



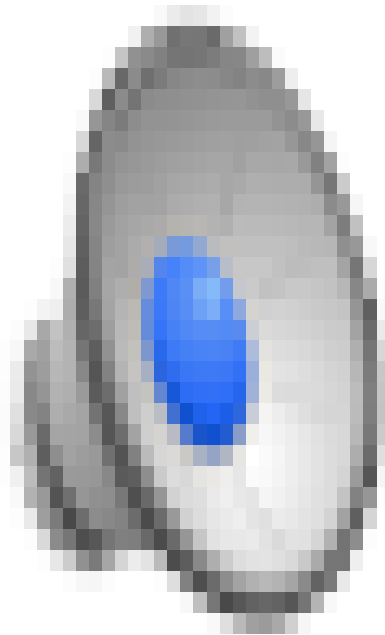
Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS) Project

NASA 870 “Ikhana” UAS
No Chase COA (NCC) Flights

Presented by: Ms. Steffi Valkov
Flight Operations



A Typical Day in America's Airspace



- **Introduction**
 - UAS-NAS Scope and Purpose
- **Development**
 - Objectives
 - Stakeholders and Participants
 - Schedule, UAS, and DAA System
 - COA Process
 - Route and Mission Planning
- **Results and Analysis**
 - Rehearsal Flight
 - Demonstration Flight
- **Lessons Learned**
- **Conclusions**

NASA 870 General Performance Characteristics	
Weight	10,500 lb
Speed	200 kts
Ceiling	40,000 ft
Endurance	24 hr

NASA 870 “Ikhana” UAS flying in the NAS on 24 May 2018





Overview of NCC



Coordination Meetings/Briefs

Flights/Flight Testing

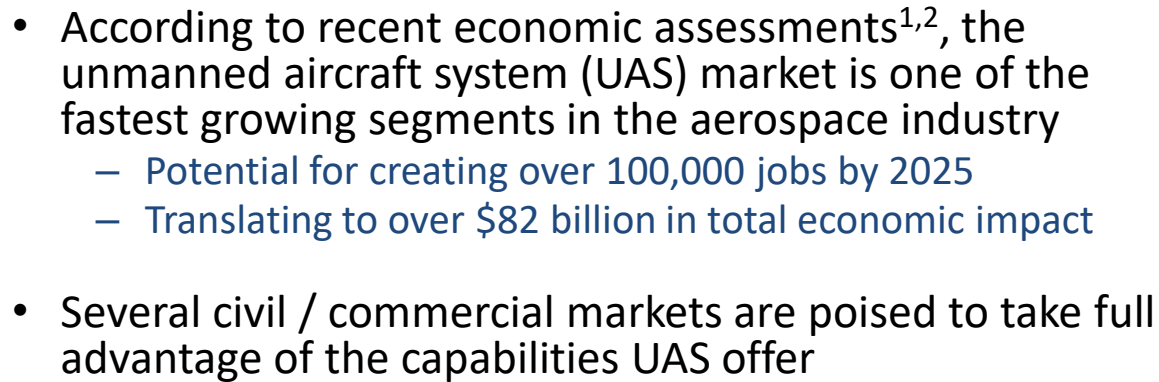
(Over 1000 Air-to-Air Encounters in 5 Campaigns)

