Quantitative Analytics for Beyond Visual Line of Sight Operational Risk Assessments

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OneSky

Overview

ASTM BVLOS approval process

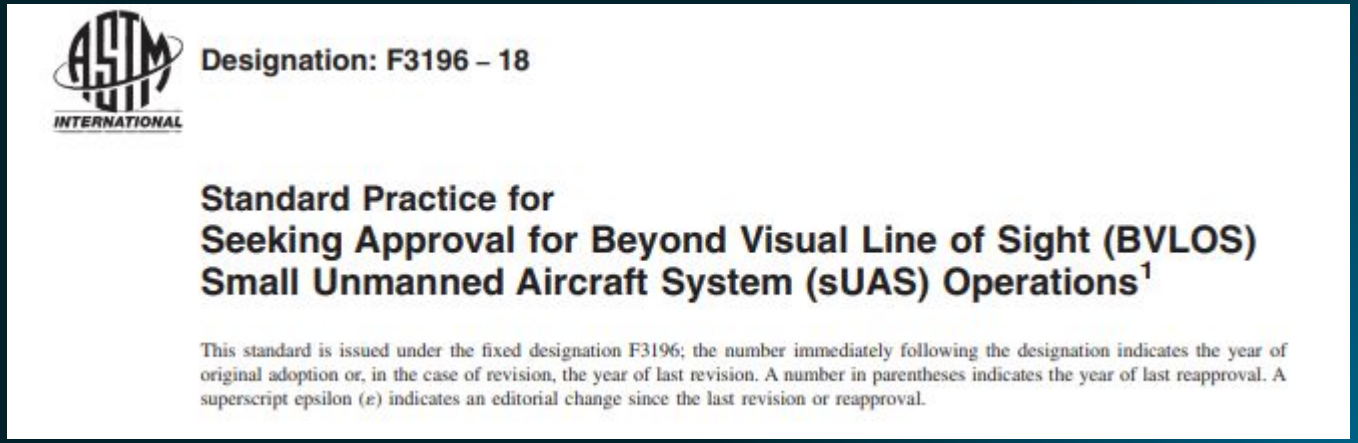
Operational Risk Assessments (ORA)

Quantitative Analytics as Risk Likelihood - Examples

Visualizing Risk Likelihood, Instantaneous and Aggregated

Steps to consider moving forward

ASTM BVLOS Approval Process



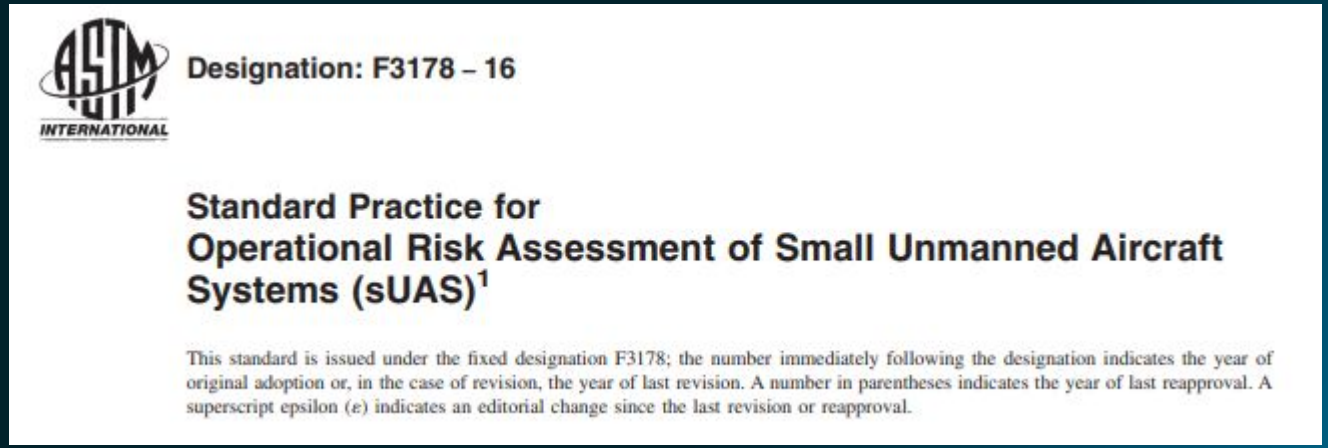
Designation: F3196 – 18

Standard Practice for
Seeking Approval for Beyond Visual Line of Sight (BVLOS) Small Unmanned Aircraft System (sUAS) Operations[1]

This standard is issued under the fixed designation F3196; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

- Section 5.1.3
  - Applicant must perform an ORA
- Section 7
  - ORA and CONOPS based on F3178

ASTM BVLOS Approval Process



Designation: F3178 – 16

Standard Practice for Operational Risk Assessment of Small Unmanned Aircraft Systems (sUAS)[1]

This standard is issued under the fixed designation F3178; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

- Table 1 - Severity Definitions
- Table 2 - Likelihood Definitions
- Table 3 - Risk Matrix

Operational Risk Assessments

Operational Risk is a combination of

- Severity
- Likelihood

Severity is dependent on the flight CONOPs

- Are you flying over Infrastructure, people?
- If something were to happen, how bad would it be?

