



Airspace Safety Threshold Study: Status Update to SC-228 DAA Safety Sub-Group

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Overview

Objective: Provide the encounter rate and relative state data that are needed to establish the safety case for UAS integration into the NAS

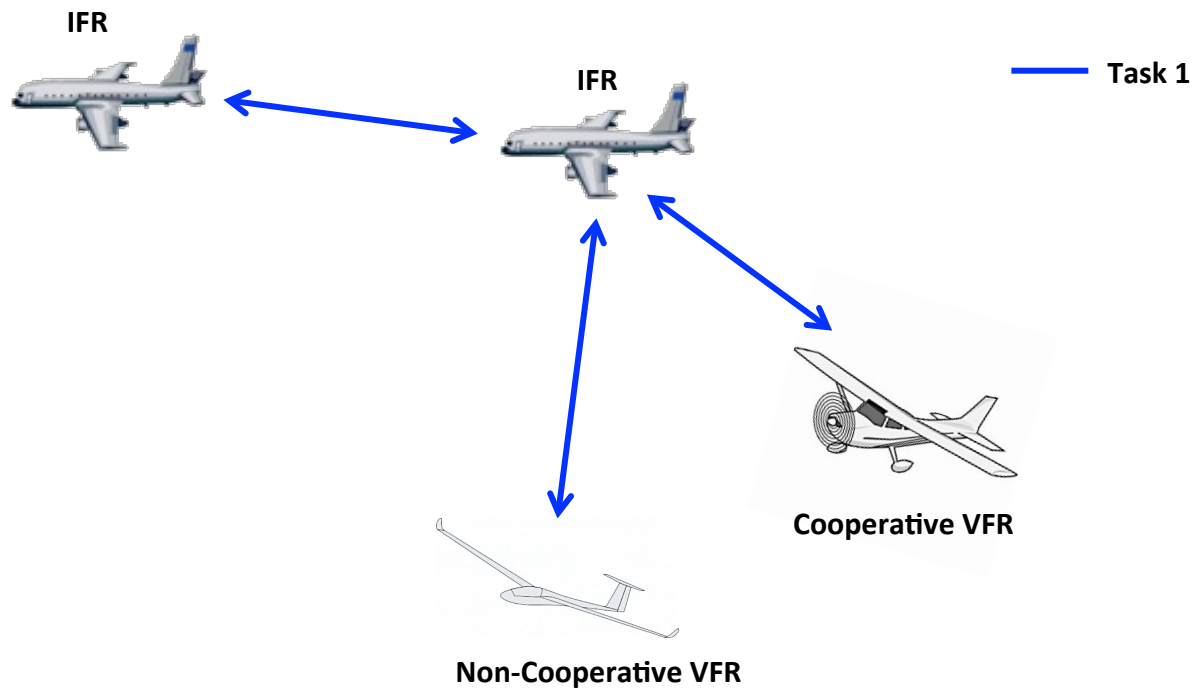
- Encounter Rates calculated at different thresholds
- Relative State Data used to initialize encounter model



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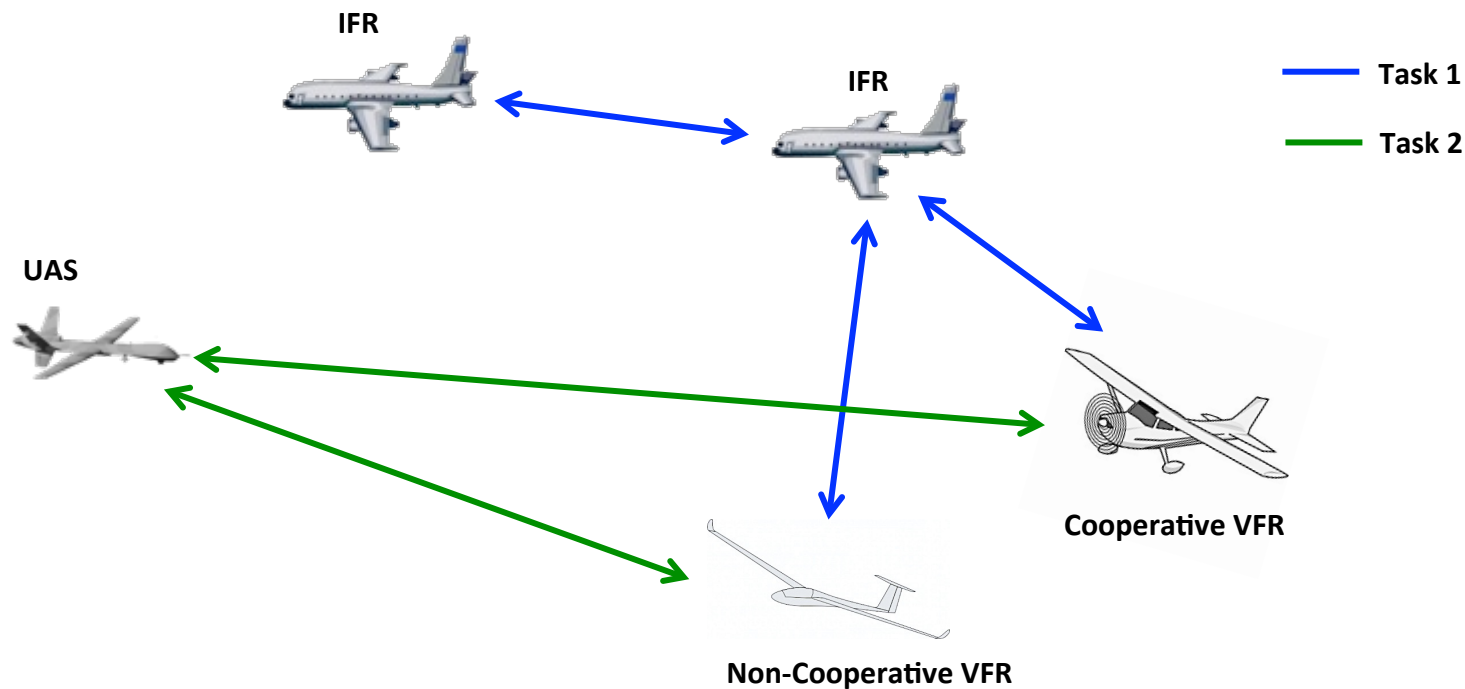
- Encounter Rates calculated at different thresholds
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Overview