Major Milestones

No Chase COA Summary		
Date	Event	Description
2/25/2013	NAC Aeronautics Committee, UAS Sub Committee recommendation to conduct a bold demonstration in the NAS	NAC recommendation to do more than just conduct research and collect data but to employ its unique capabilities to conduct a "Bold Flight Demonstration".
6/2/2014	Demonstration Kick-Off Meeting	Initial planning activities; develop goals and objectives
Dec. 2014	ACAS Xu S5	ACAS Xu Flight Testing
Summer 2015	Flight Test Series 3	FT3 Flight Testing
Summer 2016	Flight Test Series 4	FT4 Flight Testing
12/15/2016	NCC Strategy Meeting	Meeting at GA-ASI to discuss planning for NCC
2/2/2017	NCC Coordination WG	Earliest meeting on record with NCC name
5/31/2017	Phase I MOPS Released	DAA and ATAR Phase I MOPS
Summer 2017	ACAS Xu FT2	ACAS Xu FT2 Flight Testing
10/27/2017	AFRC COA Brief to Management	Brief to AFRC upper management
10/30/2017	COA Submission	Old system for COAs
12/20/2017	COA Re-submission into CAPS	Added "CONOPS" section, route modified
2/1/2018	NCC SCO Tabletop	Team training
2/8/2018	NCC SCO Tech Brief	Brief to AFRC upper management
2/14/2018	NCC SCO Flight 1	Ikhana only
2/15/2018	NCC SCO Flight 2	With intruder
2/21/2018	FAA SRMP Day 1	AFRC hosted FAA event, day 1
2/22/2018	FAA SRMP Day 2	AFRC hosted FAA event, day 2
2/28/2018	NCC SCO Flight 3	With intruder, attempt 1
3/21/2018	NCC Flight 3 Follow-up Tech Brief	Brief to AFRC upper management
3/28/2018	NCC SCO Flight 3	With intruder, attempt 2
3/30/2018	COA Approved	FAA FORM 7711-1 UAS COA Attachment, 2017-WSA-148-COA
4/5/2018	C-Band C2 STA Not Approved	STA to approve use of C-Band LOS C2 outside of SUA was denied due to the FAA Spectrum Office requiring clarification on the NCC operations and risk mitigations. Multiple FAA Spectrum Office and UAS Integration Office coordination meetings followed.
5/10/2018	NCC Demo Tech Brief	Brief to AFRC upper management
5/10/2018	NCC Demo Tabletop	Team training
5/23/2018	STAs for Operations <u>with</u> Chase Approved	STAs included C-Band C2, DPX-7 Transponder, TPA-100 TCAS, ARC-210 VHF Radio
5/24/2018	NCC Demo With Chase	Mission execution (photo chase)
6/6/2018	STAs for Operations <u>without</u> Chase Approved	STAs included C-Band C2, DPX-7 Transponder, TPA-100 TCAS, ARC-210 VHF Radio, ATAR
6/12/2018	NCC Demo Without Chase	Mission execution (no chase)

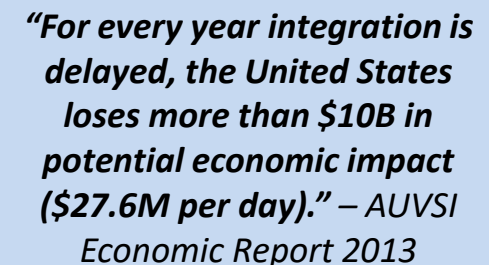


Introduction



• Agriculture Monitoring	• Freight Transport	• Powerline Surveys
• Aerial Imaging/mapping	• Law Enforcement	• Telecommunications
• Border Surveillance	• Mail/Package Delivery	• News/Sports Coverage
• Disaster Management	• Oil/Gas Exploration	• Traffic Monitoring
• Environmental Monitoring	• Pipeline/Rail Monitoring	• Wildfire Mapping

- Unfortunately, the UAS market is not able to achieve this level of growth until the barriers and challenges, currently preventing full integration, are addressed
 - Regulations, Policies and Procedures specific to UAS
 - Enabling Technologies and Standards Development
 - Air Traffic Services and NAS Infrastructure
 - Social Considerations (e.g. Privacy, Security, Noise, Trust)



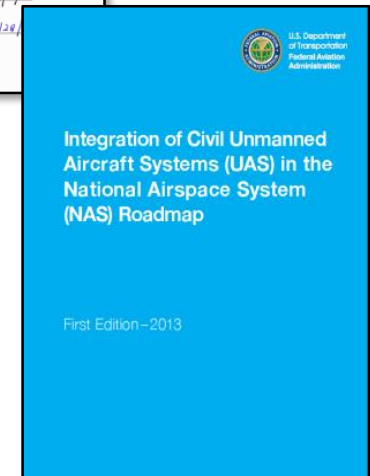
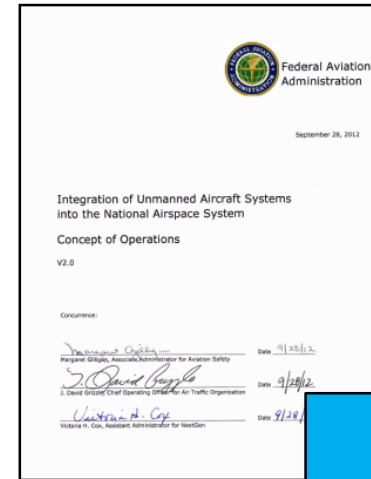
1. The Economic Impact of UAS Integration in the United States, AUVSI, March 2013
2. World Civil UAS Market Profile & Forecast, Teal Group, 2016



Importance of Developing Standards



- The FAA's *UAS CONOPs* and *Roadmap* establish the **vision** and define **the path forward** for safely integrating civil UAS operations into the NAS
 - These documents establish the importance of standards development; explicitly DAA & C2 standards
 - DAA Foundational Challenge: Detect & Avoid vs. See & Avoid
 - C2 Foundational Challenge: Pilot removed from the cockpit
- Standards are essential for multiple stakeholders:
 - **Regulators**: Need standards to certify and approve solutions in a consistent manner
 - **UAS Operators**: Need standards to utilize UAS for operational missions and new market applications
 - **UAS Manufacturers**: Need standards to develop compliant UAS platforms and solutions
 - **Industry**: Need standards to develop compliant HW/SW avionics, radios and sensors
- RTCA SC-203 was, and SC-228 now is, chartered by the FAA to establish UAS DAA and C2 Standards



Once the RTCA SC-228 ToR deliverables are approved and their requirements fulfilled, the FAA should be able to eliminate most of the major DAA and C2 barriers for integration.