Likelihood is a measure of whether something will happen

- Will navigation errors be under my threshold today?
- With this flight plan, will I have comm outages? How long will they last?

Risk Severity

CONOPs dependent
Rated as

- Negligible (1)
- Minor (2)
- Major (3)
- Hazardous (4)
- Catastrophic (5)

Possible to automate portions

Not in scope for this paper

Risk Likelihood

Whether something will happen or not

Rated as

- Extremely Improbable (1)
- Improbable (2)
- Remote (3)
- Occasional (4)
- Frequent (5)

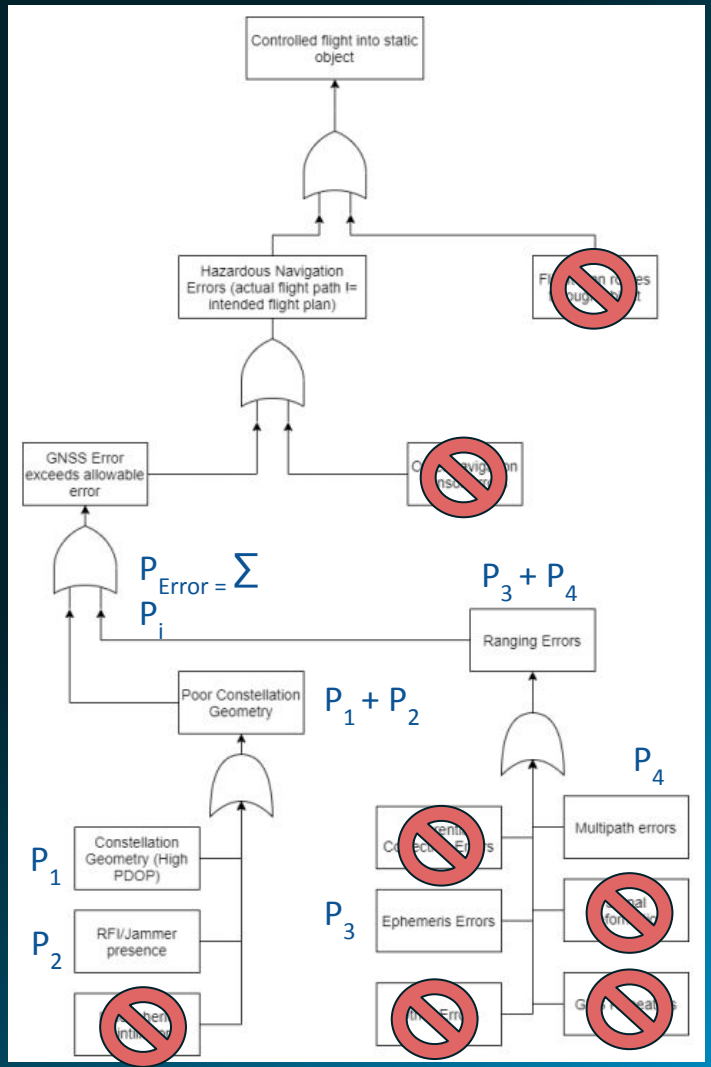
Many metrics can be modeled analytically

Metric Examples

- Navigation accuracy
- Communications performance
- Amount of time over populations
- Weather
- Lighting
- Obstacles, buildings and terrain

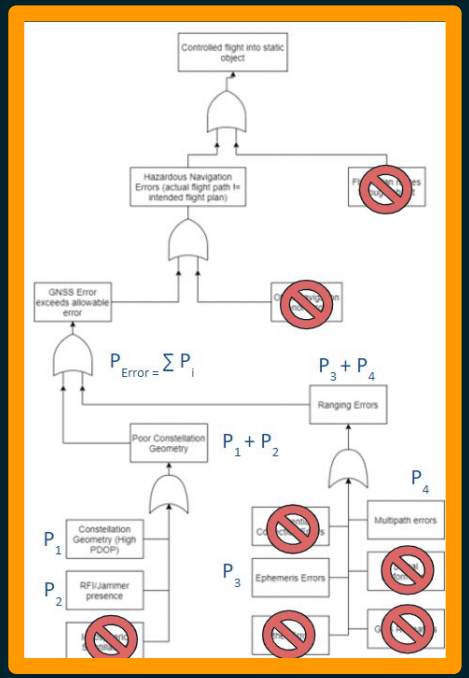
ORA Metric Example

- Fault tree analysis for GNSS Accuracy
- Consider your CONOPs
  - What is important?
- Probability associated with each step
- Sum probabilities to determine risk likelihood
- Based on your operations, experience and judgement, assign a likelihood value*



ORA Metric Example

GNSS Accuracy Likelihood: ● Occasional (4)



