National Aeronautics and Space Administration

Unmanned Aircraft Systems (UAS) Controller Acceptability Study 3 (CAS3): Collision Avoidance, Self Separation, and Alerting Times (CASSAT)

Combined PER/FER
March 6, 2015

Principal Investigators:
James R. Comstock, Jr.
Maria C. Consiglio
Rania W. Ghatas
Michael J. Vincent
NASA Langley Research Center

PER and FER Purposes

- Preliminary Experiment Review (PER):
  - “Is this the right experiment or study to address the research question(s)?”

- Final Experiment Review (FER):
  - “Has the experiment or study been designed/planned the right way?”

Outline

- Background
  - Detect And Avoid (DAA) Issues
  - Overview of Controller Acceptability Study 1 (CAS1) Results
  - Overview of Controller Acceptability Study 2 (CAS2) Results
- Upcoming Study Focus
  - Controller Acceptability Study 3 (CAS3) aka Collision Avoidance, Self Separation, and Alerting Times (CASSAT)
  - Builds on CAS1 and CAS2
  - Looking at acceptability of GCS display alerting times for both the GCS pilot and the Air Traffic Controller (to be tested separately)
  - Methodology
  - Schedule

The Sense and Avoid (SAA) Challenge for UAS

- Pilots are required to see and avoid other aircraft
  - 14CFR 91.111 (a) No person may operate an aircraft **so close to another aircraft as to create a collision hazard**.
  - 14CFR 91.113 (b) *General*. When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, **vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft**. When a rule of this section gives another aircraft the right-of-way, the pilot shall give way to that aircraft and **may not pass over, under, or ahead of it unless well clear**.

- Sense and Avoid (SAA) was defined by the FAA sponsored SAA for UAS Workshop Final Report published in October 9, 2009 as "the combination of UAS Self-Separation (SS) plus Collision Avoidance (CA) as a means of compliance with 14CFR Part 91, § 91.111 and § 91.113"

- SAA-equipped UAS should seamlessly interoperate with other aircraft, air traffic services and existing collision avoidance technologies

Self Separation and Collision Avoidance

From the SAA Workshop Final Report:*

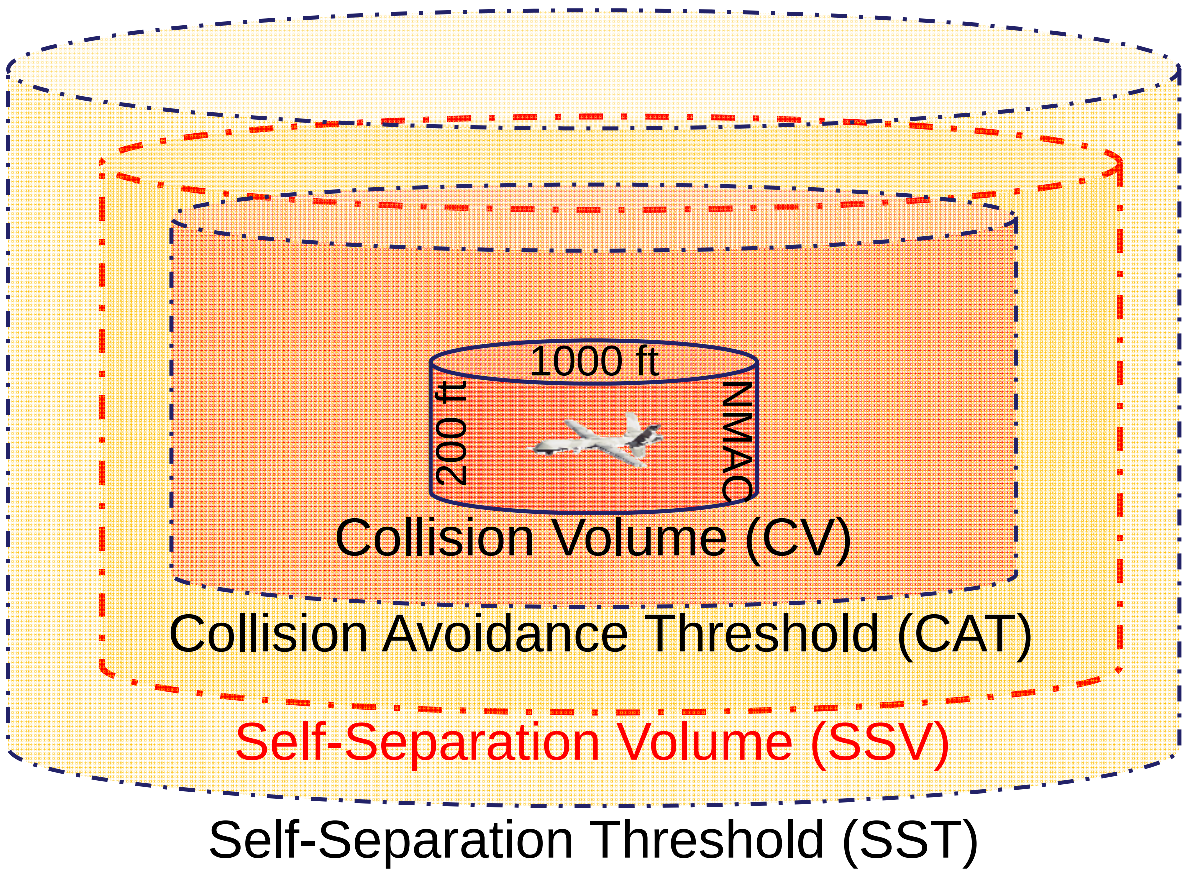
- Self Separation (SS) Function
  - SS is "essential" and "could be the only function" of SAA
  - Intended as a means to remain "well clear"
  - "Normal/operational, non obtrusive maneuvers"
  - Maneuvers made early enough to avoid CA activation

- Collision Avoidance (CA) Function
  - CA engages "when all other modes of separation fail"
  - Intended as a means to avoid Near Mid-Air Collisions (NMACs)
  - CA maneuvers made "within a relatively short time horizon before closest point of approach [CPA]"

* Sense and Avoid (SAA) for Unmanned Aircraft Systems (UAS). Prepared by: FAA Sponsored Sense and Avoid Workshop, October 9, 2009.

CV, CAT, ***SSV***, SST and "Well Clear"

Workshop Model with NASA SSI Concept's Self-Separation Volume (SSV):



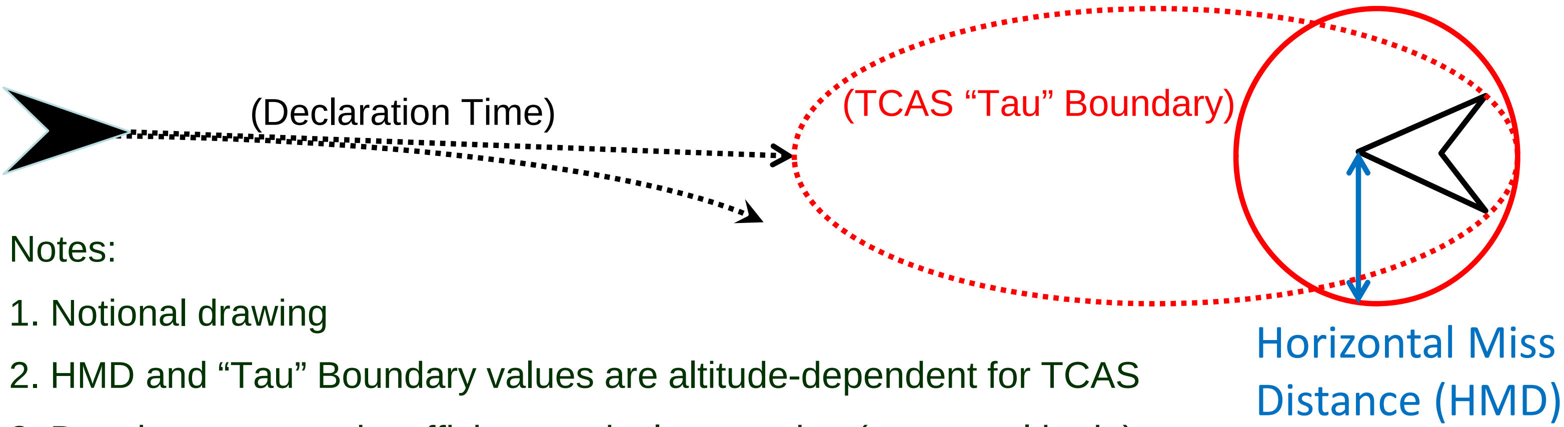
Note: CAT, SSV and SST boundaries are notional and generally not cylindrical

Clear of Self Separation Volume (SSV) = Well Clear

- SSV size should be large enough to avoid:
    - Corrective RAs for TCAS-equipped intruders
    - Safety concerns for controllers
    - Undue concern for proximate see-and-avoid pilots
- SSV size should be small enough to avoid disruptions to traffic flow
- SSV size should vary appropriately with operational area (airport vicinity, en route, etc.)

