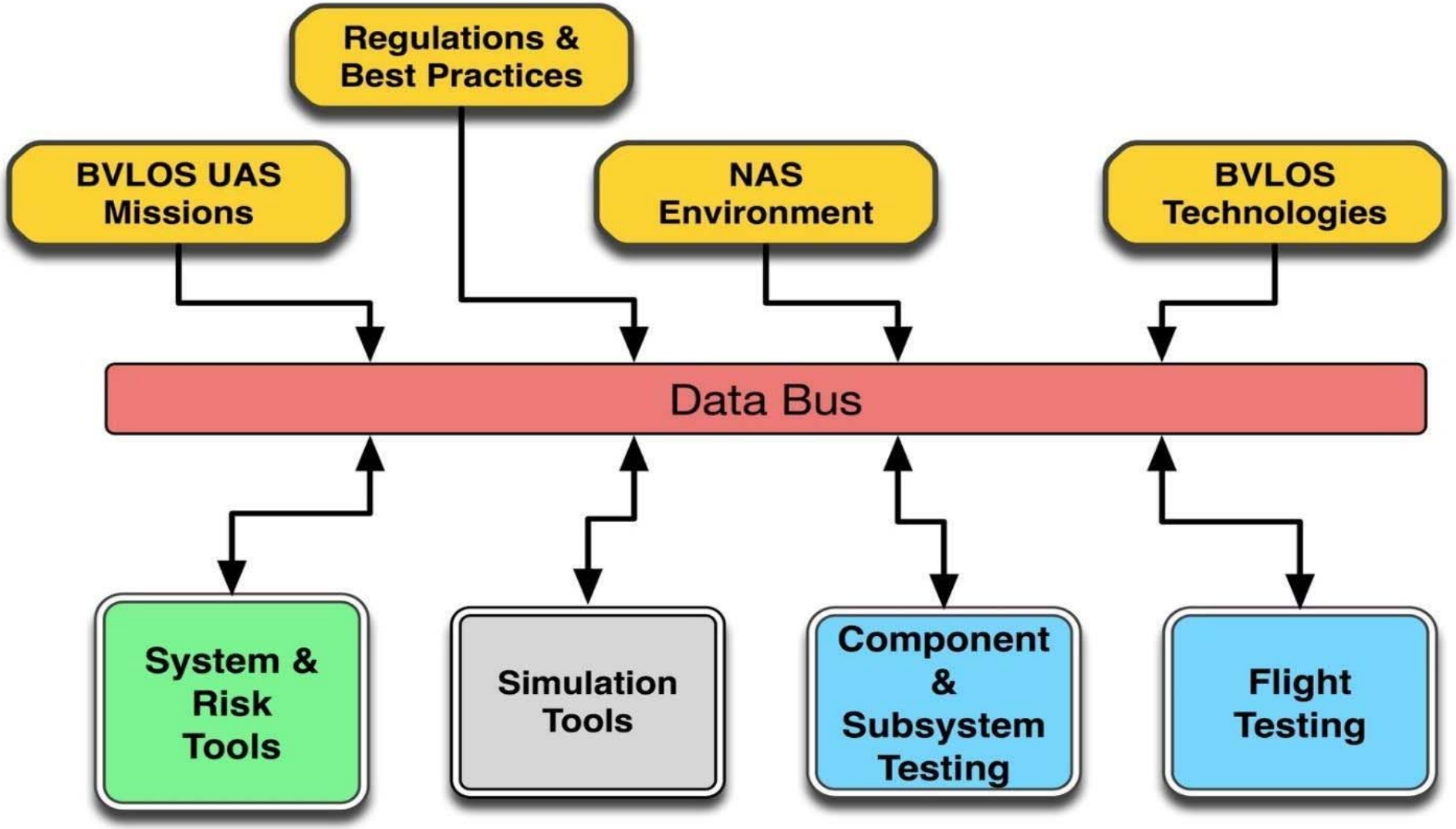
BVLOS Test Bed Hierarchy of Scenarios

- 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.