Goal: Provide research findings, utilizing simulation and flight tests, to support the development and validation of DAA and C2 technologies necessary for integrating Unmanned Aircraft Systems into the National Airspace System



Technical Challenge-C2: Command and Control (C2)

System Integration and Operationalization (SIO)

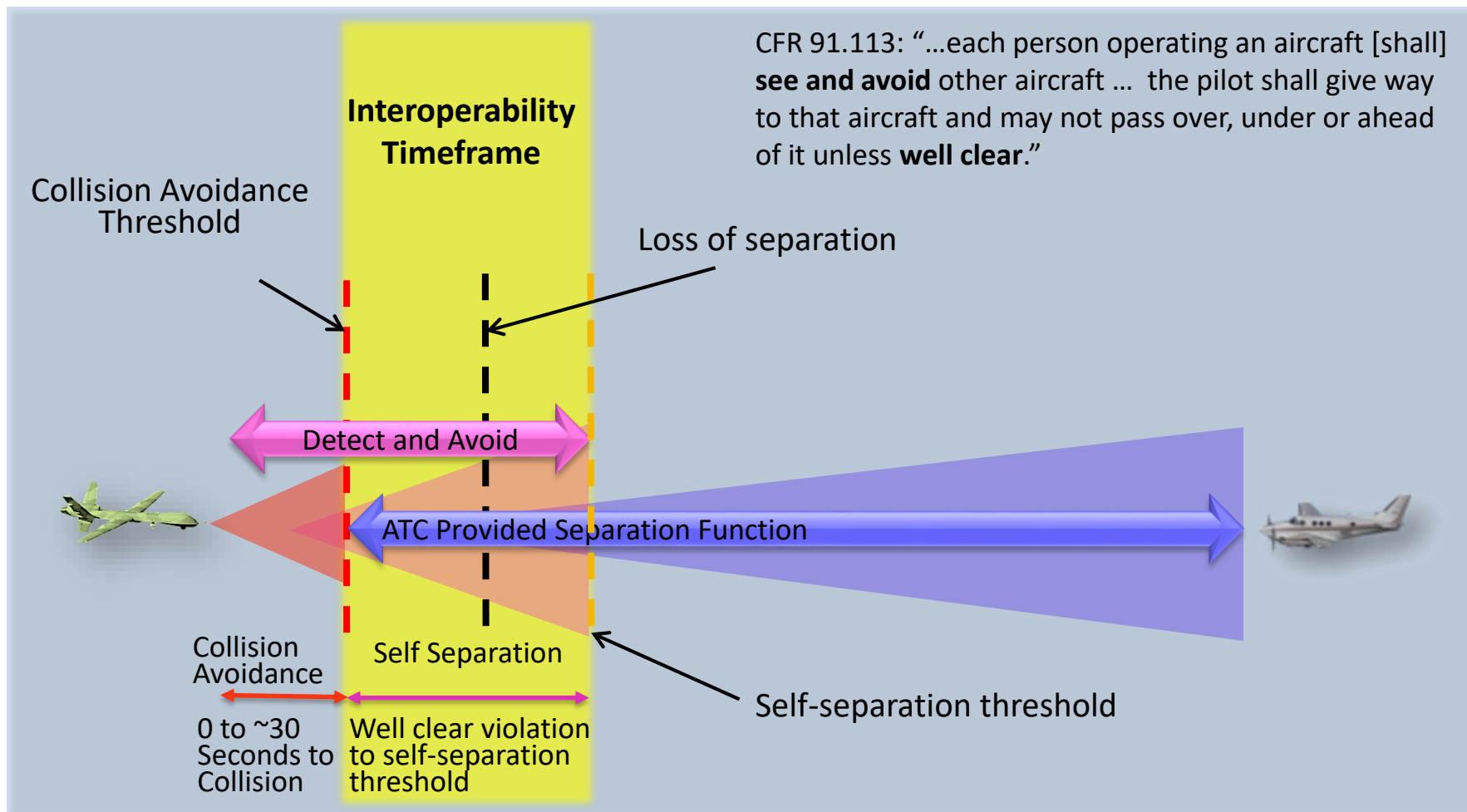
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Development