Determination of minimum and maximum operationally acceptable SSV sizes will inform the design space for required SAA surveillance accuracy

SAA "Self Separation Bands" Concept



Notes:

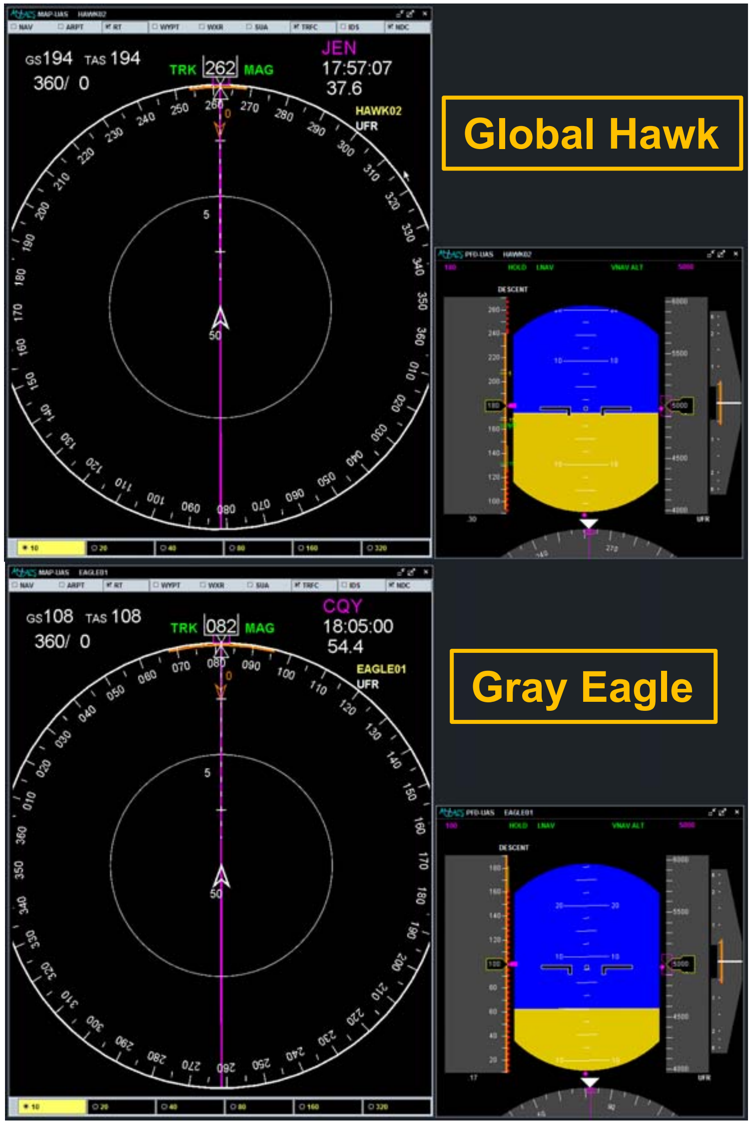
1. Notional drawing
2. HMD and "Tau" Boundary values are altitude-dependent for TCAS
3. Drawing assumes insufficient vertical separation (e.g., co-altitude)

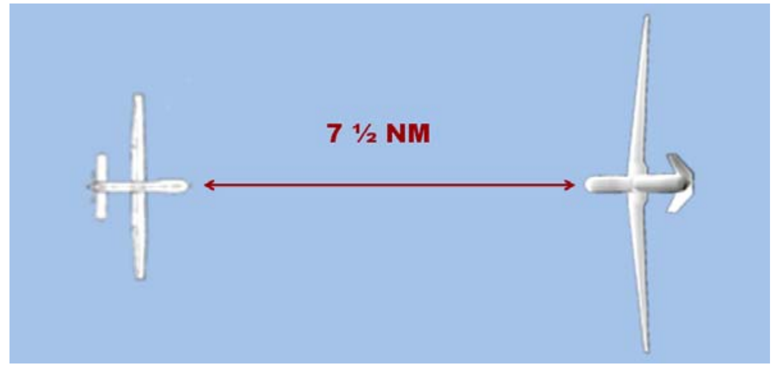
If Ownship trajectory will pass within HMD laterally of intruder then

- "Self Separation Bands" will appear on Ownship trajectory when within specified declaration time of the Tau boundary
- Pilot will need to negotiate a trajectory change outside of Bands

No Bands will appear on trajectory if it will pass outside of HMD

Self Separation Bands Example





Head-On Encounter:

- Global Hawk (194 kts, 3 deg/sec turn)
- Grey Eagle (108 kts, 1 deg/sec turn)
- Declaration Time = 120 secs
- “TCAS Bands” (20 sec tau, .35 nmi HMD)
- Different Performance = Different Bands

Tau and HMD for TCAS

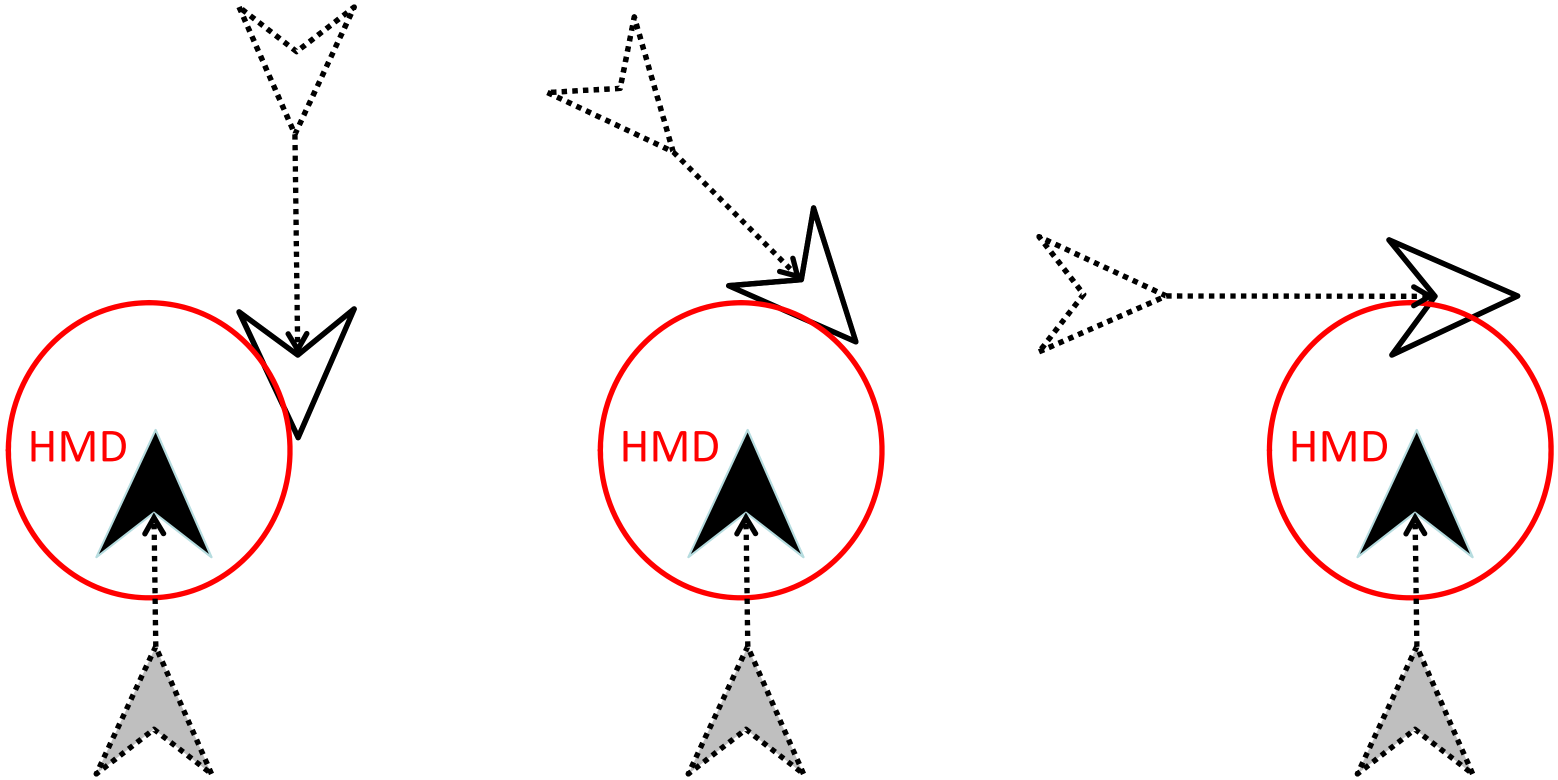
- TCAS Tau and HMD values for RA issuance are altitude-dependent (lower values at lower altitudes):

Own Altitude (ft)	Tau (sec)	HMD (nmi)	HMD + 50%
< 1000 AGL	N/A	N/A	N/A
1000-2350 AGL	15	0.20	0.30
2350-5000	20	0.35	0.53
5000-10000	25	0.55	0.83
10000-20000	30	0.80	1.2
20000-42000	35	1.1	1.7
>42000	35	1.1	1.7