Likelihood Key

- Extremely Improbable
- Improbable
- Remote
- Occasional
- Frequent

Our approach to quantifying risk likelihood

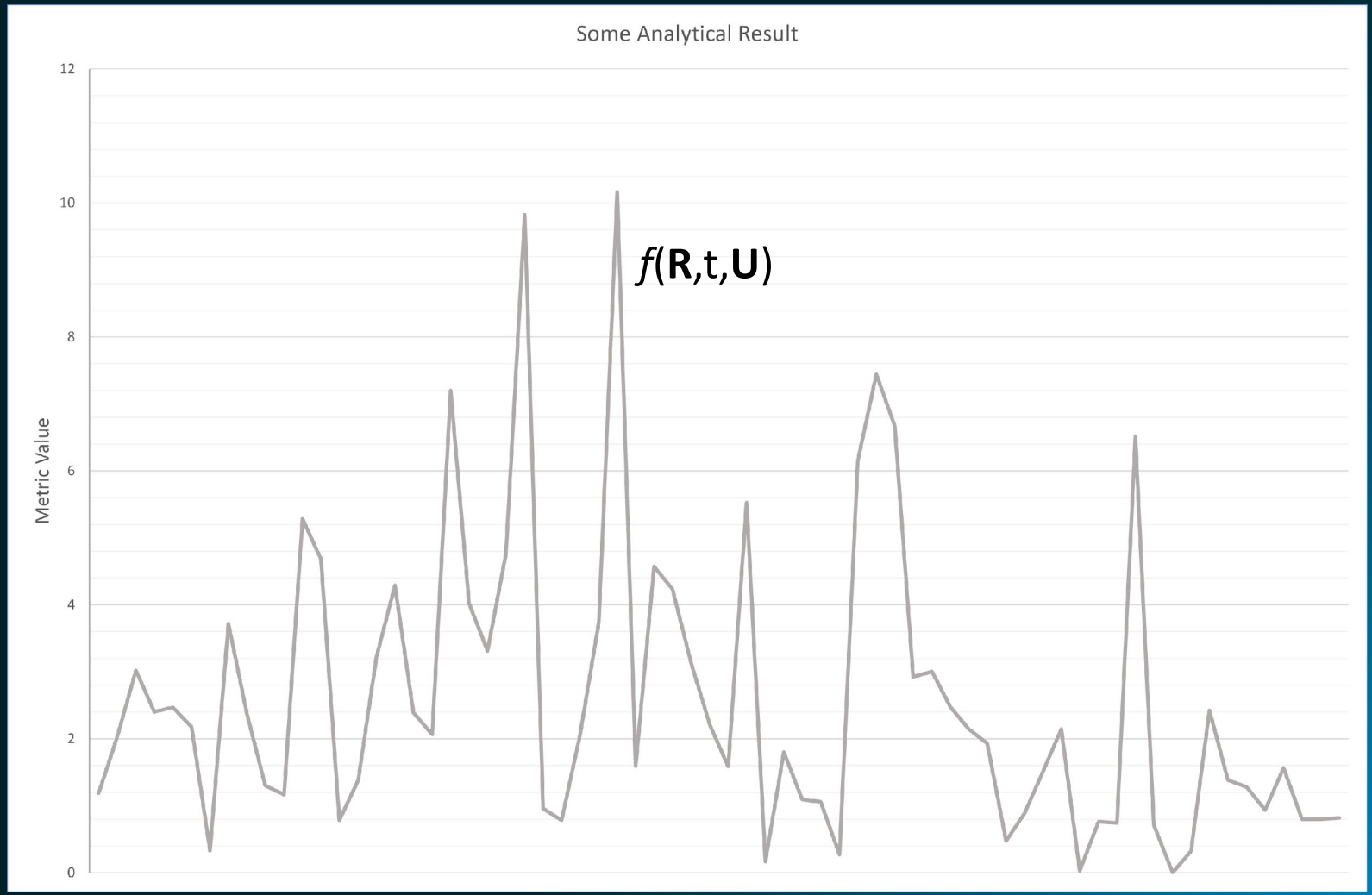
Metrics are defined by analytical functions:

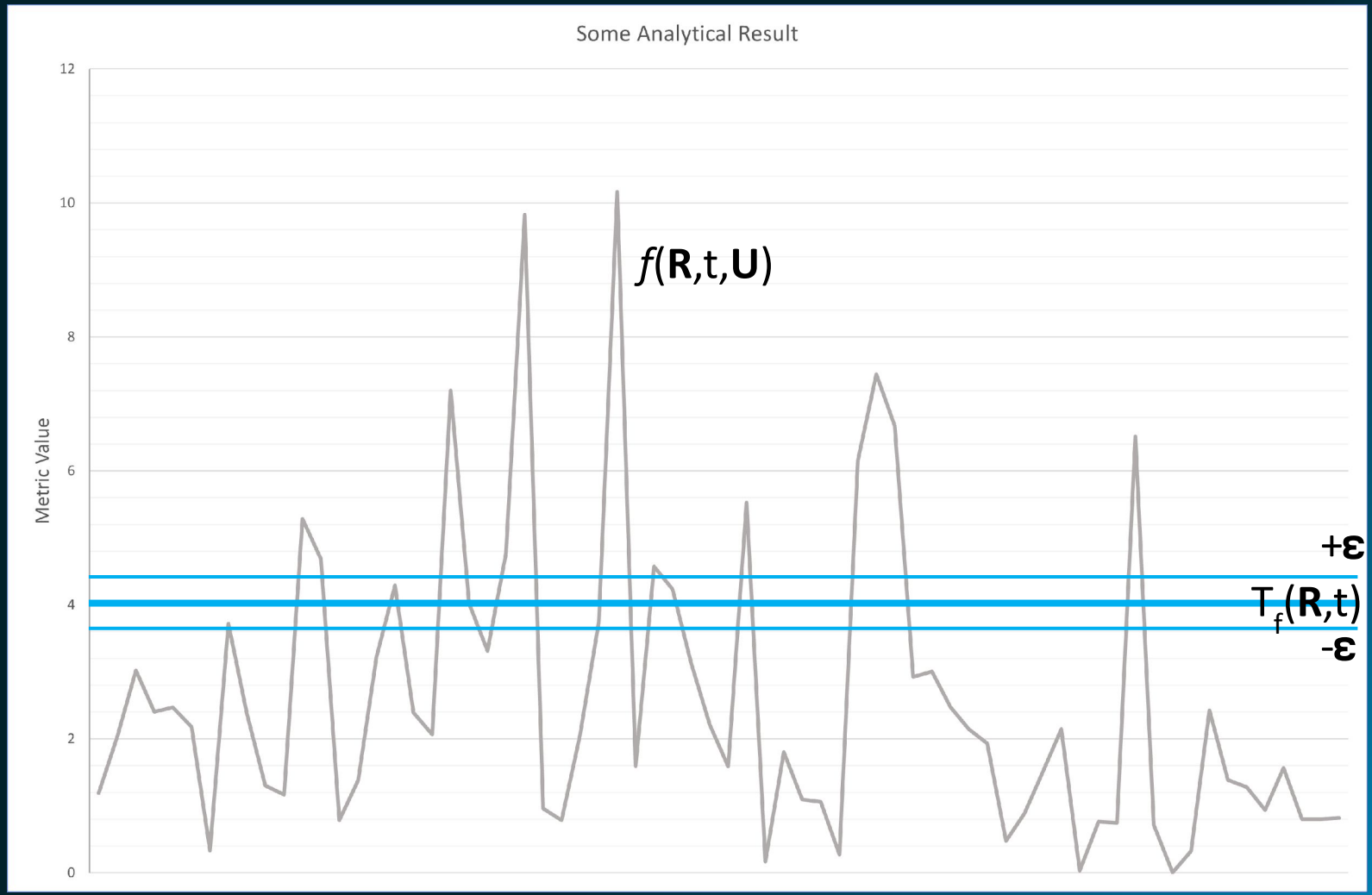
$$f(\mathbf{R},t,\mathbf{U})$$

U is a set of parameters defining how the metric is to be modeled

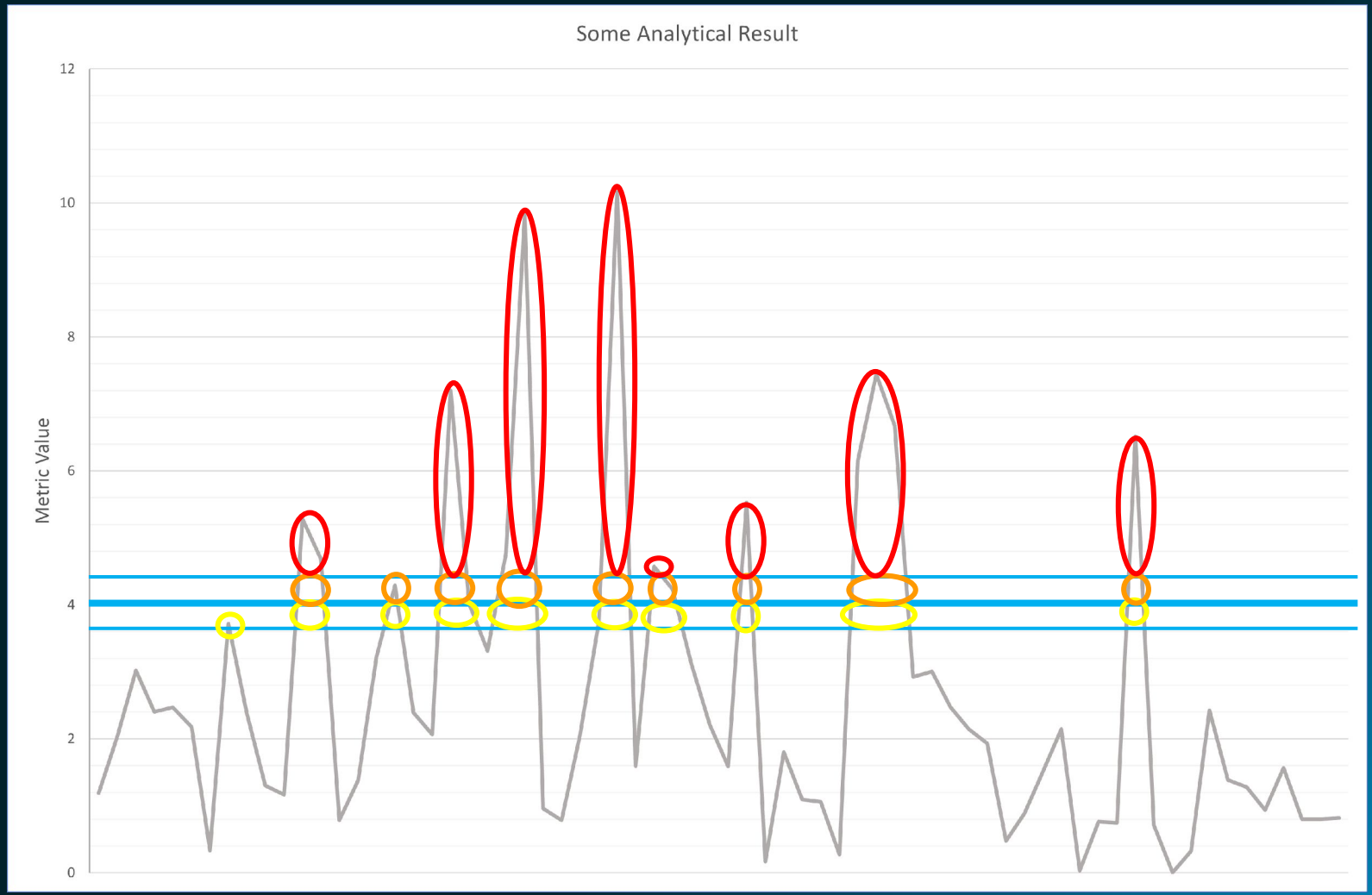
Operator consideration is modeled as a threshold function