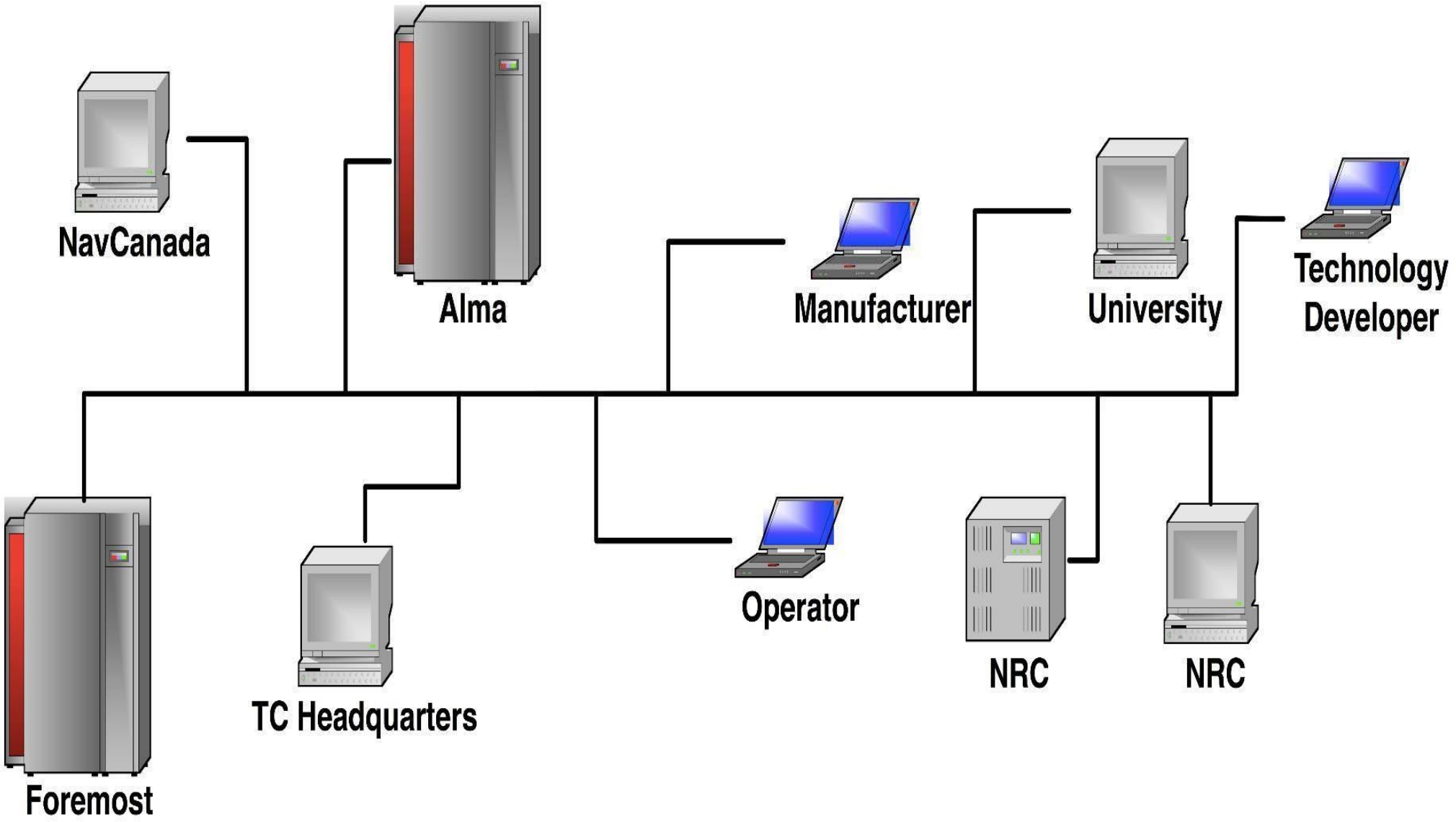
Data Interactions within the Testbed



Data Flow in the Test Bed System

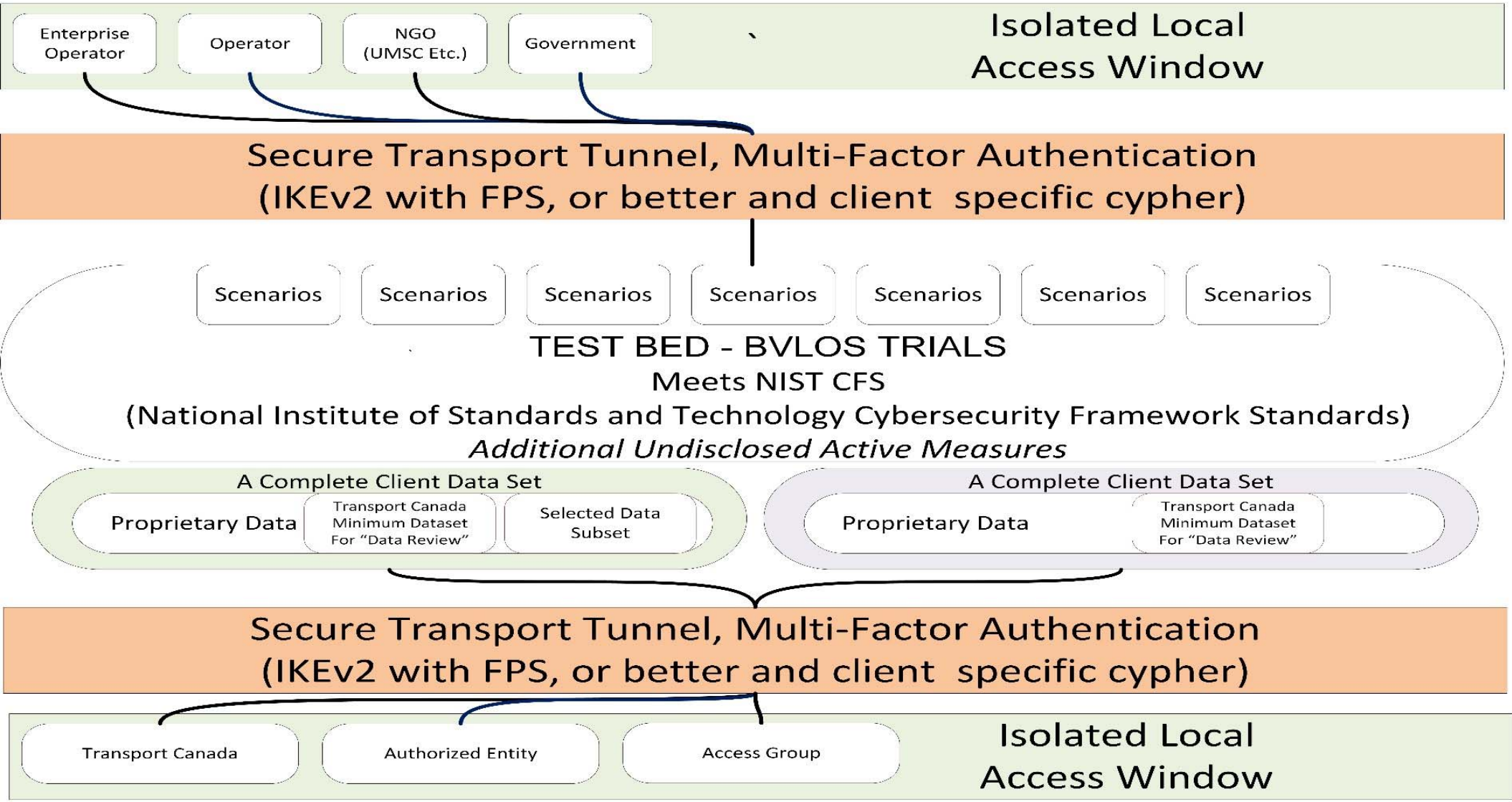


Notional Data Backbone



Test Data Warehouse and Collaboration Notional Architecture

Secure Access and Secure Data Storage Topography
For the Use Case Based Regulatory Approval Process