Separation from Other Aircraft

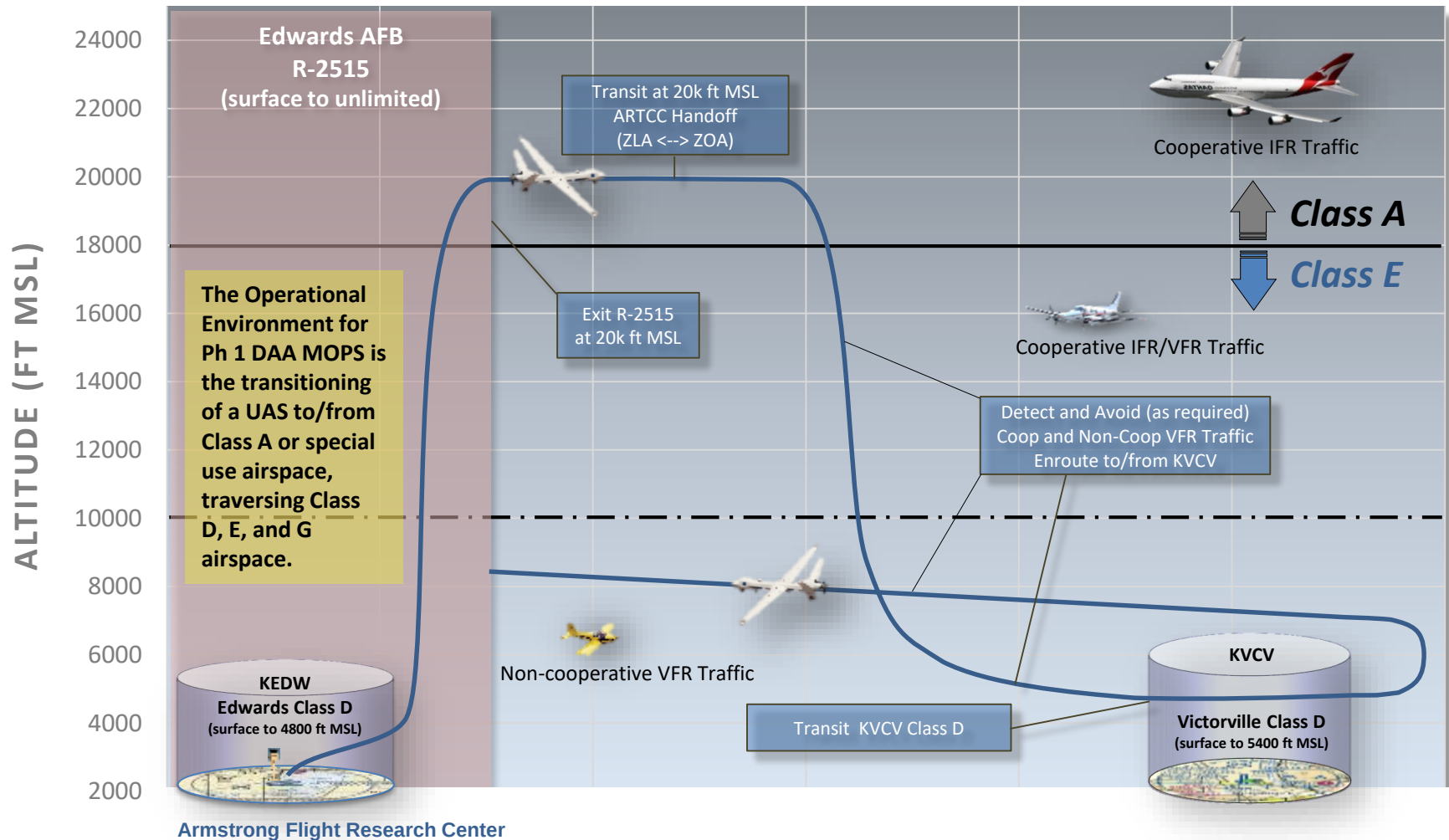
Detect-and-Avoid



***Time horizons of applicability are not to scale**

No Chase Aircraft COA Flight Demonstration

Objective: Execute a flight demonstration of a UAS transitioning to/from Class A or SUA to Class E and Class D employing the Phase 1 Detect and Avoid and Air-to-Air Radar MOPS Systems as alternate means of compliance to 14 CFR §91.111(a) and 14 CFR §91.113(b) “see and avoid/remain well clear” regulations