- Self Separation HMD distances should be no smaller than TCAS HMD values but may need to be larger for controller acceptability

HMD versus Encounter Geometry

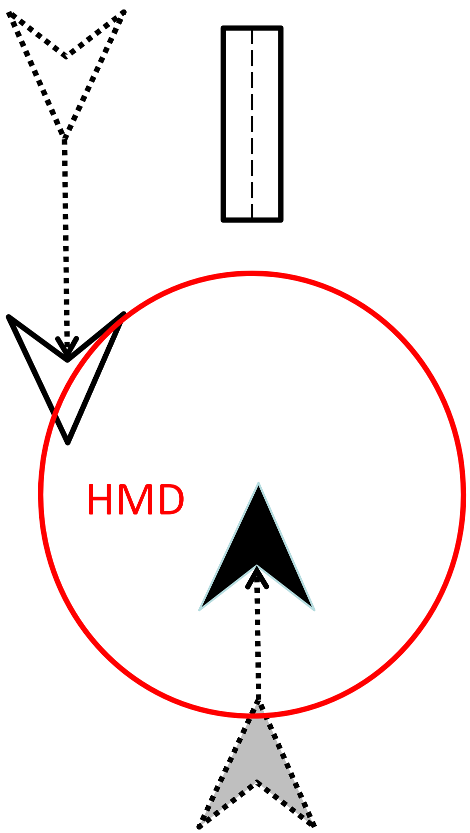
- TCAS will not activate an RA if HMD is cleared, regardless of encounter geometry:



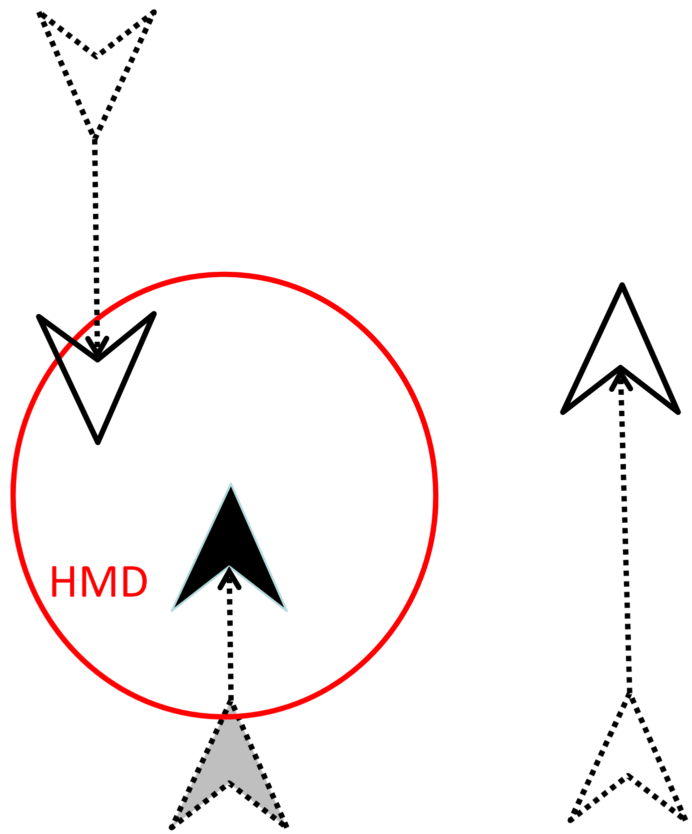
- Air traffic controllers and proximate manned aircraft pilots may desire more than TCAS HMD, especially for crossing geometries

Unacceptably Large HMD

- Excessively large HMD will be disruptive to traffic flow:



UAS on final approach,
intruder on downwind leg



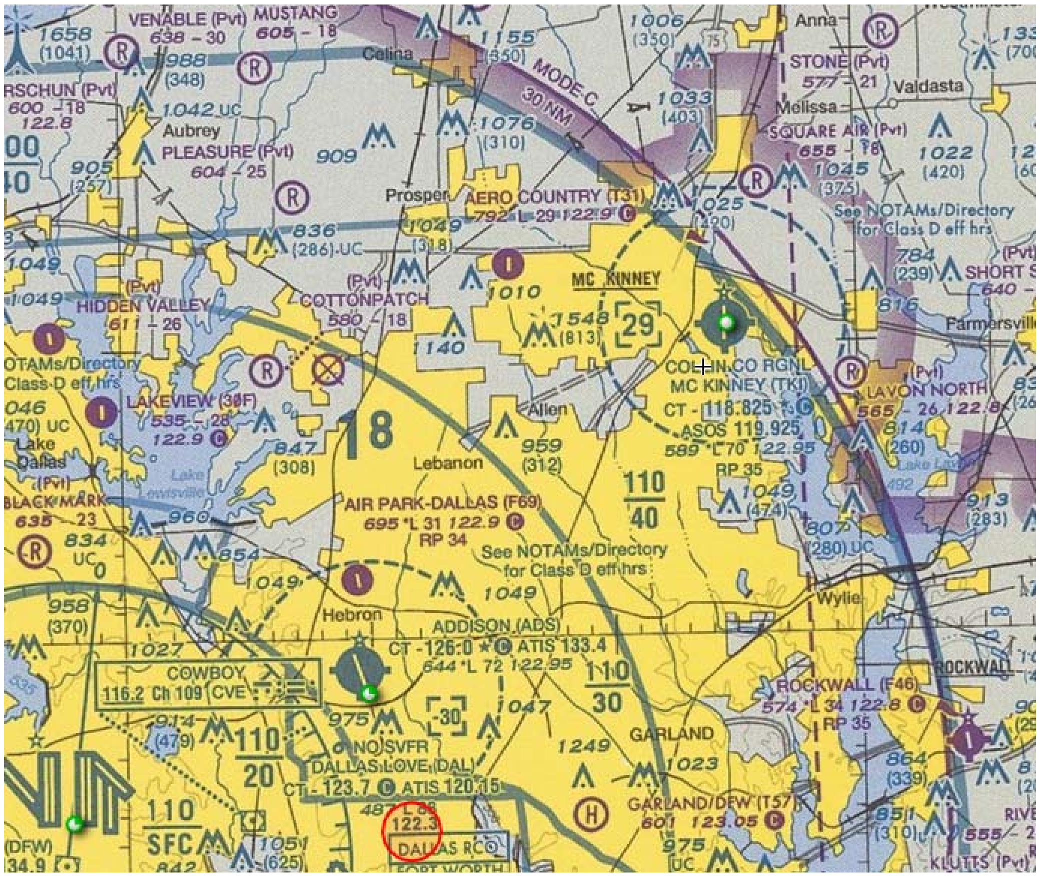
UAS “well clear” deviation
causes secondary conflicts

CAS1 Overview of Simulation Results

Based on 14 ATC Test Subjects

1176 Horizontal Miss Distance Acceptability Ratings

UAS-NAS SSI HITL Traffic Scenario Area



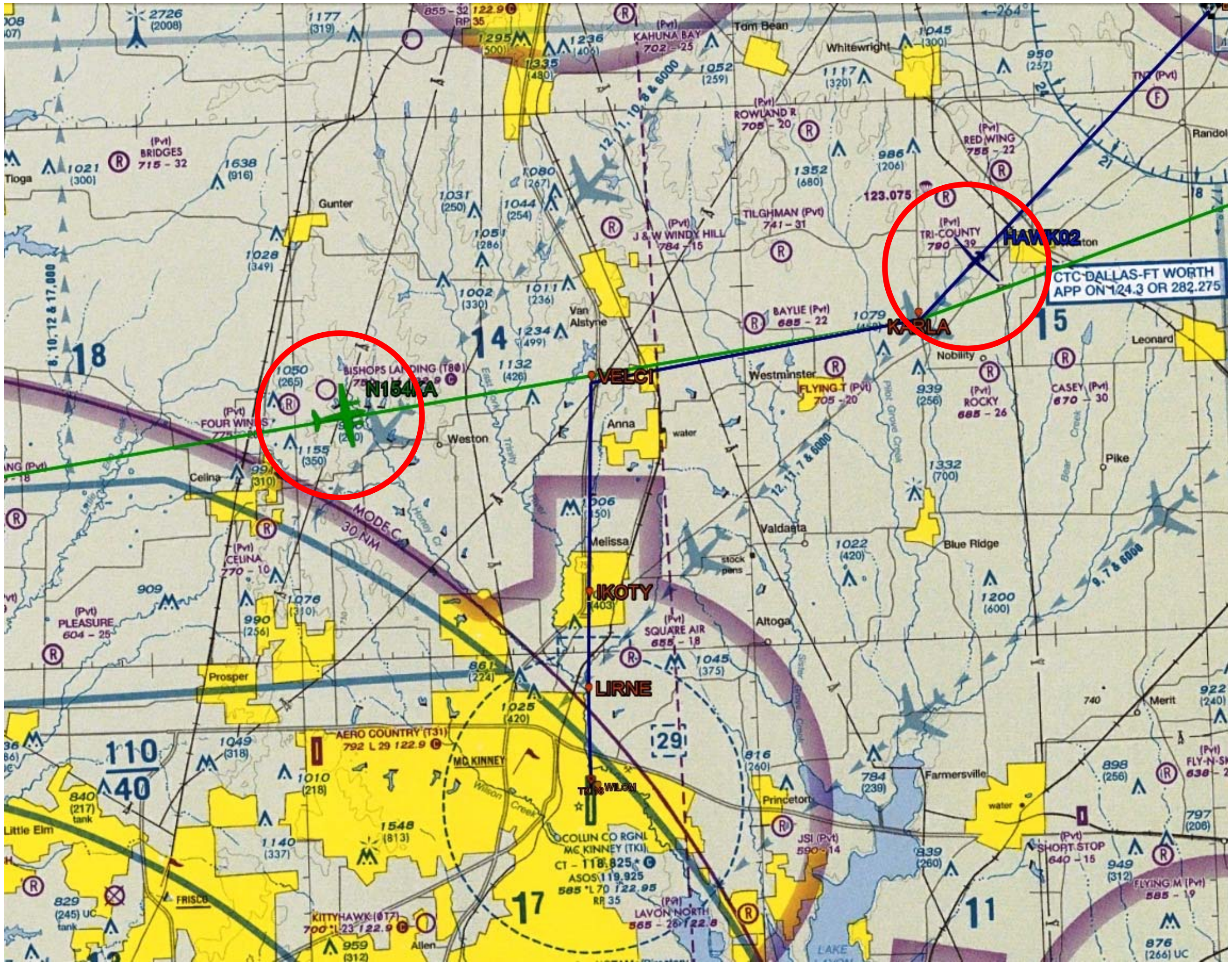
Initial scenarios focused on ATC sector handling arrivals to Collin County Regional (McKinney – TKI), ~28 nmi NE of DFW