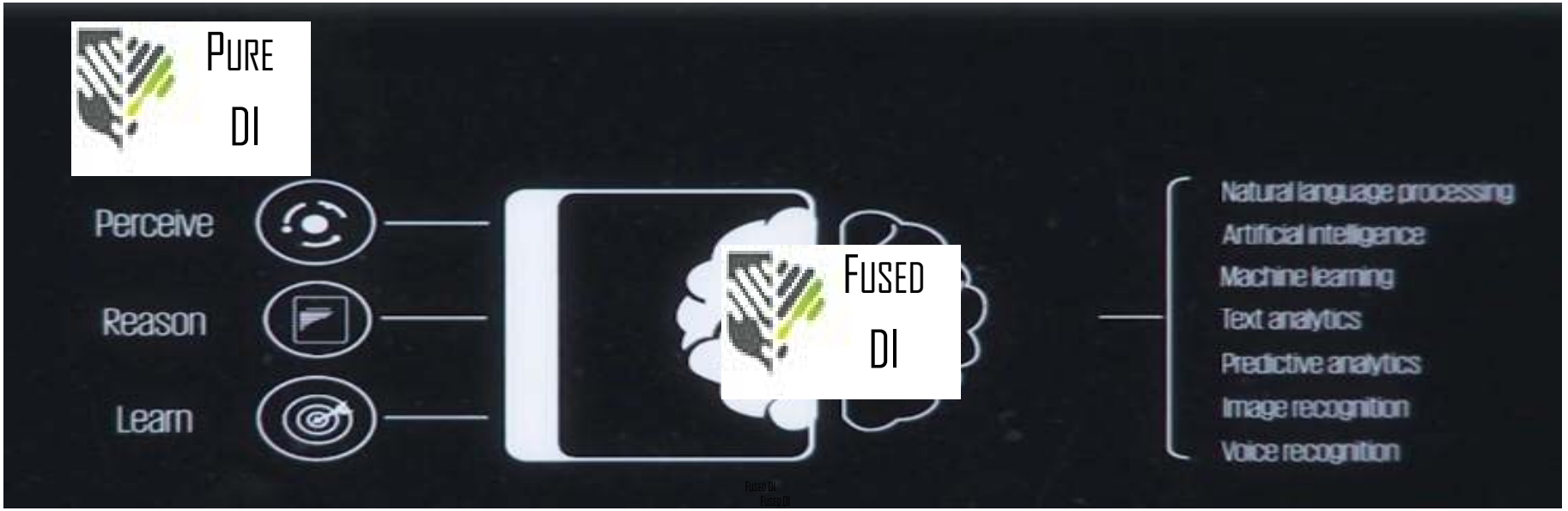


DATA DRIVEN DECISION MAKING

PL DECISION INTELLIGENCE™

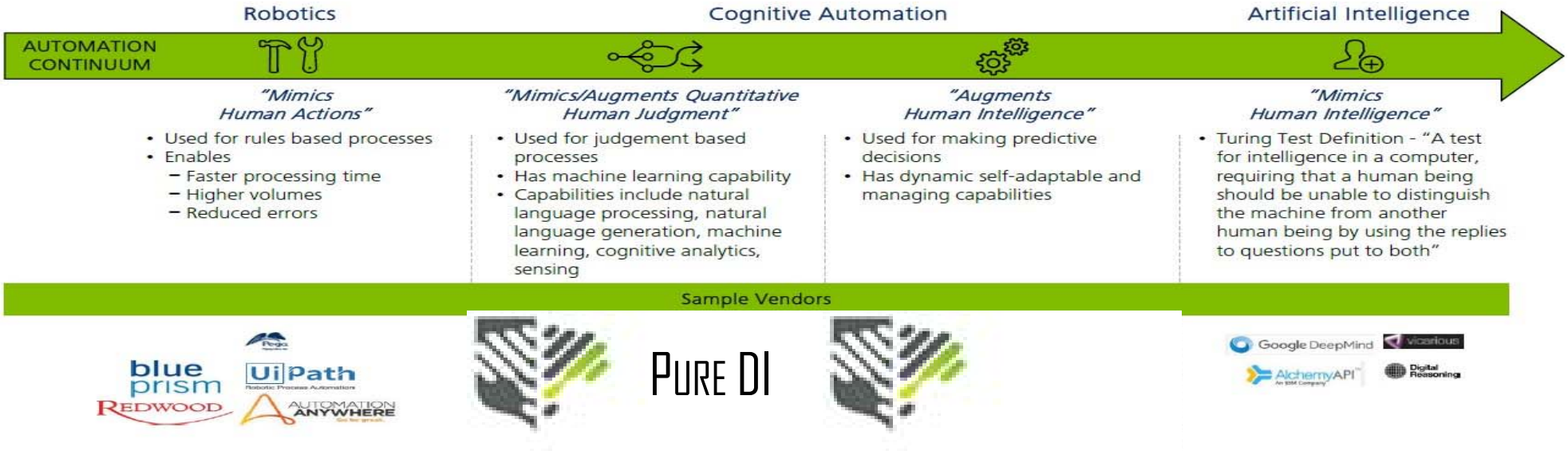
PERICULUM LABS IS A WORLD CLASS TEAM OF RISK AND DECISION ANALYSIS EXPERTS, AI AND BUSINESS TRANSFORMATION SPECIALISTS WHO HAVE DEVELOPED PL DECISION INTELLIGENCE™ (PL DI), A