$$T_f(\mathbf{R},t) \pm \boldsymbol{\varepsilon}$$


Some Analytical Result
12
10
8
6
4
2
0
Metric Value
f(R,t,U)


Some Analytical Result
Metric Value
12
10
8
6
4
2
0
f(R,t,U)
+ε
T_f(R,t)
-ε


Some Analytical Result
Metric Value
12
10
8
6
4
2
0


Some Analytical Result
Metric Value
12
10
8
6
4
2
0

Our approach to quantifying risk likelihood

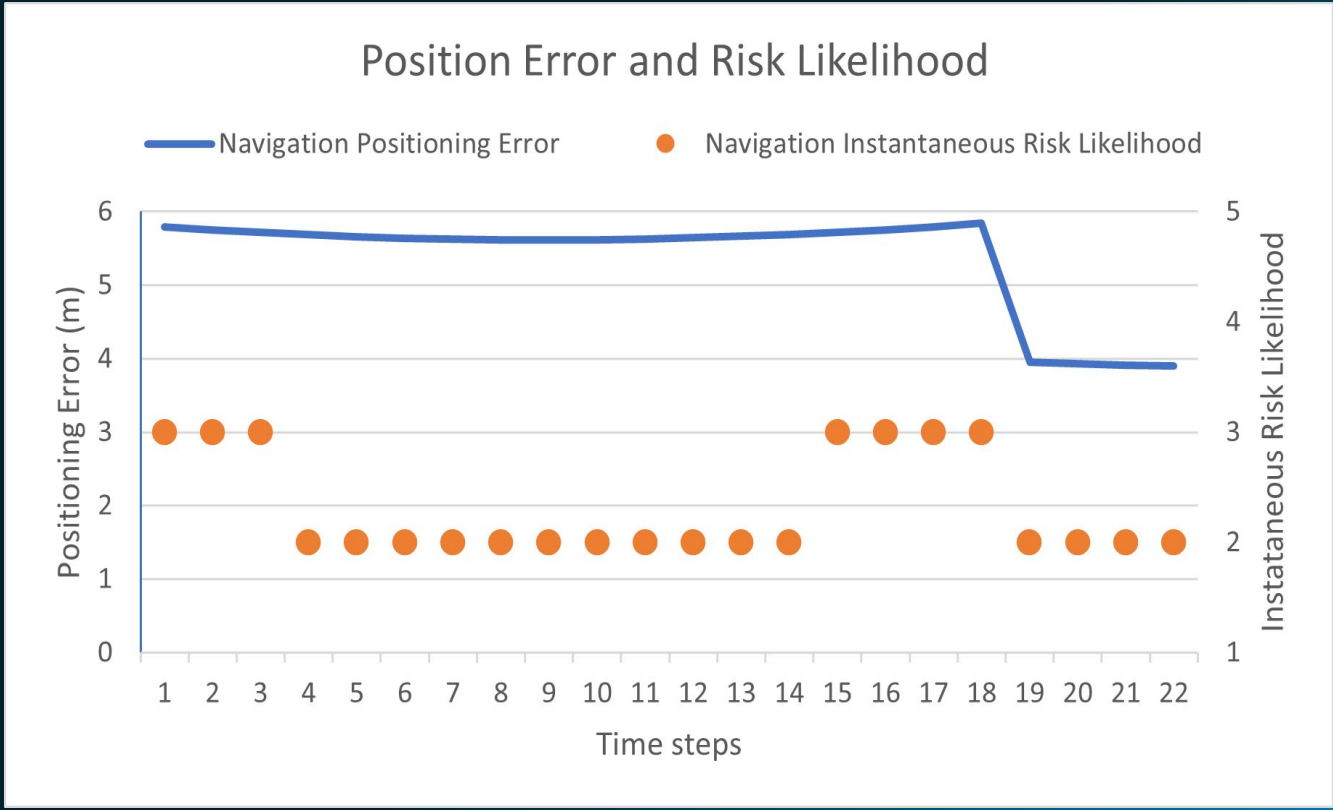
Let's take those values we're concerned with and assign a likelihood function:

$$\text{Likelihood} = L_{\textit{metric type}}\left(f(\mathbf{R},t,\mathbf{U}),\ \mathbf{T_f}(\mathbf{R},t),\ \boldsymbol{\beta}(\mathbf{R},t) \right)$$

We know that this algorithm must be tuned to the specific conditions set by the CAA and the operator

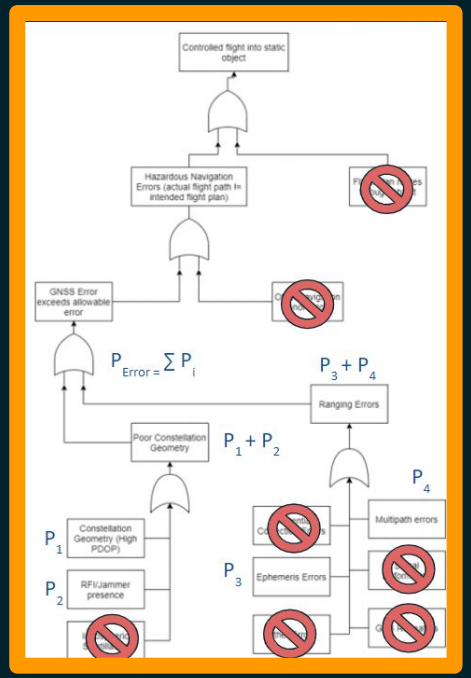
- The vector parameter $\boldsymbol{\beta}(\mathbf{R},t)$ is a set of tuning parameters specific for this CONOPs

