Enabling Commercial Autonomy in Aviation: An Ontology and Framework for Automating UAS

BUSINESS PROBLEM

Aligning across a program early in the ideation and development cycle is critical to program success. Misalignment can cause unnecessary meetings and time lost, all leading to budget costs. Saving this precious time early on in a program can allow more of the budget to fund actual product development. Autonomy is a new and complex topic that many individuals approach with pre-conceived notions and ideas, which can be a hurdle when beginning a new program that seeks to produce work that has never been done before. As such, this work aims to provide a clear guide for program managers to use, both internally and externally.

APPROACH

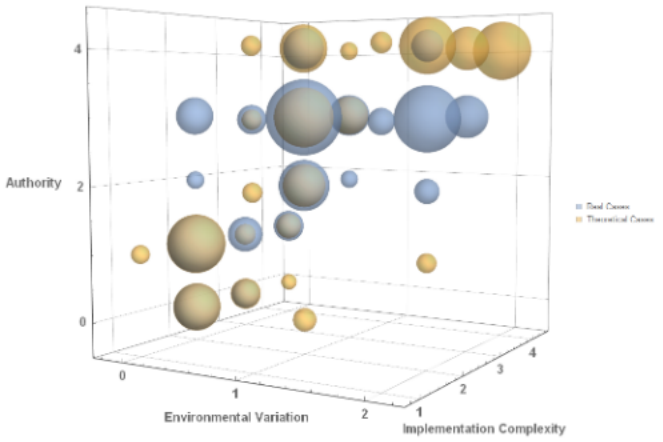
Object Process Methodology (OPM) was used to model and initially validate the ontology against the metrics of completeness, unambiguity, and congruity. For the creation of the proposed framework, an extensive literature review across different domains was performed, where over 20 separate frameworks were considered. The framework was validated by applying it to 13 different CONOPS.

DATA SOURCES

For the ontology, relevant data included leveraged work from the traditional working groups of Boeing as well as newcomers such as Aurora Flight Sciences. Additionally, industry-wide accepted resources were considered, particularly the newest aviation standard addition, Appendix X2 of ASTM F3060. For the framework, 13 use cases, both real and theoretical, were used to validate the model.

Data Types and Format

The data came in the form of documents and text, which were manually analyzed by the author.



IMPACT

Internally, the ontology provides program managers a series of concept definitions and relationships that they can choose to implement or adapt as they see fit. Additionally, the framework can be used to evaluate a new program and act as a tool in strategic investments at the division-level. With this framework, program managers can articulate how a proposed product is pushing boundaries, where there are opportunities for additional improvement, and where the safety case needs the most attention. This can be used to compare programs and develop long-term road maps towards more advanced technologies. Externally, the ontology and framework can be used to describe a particular CONOPS to a regulator. Pointing out the particular areas of uncertainty, paired with a developed safety case, can be a compelling analysis for regulators to easily understand and possibly accept. Additionally, the framework may be used to analyze competitors' efforts and see where other parties are accepting uncertainty. This can further inform the areas of product development for Boeing, either to compete against other players or to dominate in a separate area of technological innovation.

DRIVERS	Higher levels of autonomy will enable new sectors of aviation and business including urban air mobility (UAM) and unmanned aircraft delivery services. A common understanding of autonomy and a systematic means of describing the concepts and categories contained within the subject is needed to support consistent industry discussion. The variable nature of these systems and the high complexity of their implementation requires significant analysis.
BARRIERS	The largest barrier, at first, was to gain further buy-in across the Enterprise, for both the Ontology and Framework. This buy-in was paramount as Boeing interfaces with external parties, including regulators, for commercial systems so internal alignment was required for this work to be meaningful.
ENABLERS	As I gained buy-in from different parts of the Enterprise, different teams gave me meaningful feedback on my work as well as informed me of new ways this work could be applied, both within the Enterprise and beyond.
ACTIONS	Proposing the different pieces of work to different groups and helping them apply it to their specific work was the main focus of implementing this work.
INNOVATION	This work investigated current frameworks used to describe highly automated system with a focus on Unmanned Aircraft Systems (UAS) and proposed two tools to support the industry further: an ontology and framework to provide a systematic means of describing UAS and a particular system's future Operational Uncertainty in early product development phases.
IMPROVEMENT	This framework can be used to compare programs and develop long-term road maps towards more advanced technologies. Additionally, If a particular organization can consistently use the framework early on in the product development lifecycle, this framework and ontology can allow for a sharpened focus around the improvements to the system that provide an overall robust safety case.
BEST PRACTICES	To contribute to or replicate this work, an individual should follow a similar path as the author of this work, including an extensive literature review, including collating internal resources for the ontology and framework. The framework is still subjected to subjectivity, as noted in the future work section of the thesis, and so this work has future improvements to be made before it can be directly replicated.
OTHER APPLICATIONS	The same ontology and framework can be applied to any UAS, not just small commercial systems. As such, this could be modified and augmented slightly to accommodate applications such as UAM and military aircraft systems.