PLATFORM FOR AUGMENTED DECISION MAKING INVOLVING COMPLEX HIGHER ORDER HUMAN REASONING. PL-DI HAS BROAD APPLICABILITY AND TRANSFORMATIONAL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

PL Decision Intelligence Capabilities



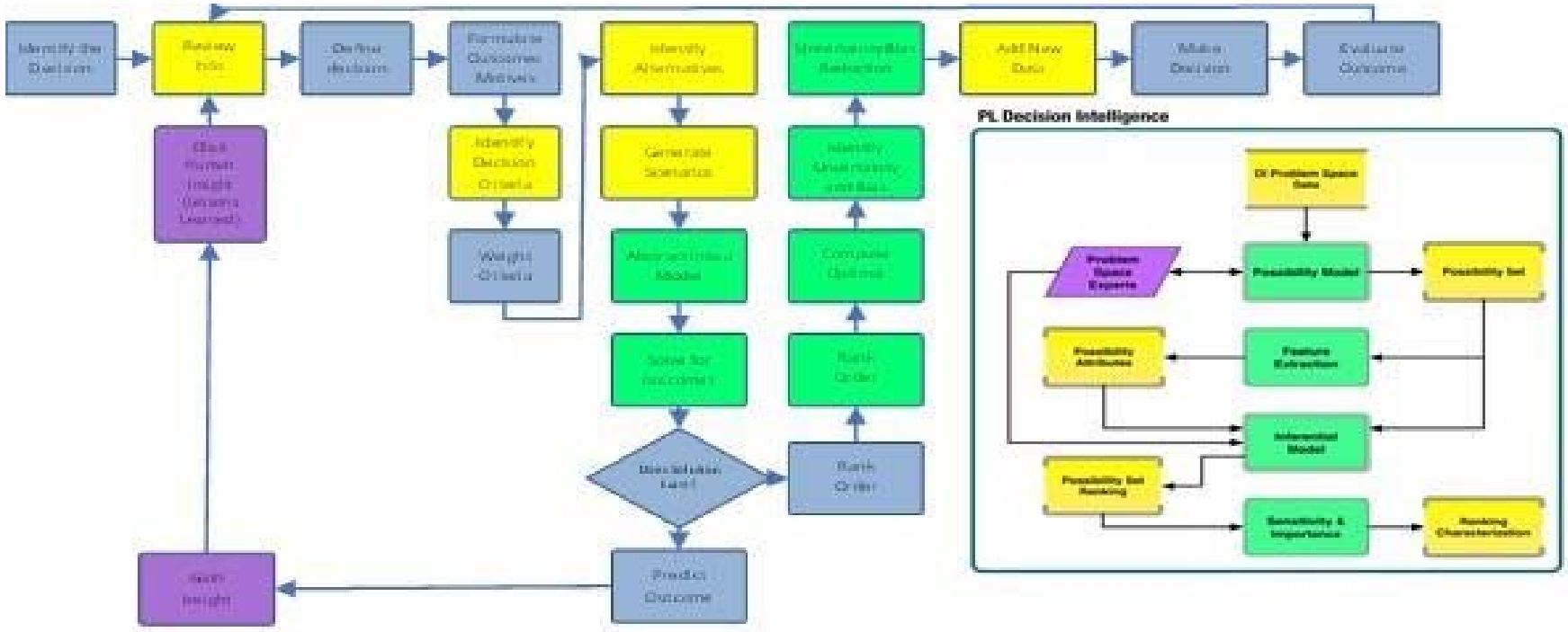
SETTING THE STAGE: THE AUTOMATION SPECTRUM