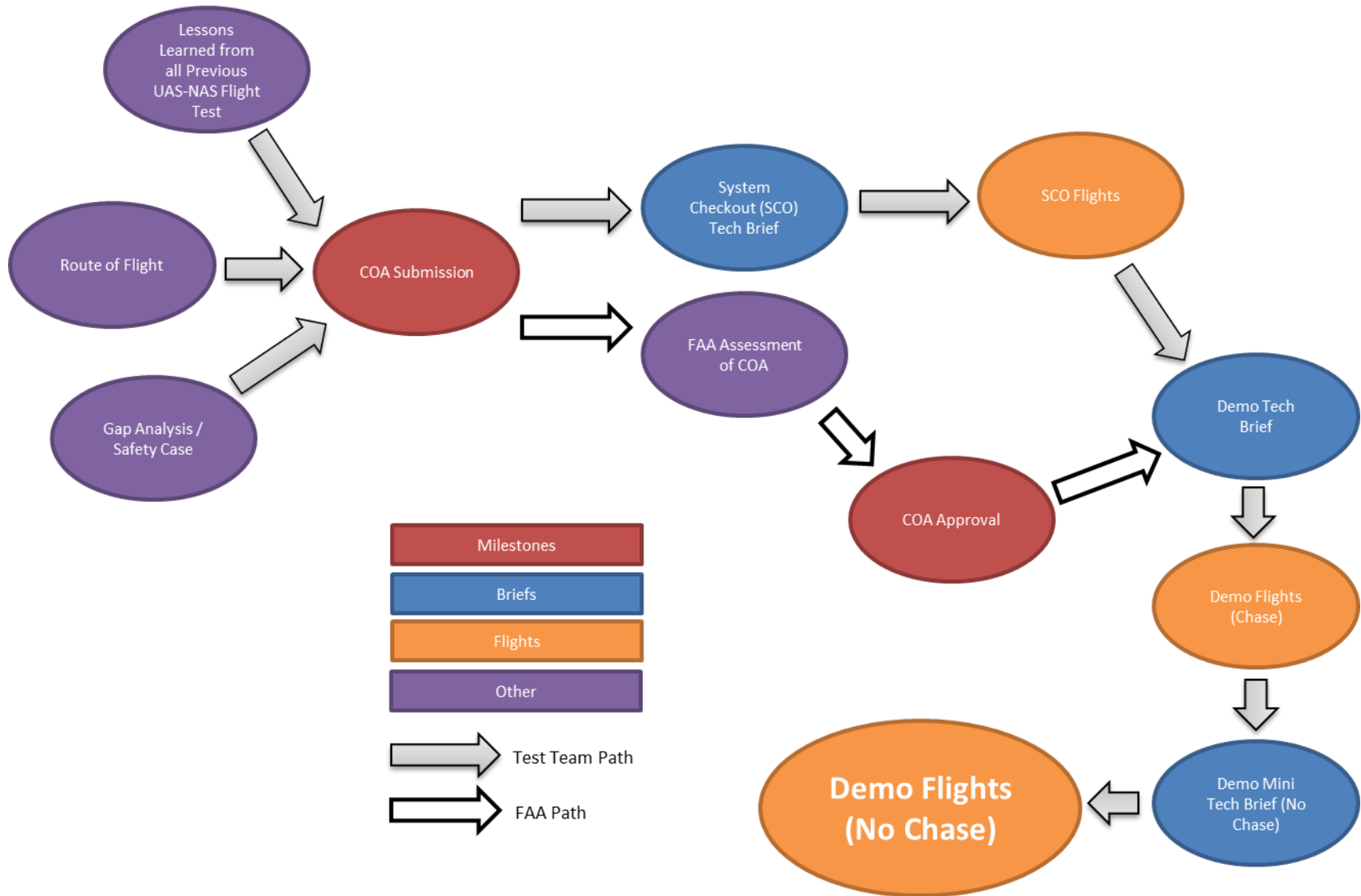
Stakeholders and Participants



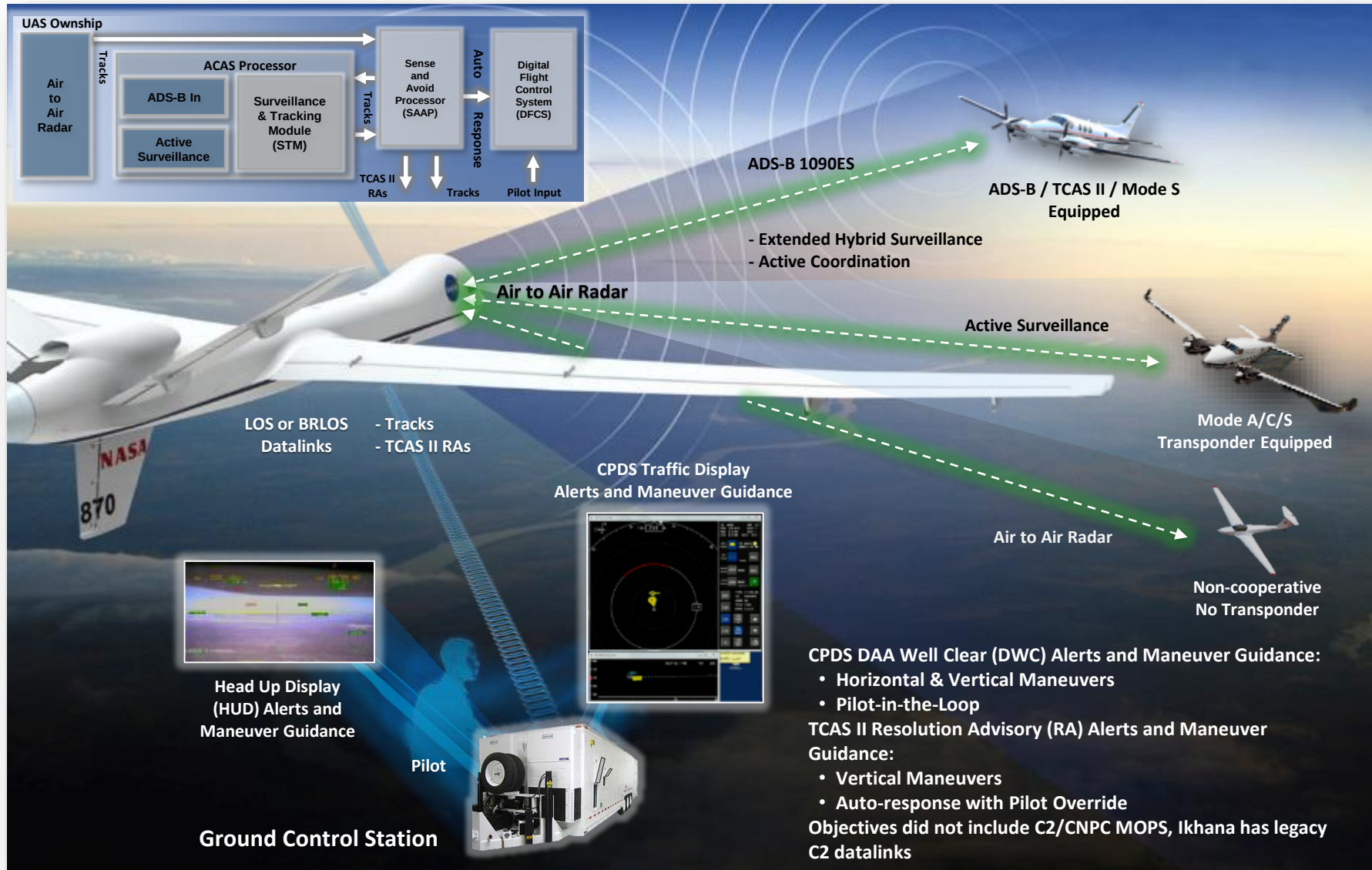
- **NASA Ames Research Center (ARC)**
 - ATC expertise on route development
 - Present at Oakland (ZOA) Air Route Traffic Control Center (ARTCC) during NAS flights
- **NASA Armstrong Flight Research Center (AFRC)**
 - Responsible Test Organization
 - Hosted ownship platform NASA 870 “Ikhana” UAS
 - Provided live intruders for system checkout flights
 - Hosted Live Virtual Constructive (LVC) environment for data collection
- **General Atomics Aeronautical Systems, Inc. (GA-ASI)**
 - Hardware, software, and integration support for Ikhana UAS
 - GA-ASI designed Detect and Avoid (DAA) system
 - Conflict Prediction and Display System (CPDS)
 - Air-to-Air Radar (ATAR)
- **Honeywell International, Inc.**
 - Hardware, software, and integration support for Surveillance and Tracking Module (STM)/ACAS prototype processor (containing Fusion Tracker and TCAS II)
- **Federal Aviation Administration (FAA)**
 - Guidance through development of COA application and final approval
 - Held Safety Risk Management Panel (SRMP) at NASA AFRC
 - Coordination to ensure resolution of spectrum management issues