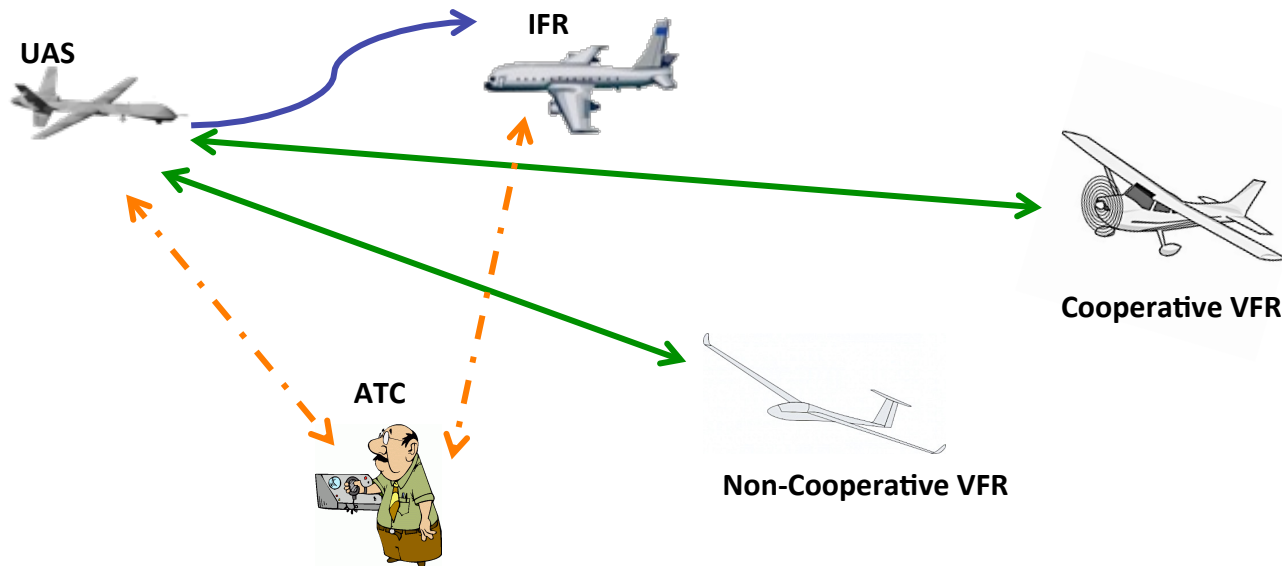
Objective: Provide the encounter rate and relative state data that are needed to establish the safety case for UAS integration into the NAS

- Encounter Rates calculated at different thresholds
- Relative State Data used to initialize encounter model



Task 2 Assumption Check

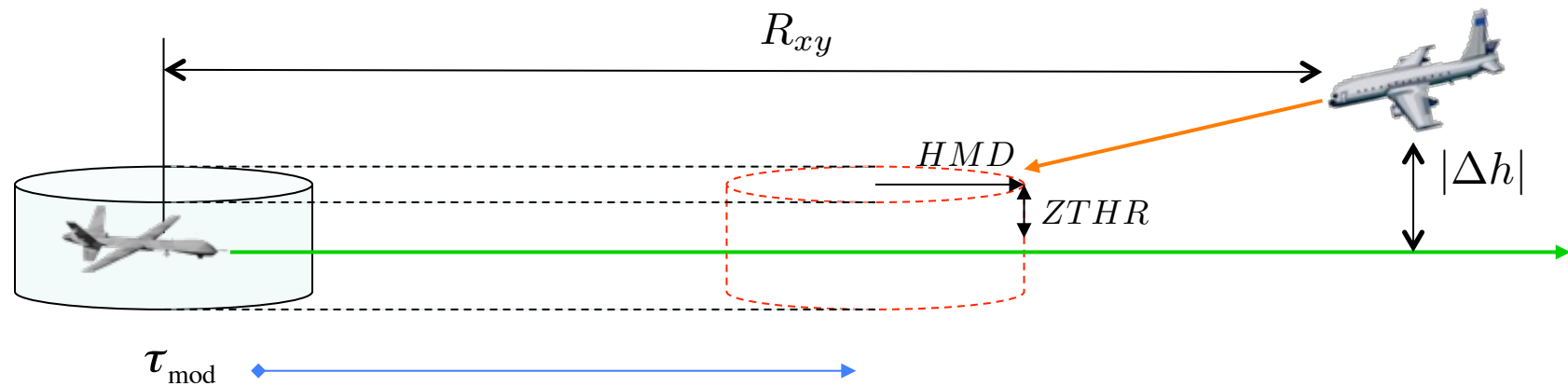
- Check assumption that ATC reroutes of UAS and manned IFR aircraft for separation (5nmi/1000ft) are infrequent and have negligible effect on UAS-VFR encounter rates and relative state data