Feature-rich airspace:

- Class B, 4000-11000' above TKI
  - VFR & IFR aircraft all under positive control, all cooperative
- Class D, SFC-2900' around TKI
  - VFR & IFR cooperative aircraft receiving Class D ATC services

❖Class E, 700' or 1200' up to FL180 and outside Class B and D
  - IFR aircraft
  - VFR aircraft, some receiving ATC services, some not
  - Some non-cooperative traffic outside of 30 nmi Mode C veil
- Class G, SFC to overlying airspace
- Nearby non-towered airports
- Visual checkpoints

Illustration of Head-on Scenario



Head-on Co-Altitude Traffic While on Approach

Rating scale used for encounter assessment

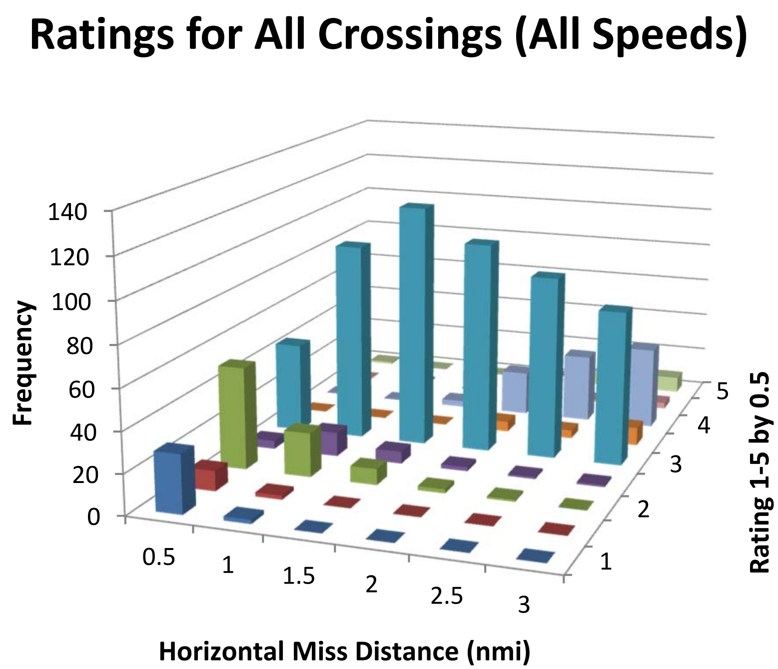
After each "well clear encounter" test subjects were asked to rate the horizontal miss distance on a five-point scale:

1. Much too close; unsafe or potentially so; cause or potential cause for issuance of a traffic alert
2. Somewhat close, some cause for concern
3. Neither unsafely close nor disruptively large, did not perceive the encounter to be an issue
4. Somewhat wide, a bit unexpected; might be disruptive or potentially disruptive in congested airspace and/or with high workload
5. Excessively wide, unexpected; disruptive or potentially disruptive in congested airspace and/or with high workload

Fractional responses, e.g., 1.5 … 4.5 were acceptable

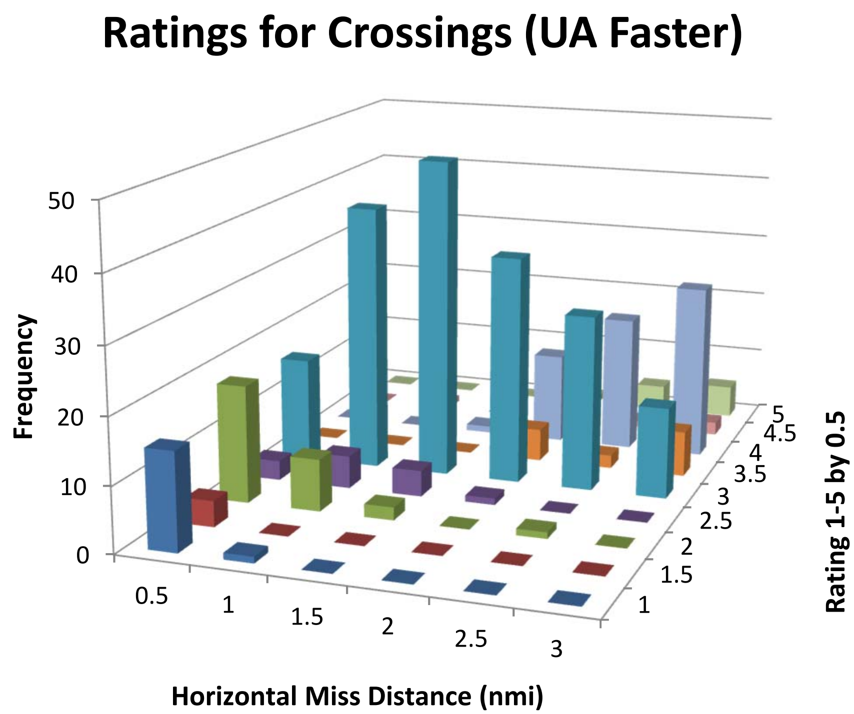
Note that some encounters did not result in a maneuver by the UAS

Ratings by Horizontal Miss Distance (HMD)
Mean of 14 ATC subjects for each encounter



The plot above includes only **Crossing encounters**,
but at **all speed differences** between encounter aircraft.

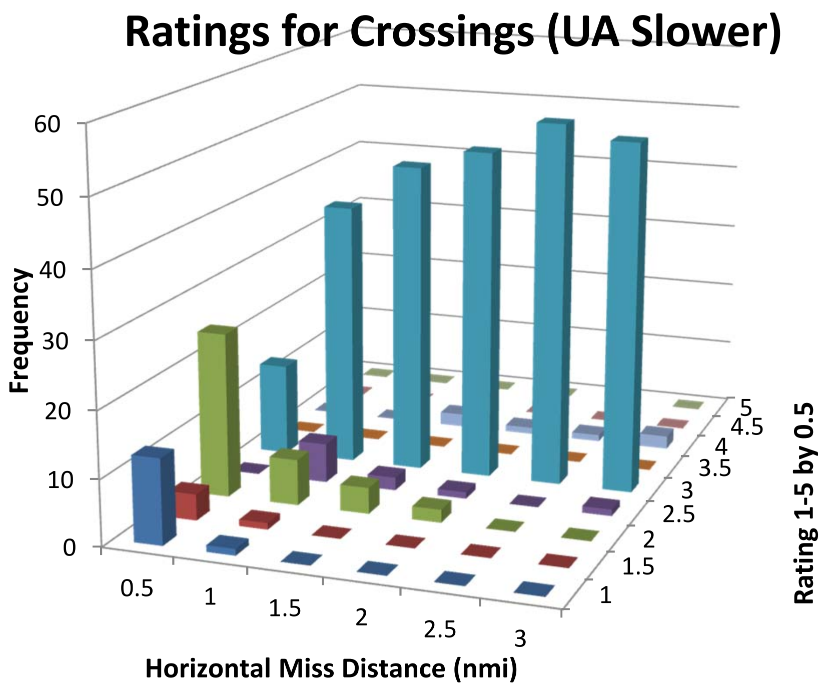
Ratings for UA faster than encounter aircraft
Mean of 14 ATC subjects for each encounter



Plot of frequency of Rating responses when UA was **faster** than the encounter aircraft.