NCC Operational Roadmap



DAA System Architecture for NCC



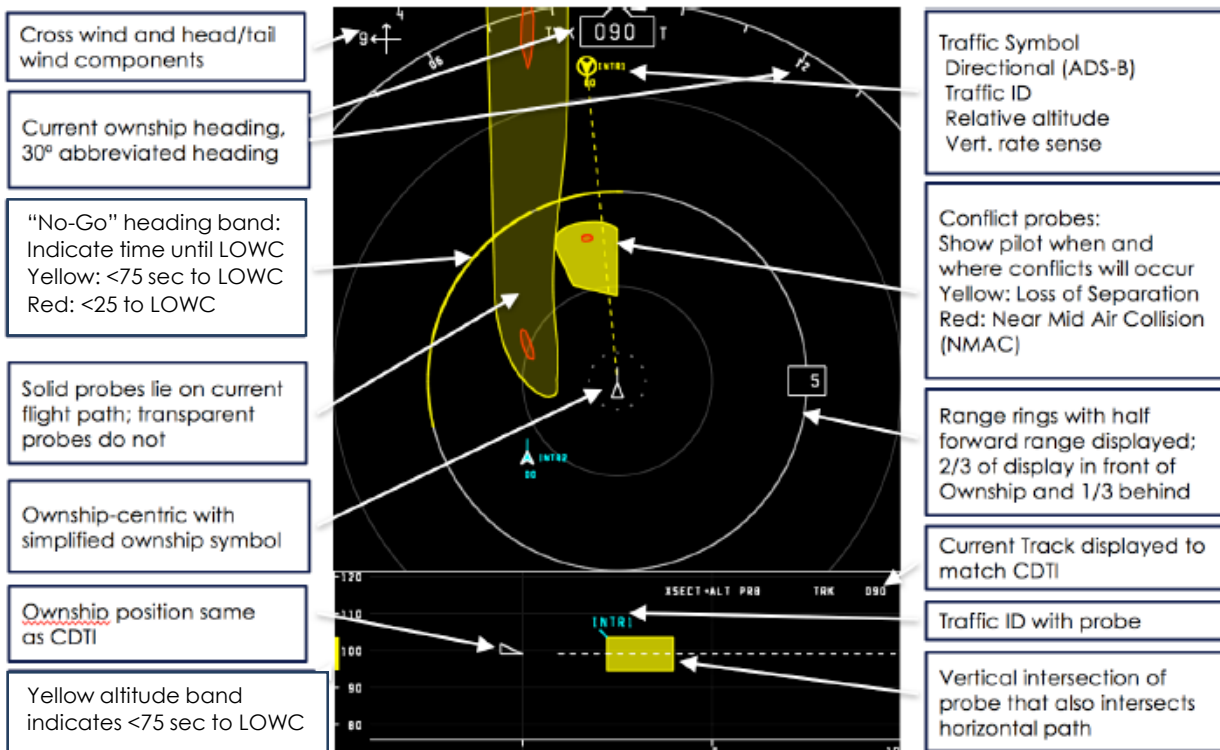
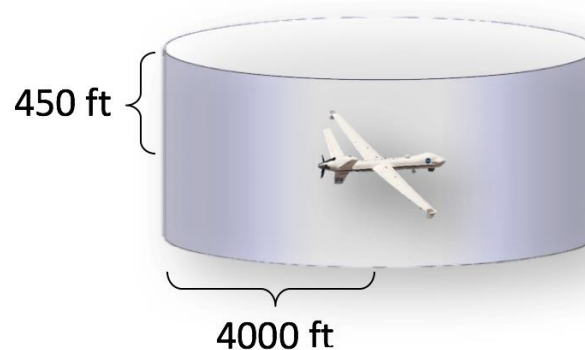
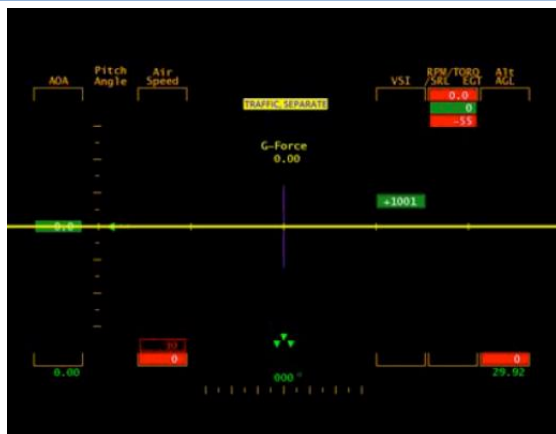


Ikhana Predator B (NASA 870) DAA System



- **Active Surveillance / TCAS II**
 - TCAS II v7.1 hosted in the Honeywell TPA-100 ACAS Processor
 - During the NCC flight demonstrations, Ikhana was configured to respond automatically to TCAS II RAs
 - Cooperative aircraft
- **Air-to-Air Radar**
 - GA-ASI manufactured X-Band ATAR field of regard ($\pm 15^\circ$ elevation and 110° azimuth)
 - Non-cooperative aircraft
- **ADS-B In**
 - ADS-B surveillance was provided by the Honeywell TPA-100 ACAS Processor
 - Receives 1090ES signals and provides track data to the fusion tracker for correlation with other sensor data
 - Employed in an extended hybrid surveillance mode to reduce 1030/1090 MHz band transmissions
 - Cooperative aircraft
- **Fusion Tracker**
 - Hosted in Honeywell TPA-100 ACAS Processor, correlates intruder tracks from multiple surveillance sensors (i.e., Active Surveillance/TCAS II, ADS-B In and ATAR) into a fused track
- **Sense and Avoid Processor**
 - Sense and Avoid Processor (SAAP) served to interface DAA systems, condition track data for downlink to the GCS, and archive data for post-flight processing
- **Conflict Prediction and Display System (CPDS)**
 - Hosted GA-ASI algorithm that predicts DAA loss of well clear
 - CPDS parsed the track data received from the Ikhana downlink and probed estimated trajectories for possible losses of well clear as DAA alerts and maneuver guidance information