Example Analytical and Likelihood metrics



ORA Metric Example

GNSS Accuracy Likelihood: ● Occasional



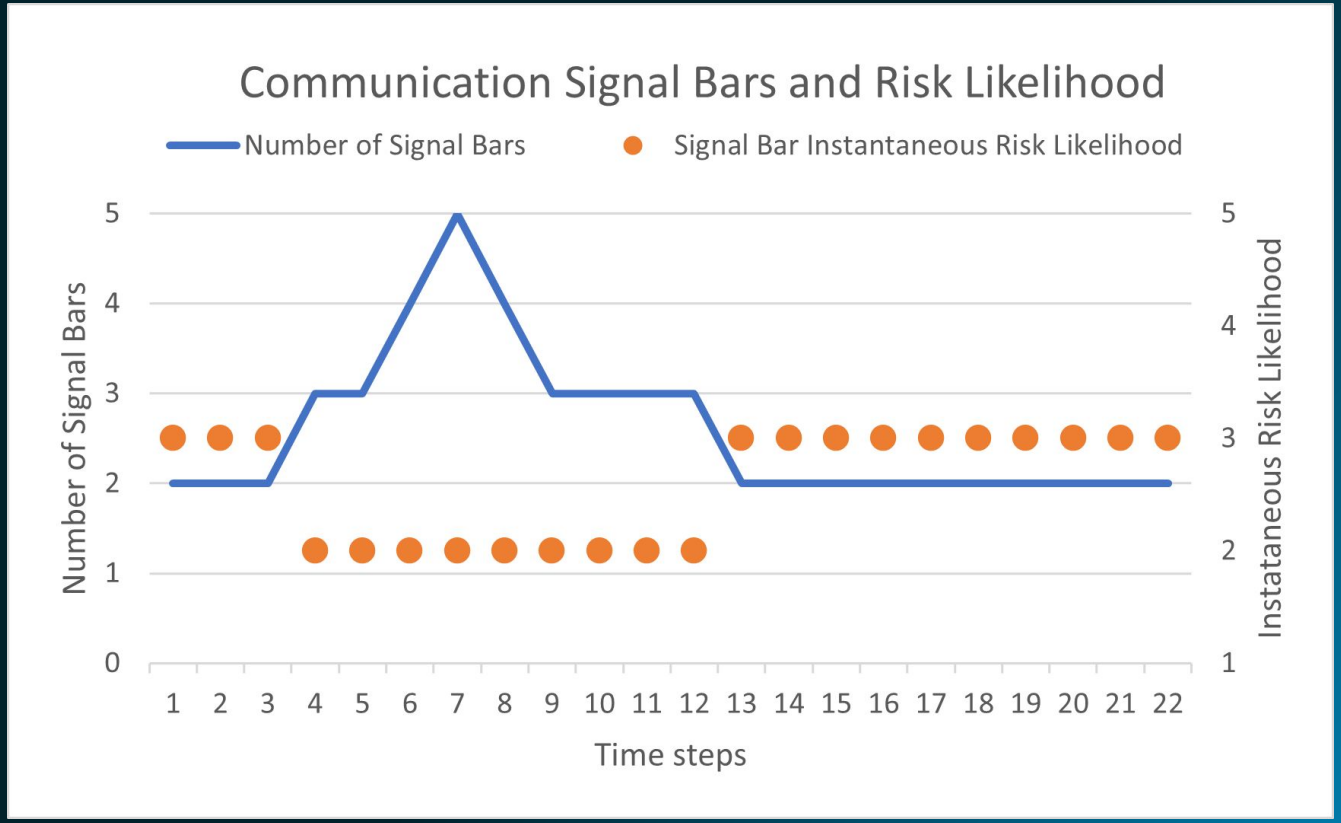
Likelihood Key

- Extremely Improbable
- Improbable
- Remote
- Occasional
- Frequent

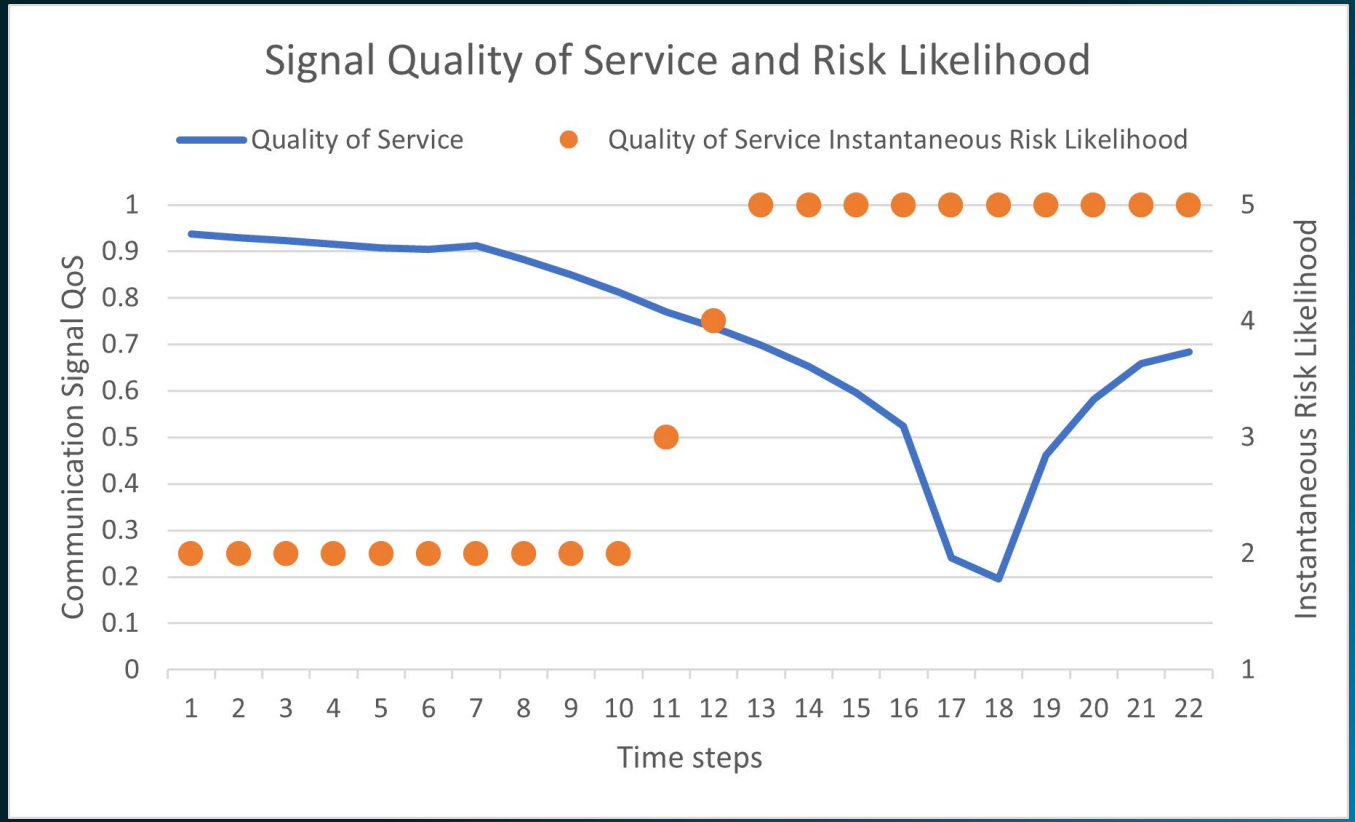
What about

- Communications Signal Strength: ??
- Communications Interference: ??
- Population: ??
- Weather: ??
- All others in your ORA?