Threshold Definitions

Thresholds

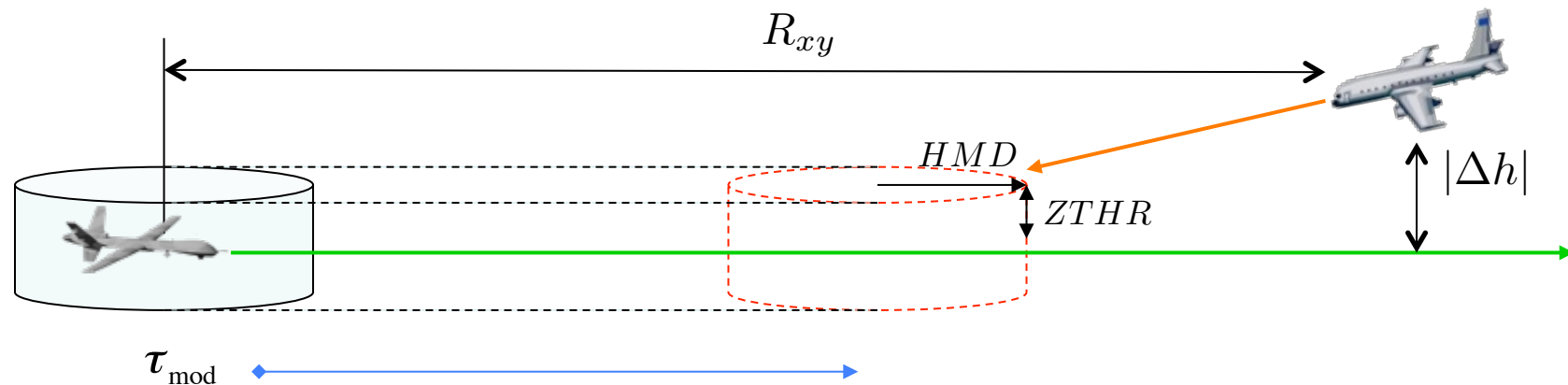


$$R_{xy} < HMD$$

$$|\Delta h| < ZTHR$$

$$0 \leq \tau_{mod} < \tau_{thr}$$

Threshold 1: Encounter #1



$$|\Delta h| < ZTHR$$

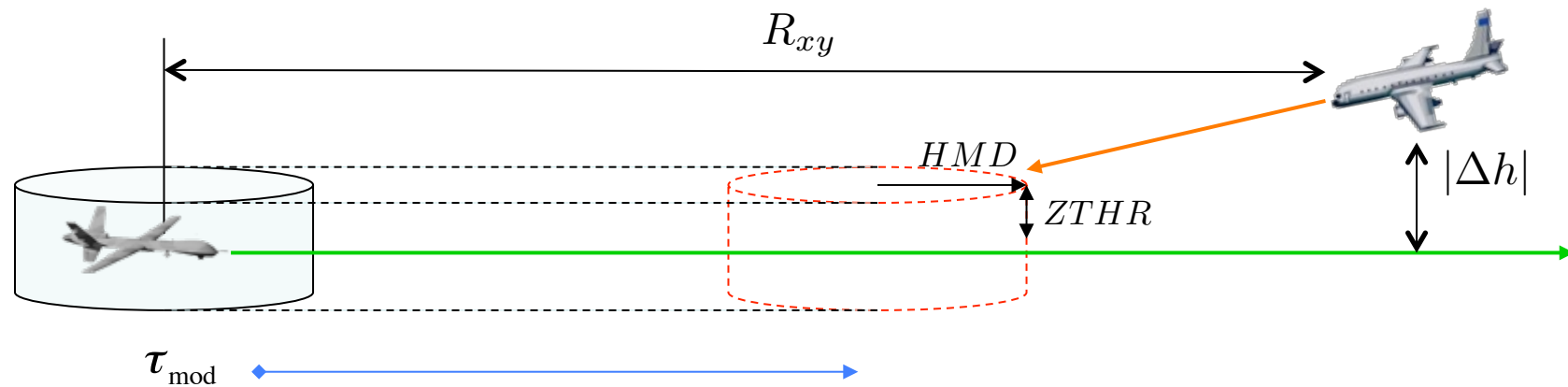
$$ZTHR = 2000 \text{ ft}$$

$$0 \leq \tau_{mod} < \tau_{thr}$$

$$\tau_{thr} = 100 \text{ sec}, DMOD = 4000 \text{ ft}$$

Threshold 4 is the CPA of Threshold 1 encounters

Threshold 5: Encounter #2



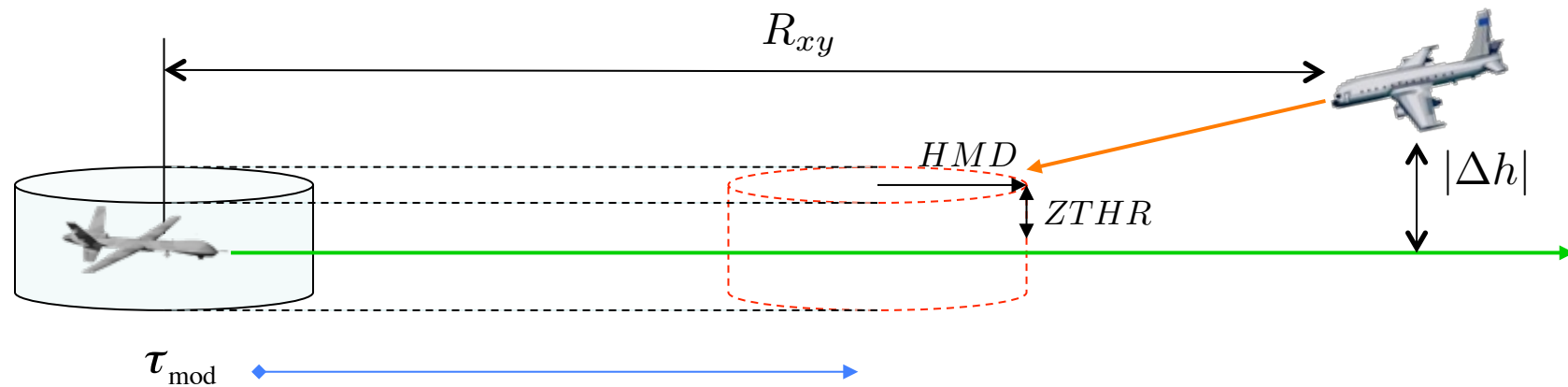
$$|\Delta h| < ZTHR$$

$$0 \leq \tau_{mod} < \tau_{thr}$$

$$ZTHR = 2000 \text{ ft}$$

$$\tau_{thr} = 150 \text{ sec}, DMOD = 4000 \text{ ft}$$

Threshold 2: Well-Clear Definition



$$R_{xy} < HMD$$

$$HMD = 4000 \text{ ft}$$

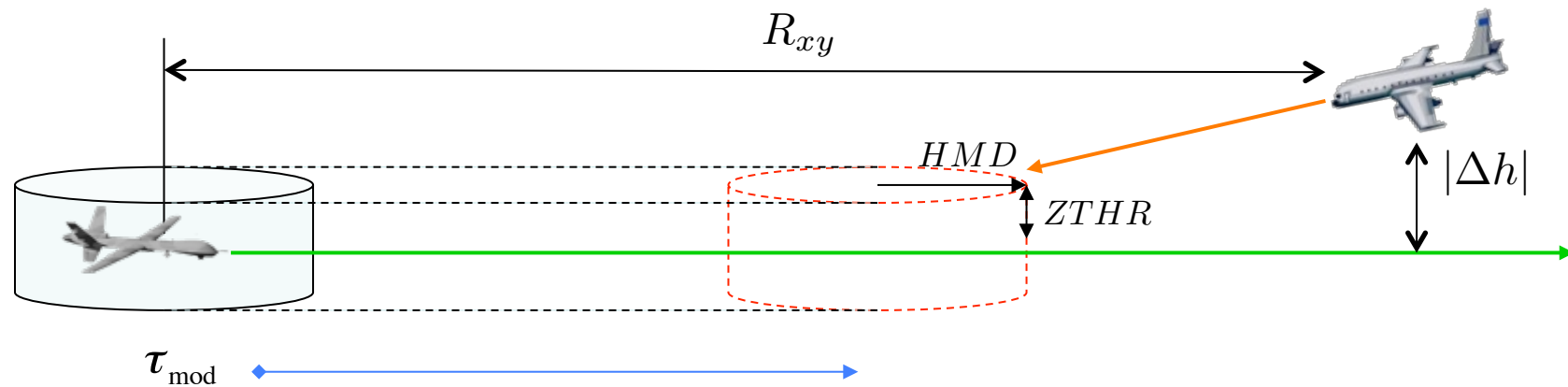
$$|\Delta h| < ZTHR$$

$$ZTHR = 450 \text{ ft}$$

$$0 \leq \tau_{mod} < \tau_{thr}$$

$$\tau_{thr} = 35 \text{ sec}, DMOD = 4000 \text{ ft}$$

Threshold 3: Near Mid-Air Collision (NMAC)



$$R_{xy} < HMD \quad HMD = 500 \text{ ft}$$

$$|\Delta h| < ZTHR \quad ZTHR = 100 \text{ ft}$$



Task 1 Status Update

Task 1: Status

- Objective: Provide encounter rates and collect relative state data for IFR vs IFR, IFR vs cooperative VFR, IFR vs non-cooperative VFR encounters
- Data Collection: Complete
 - 84th Squadron RADES (IFR and VFR) NAS-wide data from 4 months in 2012 (21 days total)



Traffic Scenario Selection

- 21 days across 4 seasons in 2012
- Each day is 24 hours starting at 0:00 UTC

January 2012						
Su	M	Tu	W	Th	F	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

April 2012						
Su	M	Tu	W	Th	F	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

July 2012						
Su	M	Tu	W	Th	F	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

October 2012						
Su	M	Tu	W	Th	F	Sa
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