Robotic and Cognitive Automation (R&CA) replicates human actions and judgement at tremendous speed, scale and quality, and lower cost



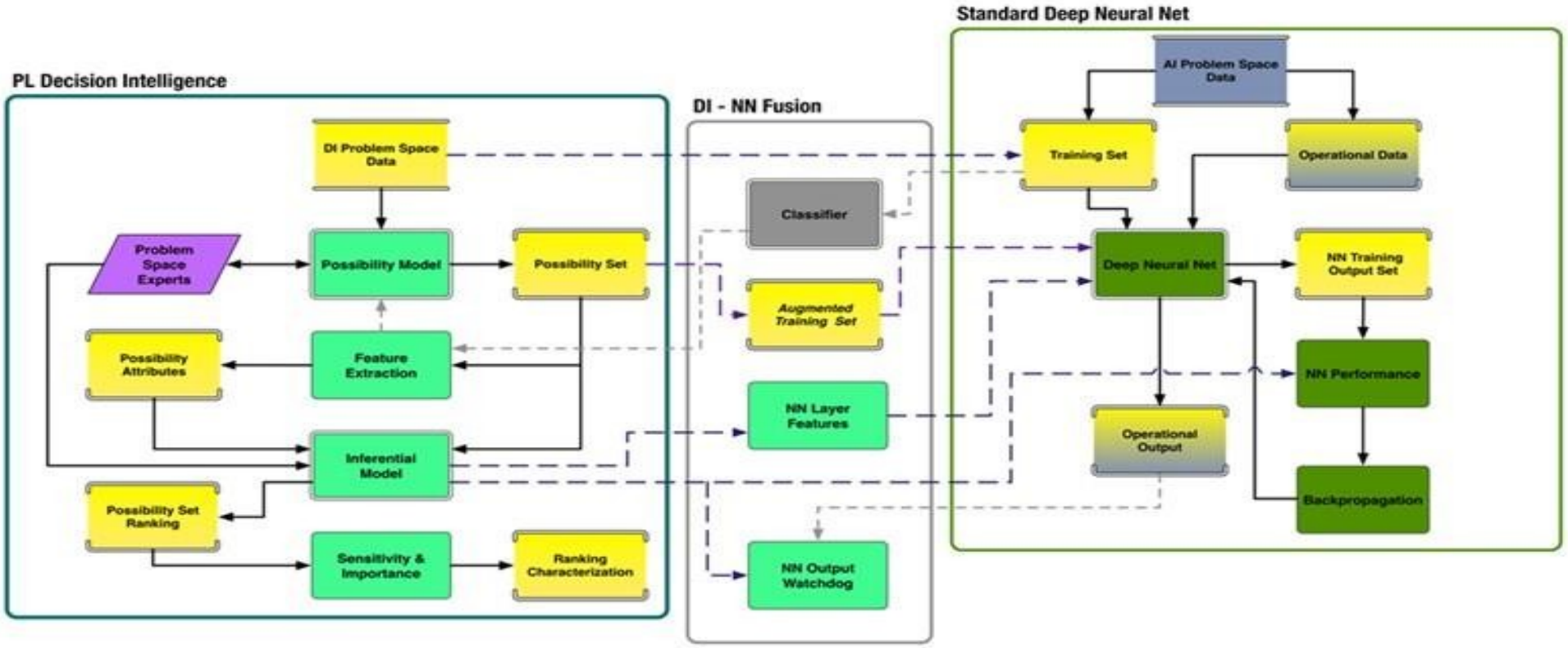
Pure Decision Intelligence

- 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.