***Note**: Horizontal Miss Distances > 1.5 nmi required a UAS lateral maneuver*

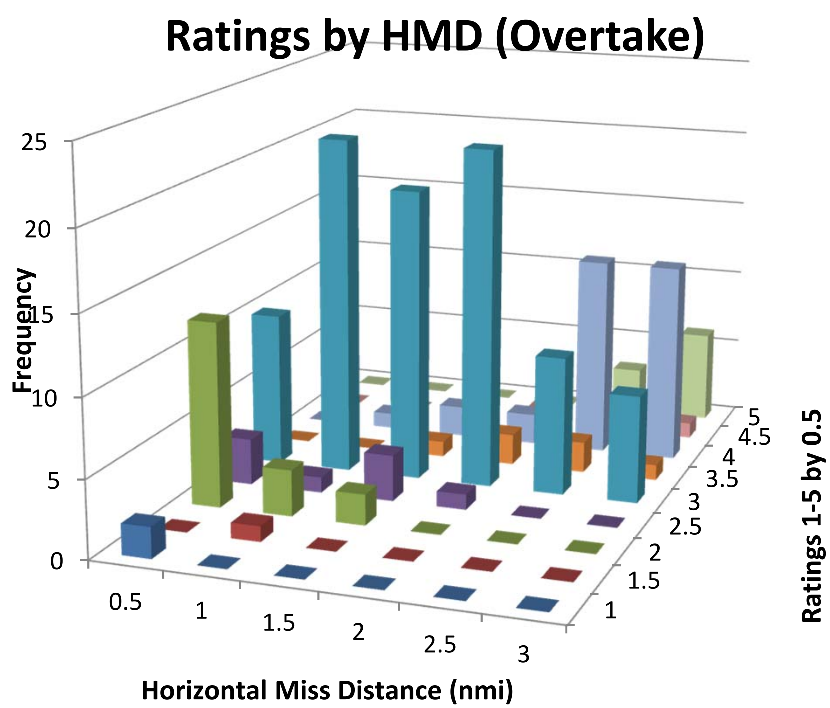
Ratings for UA slower than encounter aircraft
Mean of 14 ATC subjects for each encounter



Plot of frequency of Rating responses when UA was **slower** than the encounter aircraft.

Note*: All Horizontal Miss Distances achieved without a UAS lateral maneuver*

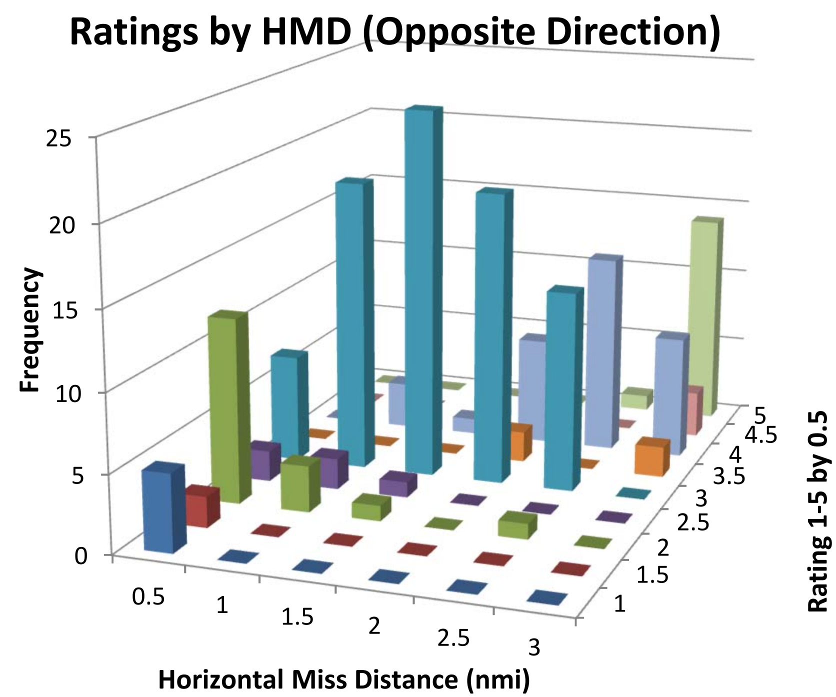
Ratings for Overtake encounters
Mean of 14 ATC subjects for each encounter



Plot of frequency of Rating responses for **overtake** encounters.

***Note**: All Horizontal Miss Distances required a UAS lateral maneuver (initially a collision course)*

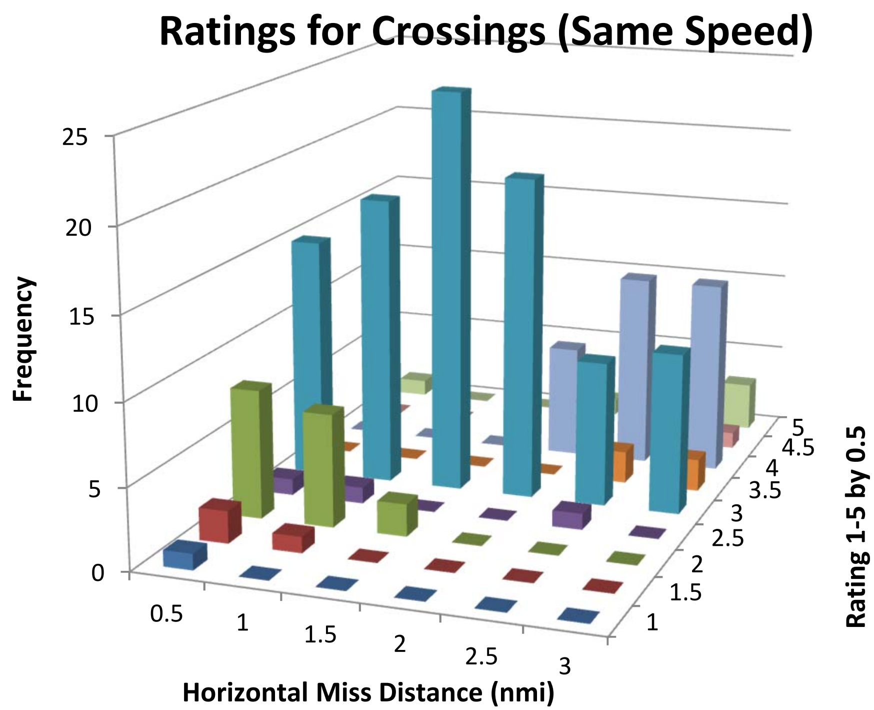
Ratings for Opposite Direction encounters
Mean of 14 ATC subjects for each encounter



Plot of frequency of Rating responses for **opposite direction** encounters.

***Note**: All Horizontal Miss Distances required a UAS lateral maneuver (initially a collision course)*

Ratings for Same-speed Crossing encounters
Mean of 14 ATC subjects for each encounter



Plot of frequency of Rating responses when both aircraft were at the **same speed**.

***Note**: Horizontal Miss Distances > 1.5 nmi required a UAS lateral maneuver*

CAS1 Conclusions

- A horizontal miss distance (HMD) of ~1.5 nmi appears to be optimal for ATC acceptability (away from the airport vicinity)
- HMD of 1.5 nmi is >150% larger than the TCAS RA HMD for all airspace below Class A, and 136% larger in Class A
- 500' IFR-VFR vertical separation (with no vertical closure rate) was universally acceptable as noted during debrief sessions (some controllers were Ok with less)
- Controllers think the SAA integration concept as presented is viable
  - "definitely viable"
  - "absolutely viable"
  - "really impressed, way beyond expectations" [from before seeing it]
  - [worked] "surprisingly well"
  - "impressed with it"
  - "don't see any controller having an issue with" [concept as seen]
- 1.5 nmi HMD matches controller separation standards between VFR and large/turbojet IFR aircraft in Class B airspace

CAS2 Overview of Simulation Results

Based on 7 ATC Test Subjects

588 Horizontal Miss Distance Acceptability Ratings

- Based on CAS1, but with fewer Horizontal Miss Distances – reduced based on CAS1 results
- Addition of winds
- Addition of communications delays that might be expected in operations of UAS controlled by way of satellite links

CAS2 Research Focus and Questions

Focus: Effect of Simulated SAA-Equipped UAS on Air Traffic Controller Acceptability and Workload when differing horizontal spacing parameters are used in the SAA algorithms and under conditions of calm and moderate winds and with varied time delays in the communications link

Specific Questions:

A. Given wind and communications delay conditions, are SAA self separation (SS) maneuvers too small/too late, resulting in issuance of traffic safety alerts or controller perceptions of unsafe conditions? Tested by traffic encounters with smaller Horizontal Miss Distances (HMD).
B. Given wind and communications delay conditions, are SAA SS maneuvers too large (excessive "well clear" distances), resulting in behavior the controller would not expect and/or disruptions to traffic flow? Tested by traffic encounters with larger Horizontal Miss Distances (HMD).
C. Given wind and communications delay conditions, are there acceptable, in terms of ATC ratings, workload, and closest point of approach data, SAA miss distances that can be applied to the development of SAA algorithms?
D. Do communications delays for the UAS in the airspace result in an impact on the controllers communications flow? Are the delays disruptive in terms of transmissions being "stepped-on" (simultaneous transmissions by several aircraft), or are additional repeats of information required with delays.