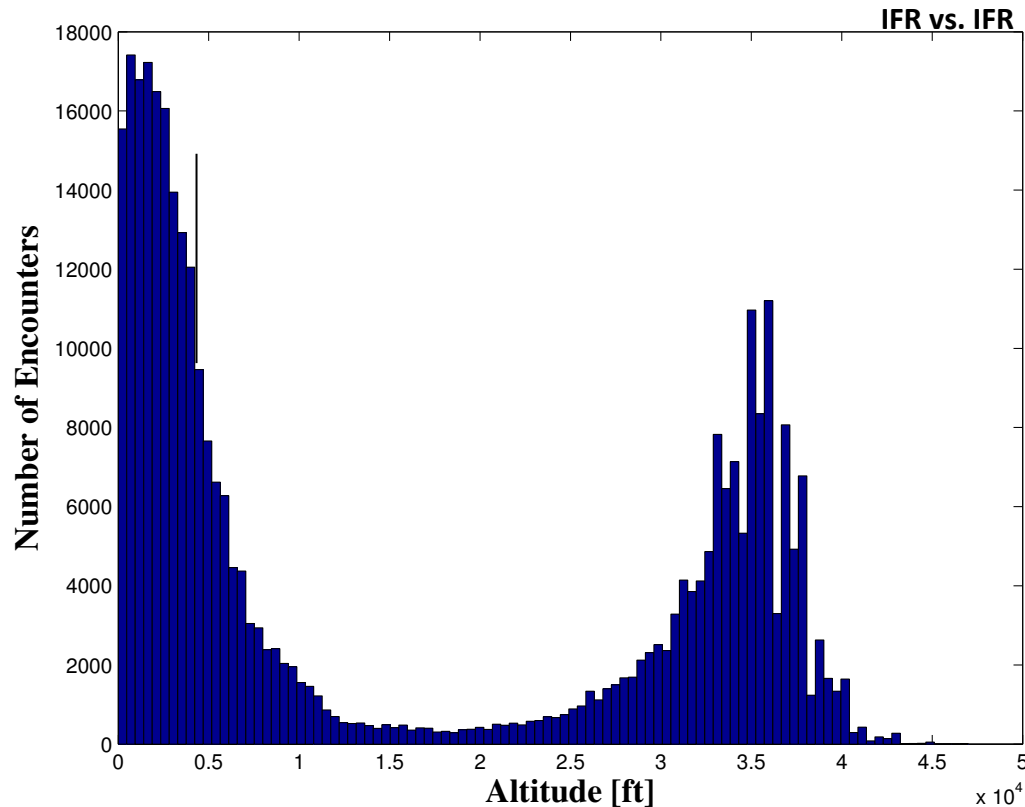


Task 1: Status

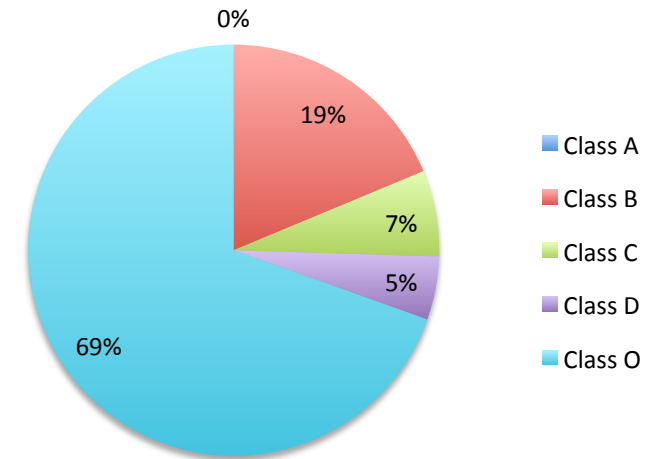
- Objective: Provide encounter rates and collect relative state data for IFR vs IFR, IFR vs cooperative VFR, IFR vs non-cooperative VFR encounters
- Data Collection: Complete
 - 84th Squadron RADES (IFR and VFR) NAS-wide data from 4 months in 2012 (21 days total)
 - RADES data processing:
 - Read/save raw radar data: RS4 (RADES Software 4) and SDK
 - Create tracks (clustering algorithm, Kalman filter): Matlab
 - Assign altitudes to non-cooperative VFR tracks based on probabilistic study of airspace densities by Honeywell
- Analysis Scripts: Complete
 - Encounter rate processing: C code
 - 11 days processed, 10 days to be processed (expected completion: 1 week)



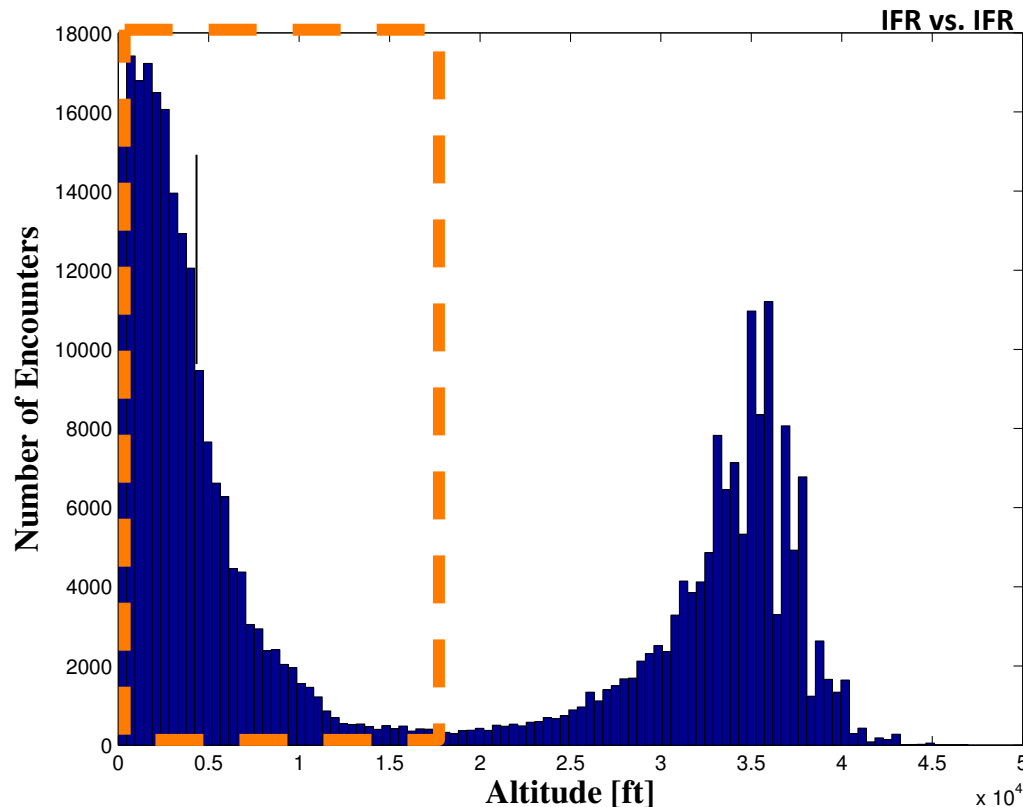
Threshold 1 Encounter Rates by Altitude/Airspace



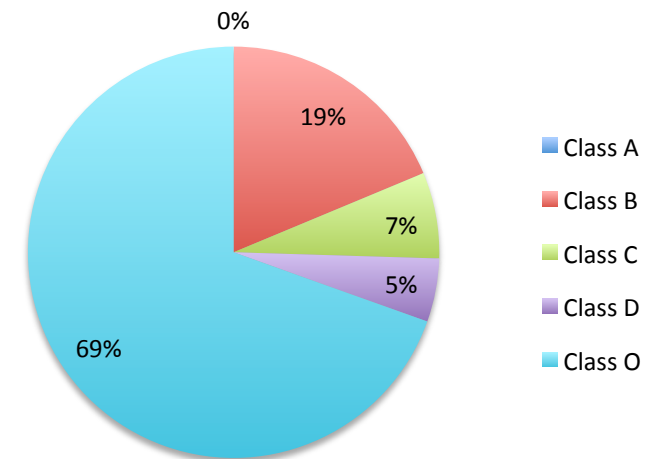
Percentage of Encounters by Class for IFR vs. IFR