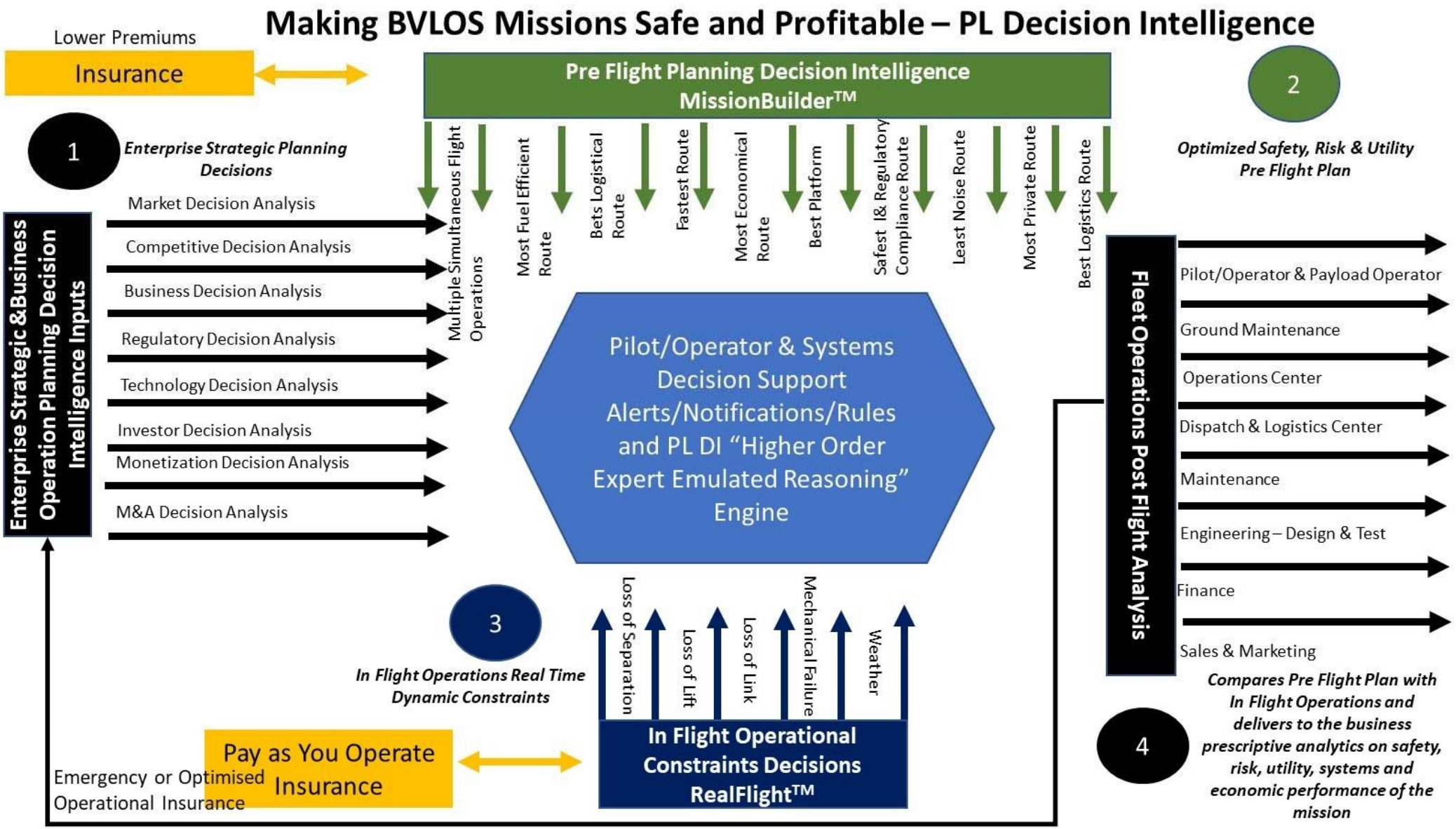
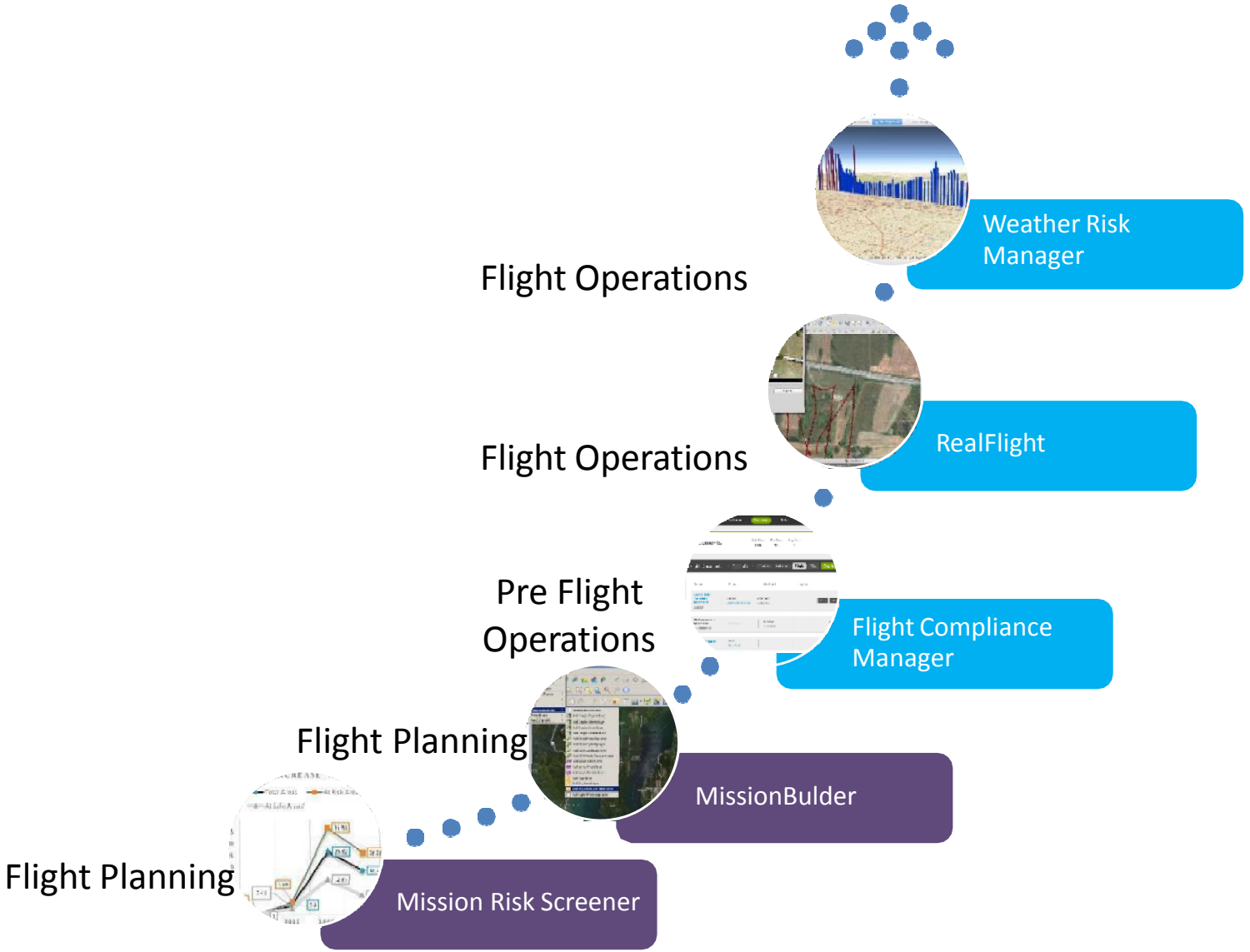


Fused Decision Intelligence

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



PL UAS Decision Apps/API's Roadmap