Research Design - Subjects

- Subjects:
  - Seven recently retired Air Traffic Controllers familiar with the Dallas-Ft. Worth East side
  - UAS and simulated manned aircraft were controlled by pseudo-pilots at control stations in a different room
  - 14 UAS traffic encounters each hour with additional traffic to achieve a realistic workload level
  - Six test hours over a two-day span
  - 588 total traffic encounters

Independent Variables

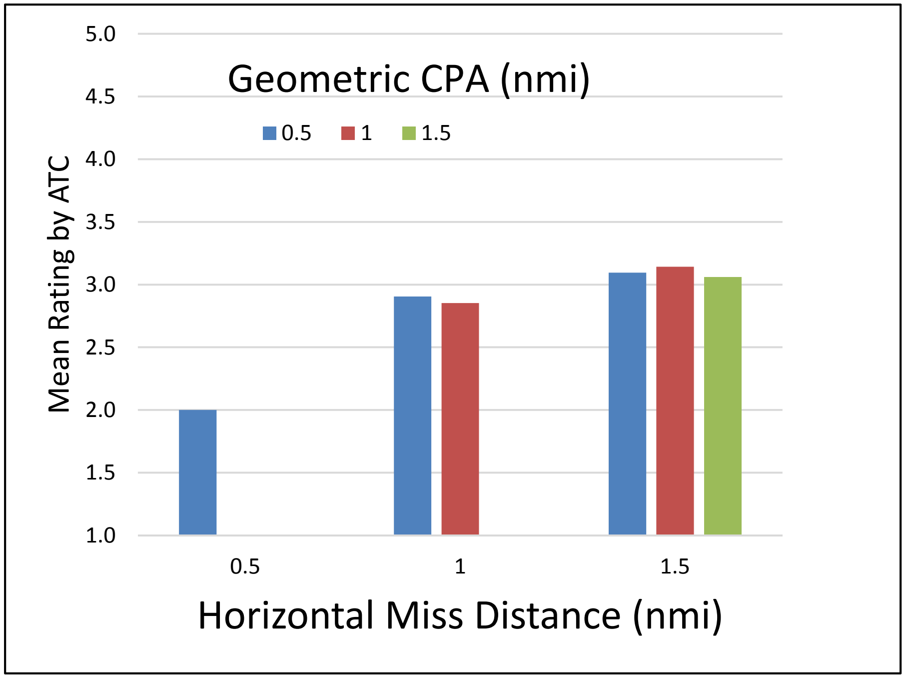
- Horizontal Miss Distance (3 values: 0.5, 1.0, 1.5, nmi)
- Encounter Geometry (3 values: opposite-direction, crossing, overtake)
  - Intruder opposite-direction at 180 degrees +/- 15 degrees (non-crossing)
  - Intruder to right at 90 degrees +/- 15 degrees (crossing)
  - Intruder ahead at 0 degrees +/- 15 degrees (overtaking, non-crossing)
  - All geometries without vertical separation (but may include climbing/descending trajectories)
  - Ownship passes to right of intruder for non-crossing geometries
  - Ownship passes in front of intruder for crossing geometries
- Intruder Speed Differential (5 values for crossing: 0, +/- 40, +/- 80 kts)
- 42 test conditions: 6 opposite-direction, 6 overtake, 30 crossing
- 14 encounters per hour (based on CAS1, tested extensively)
- Wind Conditions (2 levels: Low and Moderate)
- Communications Delay (0, 400, 1200, 1800 msec)
- 6 One-hour test sessions

Research Design - Dependent Variables

- **Human Operator Performance Metrics**:
  - Horizontal Miss Distance Ratings (verbal after each encounter)
  - Workload ratings by Air Traffic Workload Input Technique (ATWIT) like methodology at 5-minute intervals
  - Post-scenario questionnaires (after each hour)

- **System Performance Metrics**:
  - Aircraft-Aircraft separation distances for each encounter (Closest Point of Approach – CPA)
  - Counts of Instances of “step-ons” (two stations transmitting at the same time; neither can be understood)

Mean Ratings by Encounter distance (Crossings)



Rating Scale Definitions

1 Much too close; unsafe or potentially so; cause or potential cause for issuance of a traffic alert

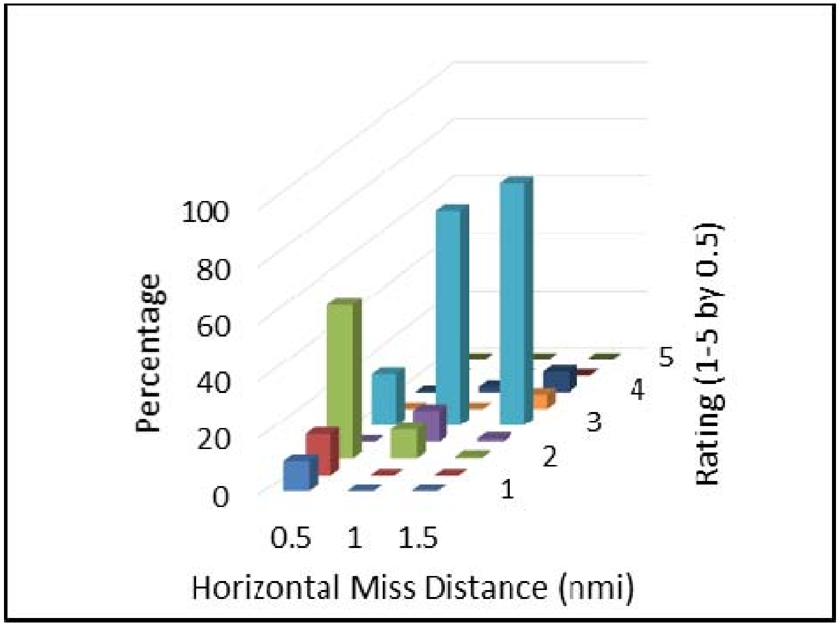
2 Somewhat close, some cause for concern

3 Neither unsafely close nor disruptively large, did not perceive the encounter to be an issue

4 Somewhat wide, a bit unexpected; might be disruptive or potentially disruptive in congested airspace and/or with high workload

5 Excessively wide, unexpected; disruptive or potentially disruptive in congested airspace and/or with high workload

Ratings by Horizontal Miss Distance (Crossings)



Rating Scale Definitions

1 Much too close; unsafe or potentially so; cause or potential cause for issuance of a traffic alert

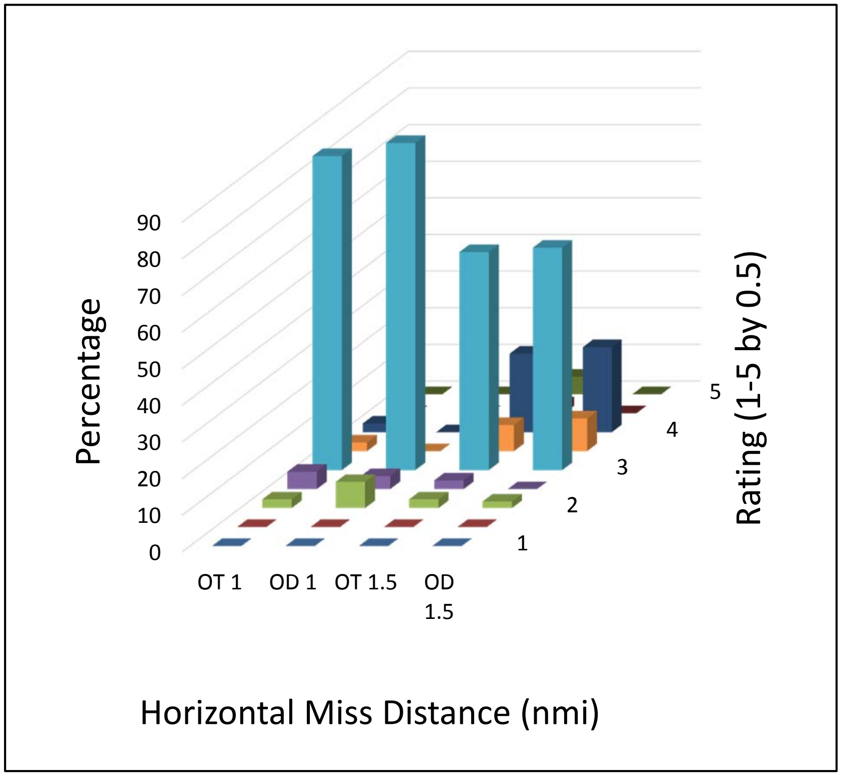
2 Somewhat close, some cause for concern

3 Neither unsafely close nor disruptively large, did not perceive the encounter to be an issue

4 Somewhat wide, a bit unexpected; might be disruptive or potentially disruptive in congested airspace and/or with high workload

5 Excessively wide, unexpected; disruptive or potentially disruptive in congested airspace and/or with high workload

Ratings by HMD for Overtake and Opposite Direction



Rating Scale Definitions

1. Much too close; unsafe or potentially so; cause or potential cause for issuance of a traffic alert
2. Somewhat close, some cause for concern
3. Neither unsafely close nor disruptively large, did not perceive the encounter to be an issue
4. Somewhat wide, a bit unexpected; might be disruptive or potentially disruptive in congested airspace and/or with high workload
5. Excessively wide, unexpected; disruptive or potentially disruptive in congested airspace and/or with high workload

Additional CAS2 Findings

- Traffic Density - "*Rate the realism of the Traffic Density of the simulation during the preceding hour,*"
  - 66.7% of responses were "*Traffic Density was about the same as would be found in real world operations*"
  - 31.0% of the responses were "*Traffic Density was somewhat lower than real world operations*."