Threshold 1 Encounter Rates by Altitude/Airspace

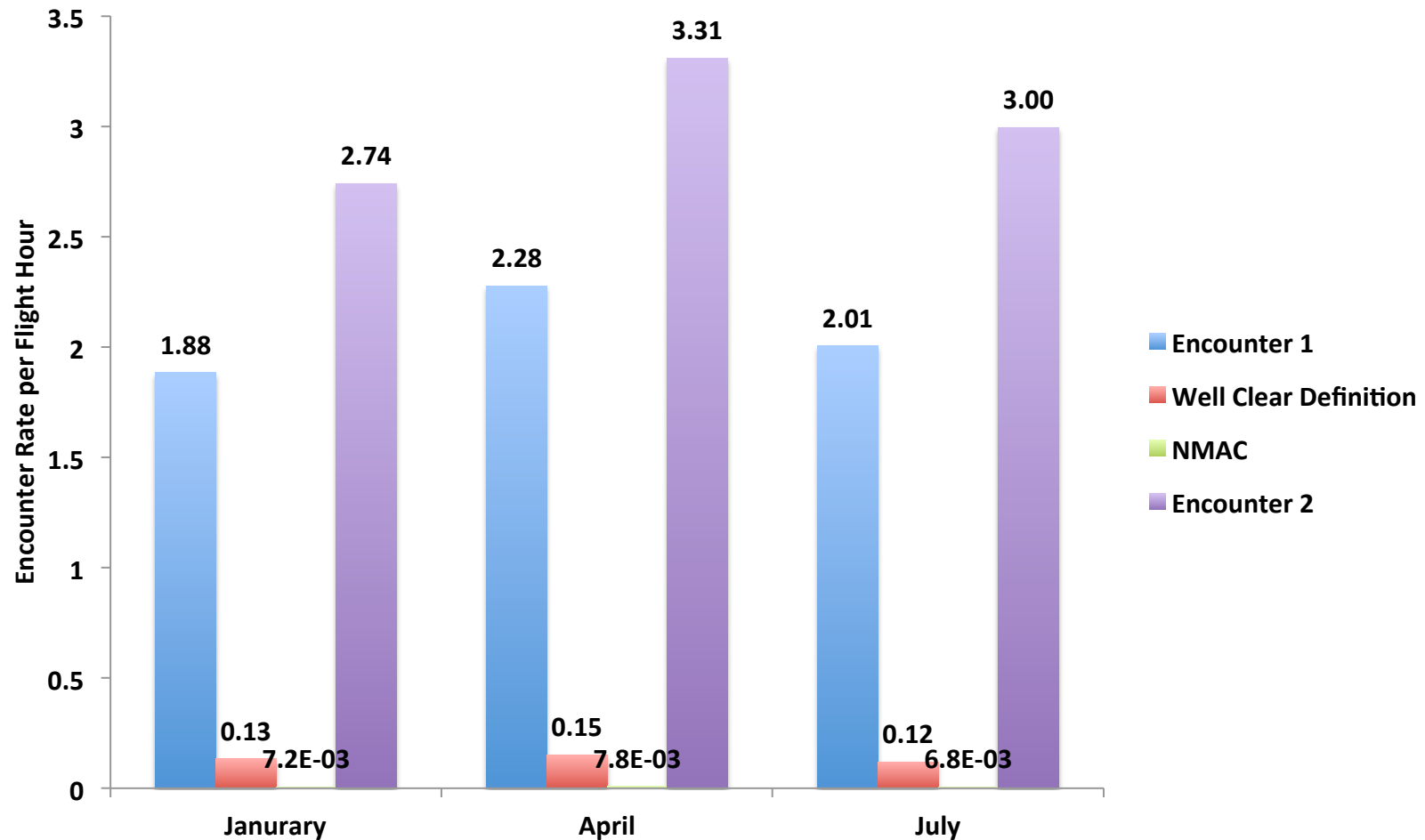


Percentage of Encounters by Class for IFR vs. IFR

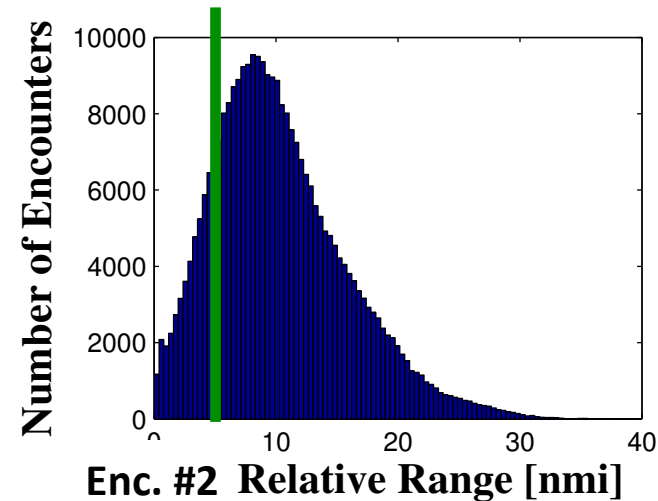
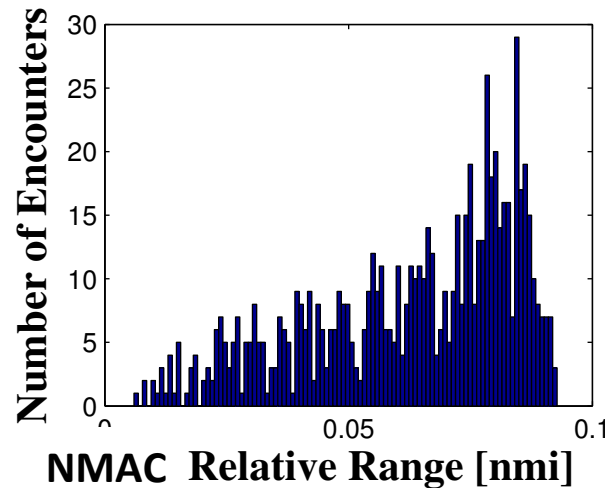
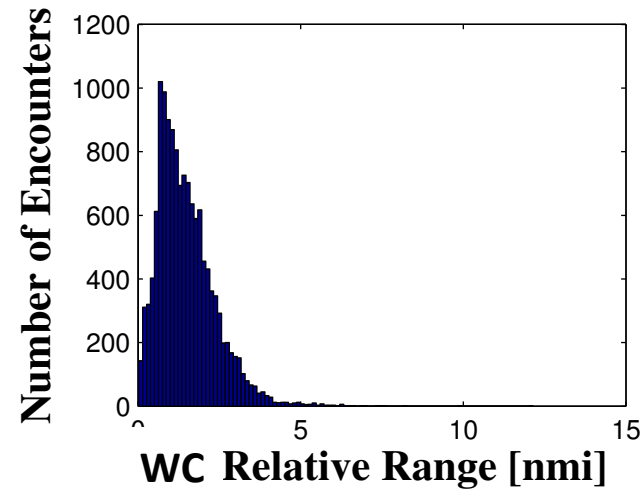
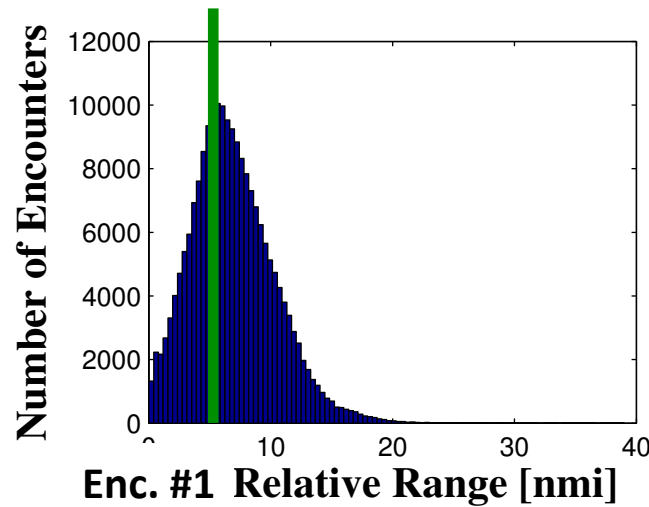