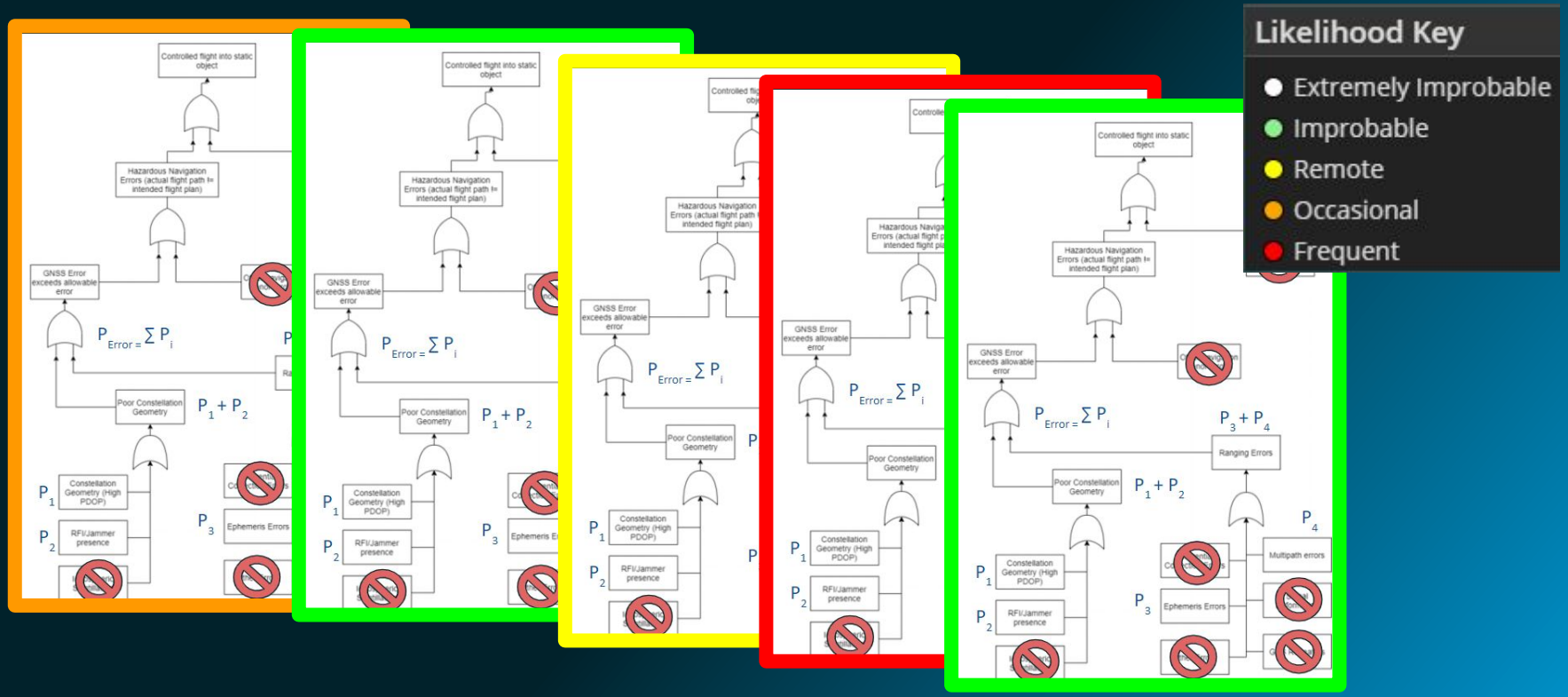
Example Analytical and Likelihood metrics



Example Analytical and Likelihood metrics



Aggregate Risk



Quantitative Aggregate Risk

Creating an aggregate likelihood value, uses all calculated likelihoods

$$\text{Aggregate Likelihood} = L_{Aggregate}(L_{GPS}, L_{Comm\ strength}, L_{Comm\ QoS}, \ldots)$$

The aggregate likelihood represents the overall likelihood for the entire route

- Including all metrics under consideration
- Metrics combined at a single time for a single likelihood at that time

Aggregate metrics will aid *fly/no fly* decisions

Methods being developed to assess changes in a single metric's risk against the whole ORA

Visualizing Risk Likelihood

Matt’s demo

Final Thoughts

Realizing no algorithm is perfect, we are working with operators to develop tuned risk predictions

- We’re always looking for more participants

To achieve automated approvals, we must also work with Civil Aviation Authorities

- Different organizations have different rules
- CAA and operator agreement on validity of risk is paramount

Multiple providers must produce same results

- Standardized algorithms and datasets are necessary for large-scale automation of operational risk assessments

Summary

Operational Risk Assessments are required for BVLOS approvals

Risk likelihood can be automated using analytical algorithms

Likelihood for multiple risk factors can be combined in aggregate

Visualization is key to determining overall risk, and judging the impact to flight operations

Important steps must occur to make predictions accurate, and viable across all producers, leading to automation of ORAs

Questions?

Stop by our round table right after this presentation

Check out the OneSky booth as well!