- Wind – No issues or performance differences attributable to the "low" and "moderate" wind conditions

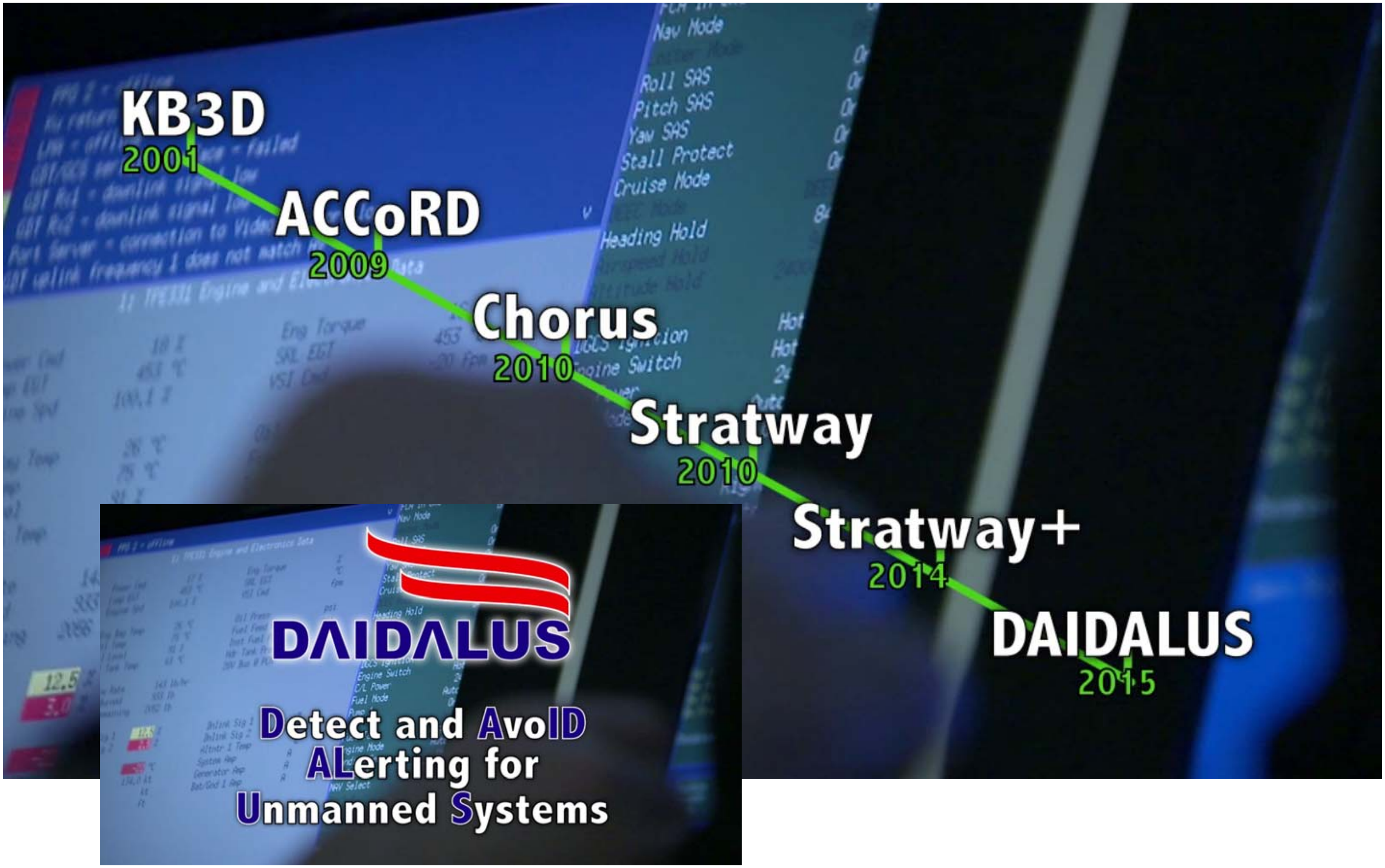
- Communications Delays – no differences in HMD or workload ratings, however comments reflected the difficulties that long delays caused.

CAS3 - Collision Avoidance, Self Separation, and Alerting Times (CASSAT)

CAS-3 Objectives

This experiment will address minimum and maximum acceptable declaration times for projected well clear losses, from the perspectives of both the air traffic controller and the UA pilot, i.e., what declaration times are excessive, leading to nuisance alerts for controllers and UA pilots and what times are too short providing insufficient time to query/negotiate maneuvers with ATC and execute them before triggering TCAS RAs. For this experiment a concept for the functional integration of CA&SS functions will be developed together with pilot procedures, controller-pilot interactions and options for compatible SS and CA indicators and alerts. The ongoing implementation involves the integration of Daidalus (update from Stratway+) with TCAS as a CA capability for the UA.

History of Aircraft Separation Algorithms



Research Questions

- Given a projected well clear loss, what is the minimum acceptable declaration time?
- Given a projected well clear loss, what is the maximum acceptable declaration time?
- Which, if any, of the declaration times are too excessive leading to nuisance alerts for the controllers and UA pilots?
- Which, if any, of the declaration times are too short providing insufficient time to query/negotiate maneuvers with ATC and execute said maneuvers before triggering TCAS RAs?
- Is there an interaction between Alerting Time and Horizontal Miss Distance?
- Given the TCAS alerting symbology sets, does the change in display icons (between caution and warning) affect the saliency of alert levels to the UA pilot?
- In Vertical encounters, does prediction of time to co-altitude (TCOA) affect acceptability of the Alert?

Scenario Environment

- Similar to CAS-1 and CAS-2, the scenarios will be focused on the ATC sector handling arrivals to Collin County Regional (now known as McKinney National – KTKI), which is approximately 28 nmi NE of Dallas/Fort Worth (DFW), and the surrounding airspace and airports

- Traffic in the scenario includes 14 encounters per hour between GA aircraft that are transponding but not in voice communications with ATC, and UAS (large). In addition there are approximately 45 additional aircraft per hour (Background traffic) in the same airspace that are also in communications with the subject Controller.

CAS3 (CASSAT) Methodology

Two-part study based on CAS1 and CAS2 methodology

(1) UAS ground control station pilots as subjects, ATC is part of experimental team; varied Alerting Times and Horizontal Miss Distances

- 12 pilots total; 6 UAS pilots and 6 IFR pilots
- Pilots will fly multiple-UAS each hour in the DFW area using MACS interface with additional alerting symbology incorporated

(2) ATC subjects rating acceptability of UAS encounters with non-communicating (with ATC; but transponding) aircraft when UAS self-separate with varied alerting times (Variable of interest, fixed levels)

- 10 active ATC (experience at DFW a plus, but training on the sector for all)
- Similar to CAS1 and CAS2 except additional sector traffic to boost workload and addition of several vertical traffic encounters per hour

CAS3 (CASSAT) Methodology (2)

- Independent Variables
  - Horizontal Miss Distance (0.7, 1.0 and 1.5 nmi)
  - Alerting Times (used by Daidalus algorithms)
    - 30 sec, 45 sec, 75 sec
  - Time to Co-altitude (TCOA) for vertical encounters (used by Daidalus algorithms)
    - 0 and 20 sec
    - Vertical Rates 1000 and 3000 feet per minute (between encountering aircraft)

- Variables from CAS1 and CAS2 being held Constant
  - Wind – only medium wind profile for all encounters
  - Communications delay – 400 msec for all UAS voice communications

- UAS GCS display manipulations
  - Pilots will rate candidate alerting symbology sets
  - For pilot subject runs, will require triggering TCAS on some encounters to see full range of symbology

Matrix of test combinations (Update)

Horizontal encounters

Alerting Time	0.7 nmi HMD	1.0 nmi HMD	1.5 nmi HMD
30 sec	√	√	√
45 sec	√	√	√
75 sec	√	√	√

Vertical encounters

Vert Rate	0 sec TCOA	20 sec TCOA
1000 fpm	√	√
3000 fpm	√	√

A special case at high altitude is needed to test 5000 fpm (only for UAS pilot testing)

Data Analyses

- Many of the distance (HMD) and time (Alerting Time) research questions can be answered through descriptive statistics and graphical methods alone, such as was done for CAS1 and CAS2

- Where needed, ratio scaled variables, such as miss distance errors will be analyzed by parametric methods (e.g., within-subjects ANOVA)
  - If needed, acceptability ratings can be analyzed by within-subjects ANOVA

- Some data represent counts (e.g., frequency of selected events, ATC re-route issued, errors noted, etc.) and will be handled by non-parametric methods (e.g., Cochran Q {repeated} or Chi-square {independent})

Facilities and Resources

- The experiment will be run in a dedicated UAS facility within the ATOL. This part of the lab runs a NASA LaRC modified version of the Multi Aircraft Control System (MACS).*
- The two UAS GCS pilots will utilize the MACS interface within one of the pilot station rooms within the ATOL.
- The implementation team is from SGT, Adaptive Aerospace Group (AAG), and Intelligent Automation, Inc. (IAI)

* In case of major scheduling difficulties, a dedicated UAS lab facility, currently housed at Stinger Ghaffarian Technologies (SGT), can be used. The lab at SGT was used to run CAS-1 and CAS-2.