- Results presented in follow-up slides are for encounters that occurred at 18,000 ft and below

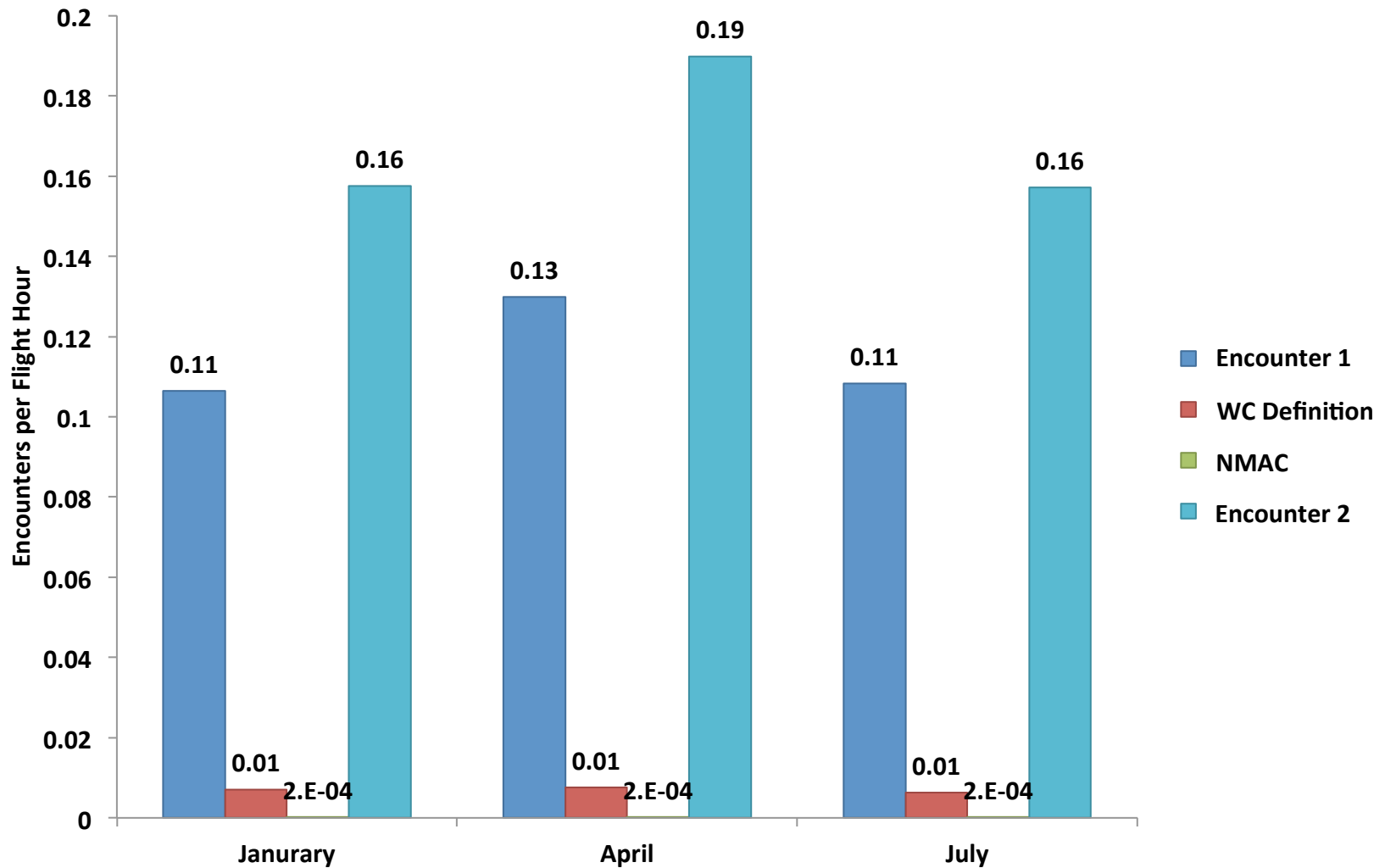
Task 1 Results: IFR vs. IFR below FL180



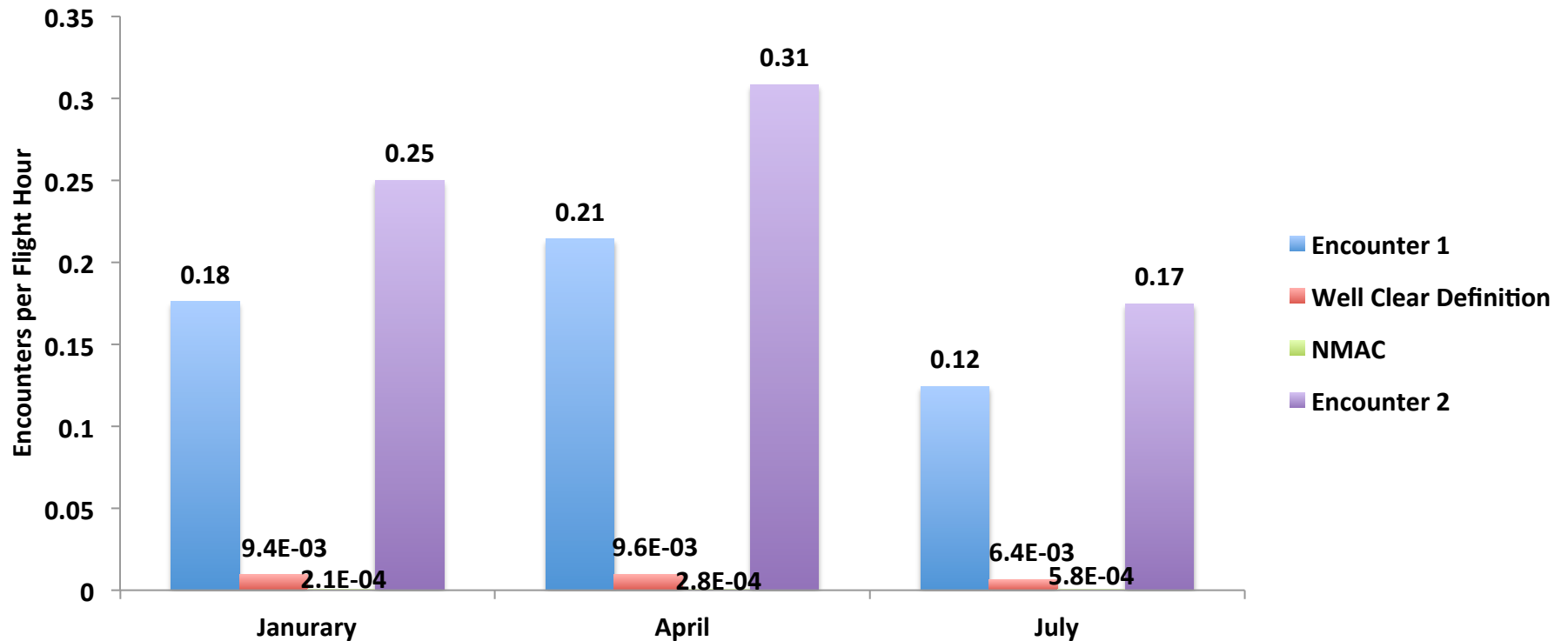
Relative Range for IFR vs. IFR



Task 1 Results: IFR vs. Cooperative VFR below FL180



Task 1 Results: IFR vs. Non-Cooperative VFR below FL180





Task 2 Status Update

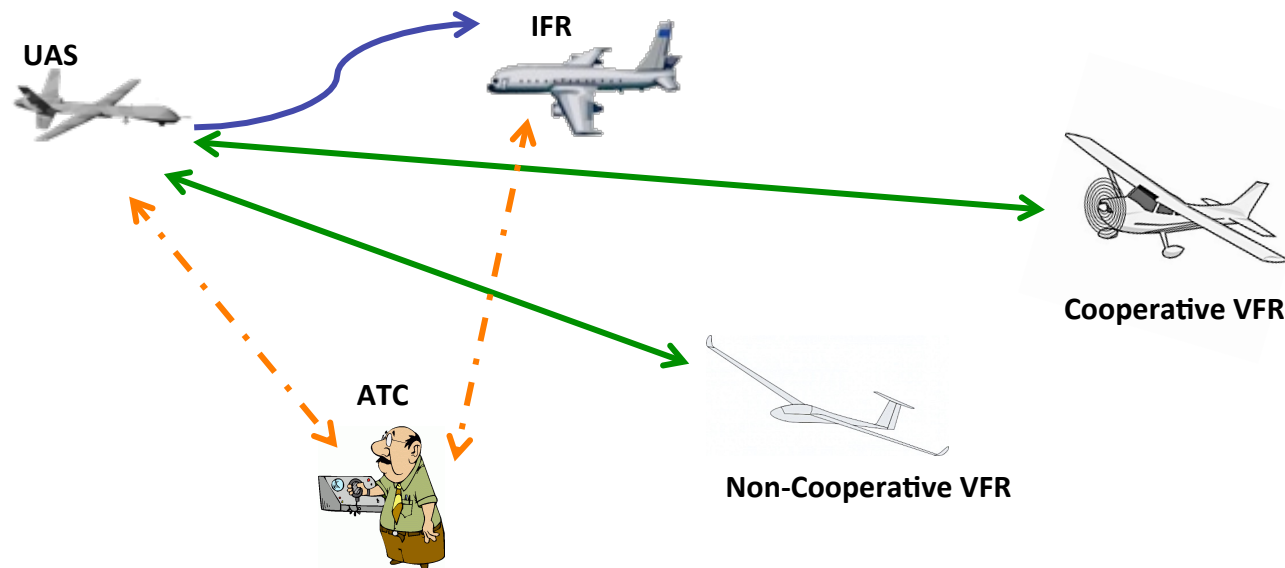
Task 2: Status

- Objective: Provide encounter rates and collect relative state data for UAS vs cooperative VFR and UAS vs non-cooperative VFR encounters (no mitigation)
- Data Collection: In-progress (estimated completion: 1 week)
 - Data Sources: 18 UAS mission types (IAI), cooperative and non-cooperative VFR (RADES) data from 4 months in 2012
 - Platform: ACES (Airspace Concept Evaluation System)
 - 13 days simulated, 8 days to be simulated
- Analysis: In-progress (estimated completion 2 weeks)
 - Encounter rate processing: Matlab scripts (complete)
 - All days need to be analyzed



Task 2 Assumption Check

- Check assumption that ATC reroutes of UAS and manned IFR aircraft for separation (5nmi/1000ft) are infrequent and have negligible effect on UAS-VFR encounter rates and relative state data



Task 2 Assumption Check: Status

- Additional simulation capabilities identified and in work (expected completion: 2 weeks)
- Data Collection: 2-4 days of data to be simulated and analyzed (expected completion: 2 weeks)
 - Data Sources: ASDI (IFR), IAI UAS Missions, RADES (VFR)
 - Platform: ACES (Airspace Concept Evaluation System)
- Post-processing analysis scripts in work



Concluding Remarks

Status Update:

- Task 1: IFR vs IFR, IFR vs cooperative VFR, IFR vs non-cooperative VFR encounter rates and relative state data in progress. Expected completion: 1 week.
- Task 2: Data collection for UAS-VFR encounters is underway. Expected completion (including data analysis): 2-3 weeks
- Task 2 assumption check that UAS-IFR reroutes by ATC have negligible effect on UAS-VFR encounter rates and relative state data: Software development scoped out and in-progress, data collection and post-processing expected completion: 4 weeks.

Questions?

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- Marcus Johnson: marcus.johnson@nasa.gov