ATOL areas for the CASSAT study

Figure 1. UAS Lab Setup

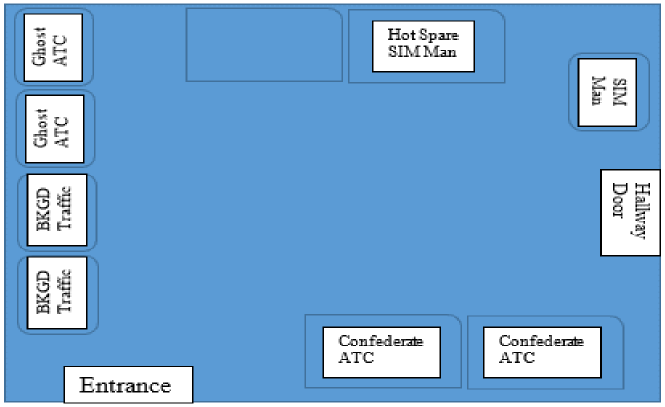


Figure 2. Pilot Room B Setup

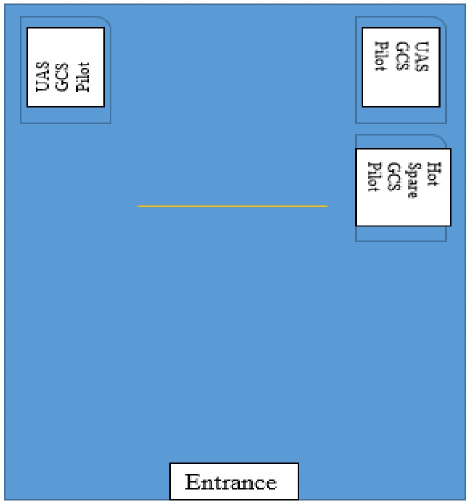
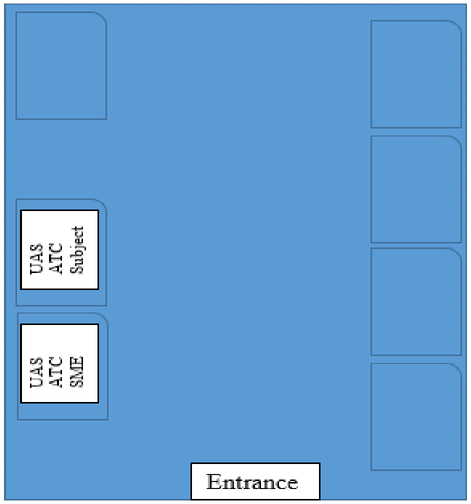


Figure 3. ATC Room B Setup



Assumptions and Risks

- Acquiring Active Controllers
  - Will be searching for active controllers with some DFW experience
  - Current DFW controllers are NOT available
- Scheduling conflicts within the ATOL – can run while IMAC checkout is going on
- Scheduling conflicts with individual subjects

Desired Outcomes

- To obtain enough subjective and objective data points to analyze the acceptable declaration time for projected well-clear losses
- To obtain subjective feedback from UA pilots regarding the GCS display
- Deliver preliminary results at an SC-228 plenary
- Deliver a technical report to the project office documenting the results and lessons learned

Proposed Daily Schedule UAS Pilot Runs

Day 1

- 8:30 Arrival & Briefing
- 9:00 Familiarization & Training
- 10:30 Data Run (Selected from Hours 1, 2, or 3)
- 11:45 Post Run Evals
- 12:00 Lunch Break
- 1:00 Reconvene at Sim
- 1:30 Data Run (Selected from Hours 1, 2, or 3)
- 2:45 Post Run Eval / Break
- 3:00 Data Run (Selected from Hours 1, 2, or 3)
- 4:15 Post Run Eval

Day 2

- 8:30 Arrival & Briefing
- 9:30 Data Run (Selected from Hours 4, 5, or 6)
- 10:45 Post Run Evals / Break
- 11:00 Data Run (Selected from Hours 4, 5, or 6)
- 12:15 Post Run Eval / Lunch
- 1:30 Reconvene at Sim
- 1:45 Data Run (Selected from Hours 4, 5, or 6)
- 3:00 Post Run Eval /
- 3:15 Debriefing

Proposed Daily Schedule ATC Test Subjects

Day 1 - Training

- 8:30 Arrival & Overview Briefing
- 9:30 Familiarization with DFW D10
- 11:30 Training Run 1
- 12:00 Lunch Break
- 1:00 Reconvene at Sim Review Procedures
- 1:30 Training Run 2
- 2:45 Post Run Eval / Feedback
- 3:00 Training Run 3
- 4:15 Post Run Eval / Feedback

Day 2 – Data Runs

- 8:30 Arrival & Briefing
- 9:00 Familiarization & Training Run 4
- 10:15 Break
- 10:30 Data Run (Selected from Hours 1, 2, or 3)
- 11:45 Post Run Evals
- 12:00 Lunch Break
- 1:00 Reconvene at Sim
- 1:30 Data Run (Selected from Hours 1, 2, or 3)
- 2:45 Post Run Eval / Break
- 3:00 Data Run (Selected from Hours 1, 2, or 3)
- 4:15 Post Run Eval

Day 3 – Data Runs

- 8:30 Arrival & Briefing
- 9:30 Data Run (Selected from Hours 4, 5, or 6)
- 10:45 Post Run Evals / Break
- 11:00 Data Run (Selected from Hours 4, 5, or 6)
- 12:15 Post Run Eval / Lunch
- 1:30 Reconvene at Sim
- 1:45 Data Run (Selected from Hours 4, 5, or 6)
- 3:00 Post Run Eval /
- 3:15 Debriefing

CAS3 (CASSAT) Schedule

Event	Date
• IRB (Institutional Review Board)	Document In Progress
• Experiment Review (PER/FER)	March 6, 2015
• "Dress Rehearsal" runs	April 2015 (second half)
• Data Collection UAS Pilots	April 2015 (begin last week)
• Data Collection ATC Subjects	May-July 2015
• Data Analysis complete	November 2015
• Documentation complete	March 2016

April 2015

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
29	30	31	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20 ATC Dress Rehearsal	21 ATC Dress Rehearsal	22 ATC Dress Rehearsal	23 Pilot Dress Rehearsal	24 Pilot Dress Rehearsal	25
26	27 Pilots 1 & 2	28 Pilots 1 & 2	29	30 Pilots 3 & 4	1 Pilots 3 &4	2

May 2015

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
26	27	28	29	30	1 Active ATC Requested	2
3	4	5	6 Active ATC Subject #1	7	8	9
10	11	12	13 Active ATC Subject #2	14	15	16
17	18	19	20 Plenary Week – No Runs	21	22	23
24/31	25 Memorial Day	26	27 Active ATC Subject #3	28	29	30

June 2015

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
31	1	2	3 Active ATC Subject #4	4	5	6
7	8	9	10 Active ATC Subject #5	11	12	13
14	15	16	17 Active ATC Subject #6	18	19	20
21	22	23	24 Active ATC Subject #7	25	26	27
28	29	30 Active ATC Subject #8	1	2	3 4th of July Observed	4 Independence Day

July 2015

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
28	29	30	1	2	3 4th of July Observed	4 Independence Day
5	6	7	8 Active ATC Subject #9	9	10	11
12	13	14	15 Active ATC Subject #10	16	17	18
19	20 Pilots 5 & 6	21 Pilots 5 & 6	22	23 Pilots 7 & 8	24 Pilots 7 & 8	25
26	27 Pilots 9 & 10	28 Pilots 9 & 10	29	30 Pilots 11 & 12	31 Pilots 11 & 12	1

August 2015

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
26	27	28	29	30	31	1
2	3	4	5 Extra Available Data Collection Week	6	7	8
9	10	11	12 Extra Available Data Collection Week	13	14	15
16	17	18	19	20	21	22
23/30	24/31	25	26	27	28	29

Questions?

After Cassat