CPDS Traffic Display



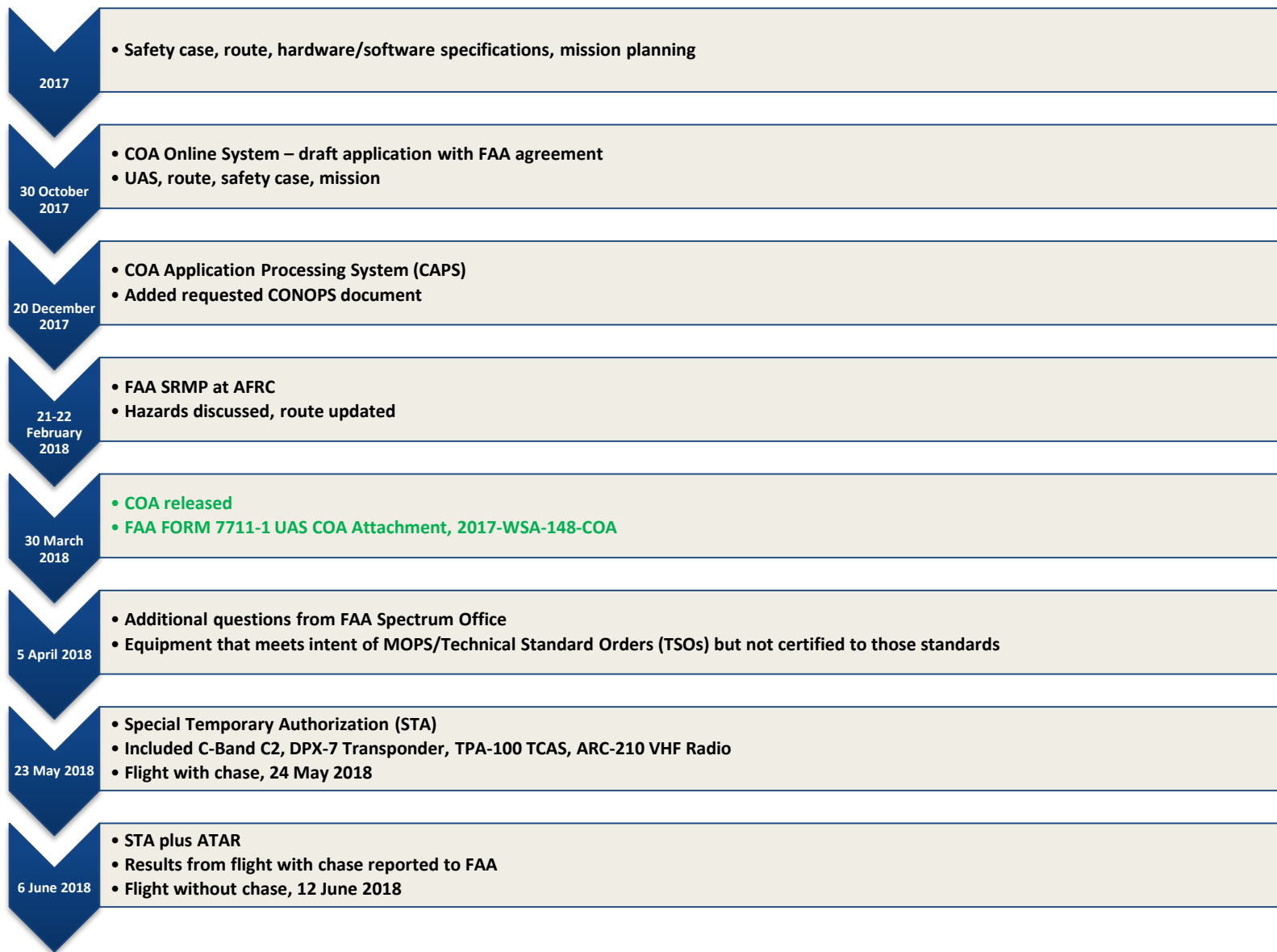


***CPDS Pilot Display
Used for DAA***

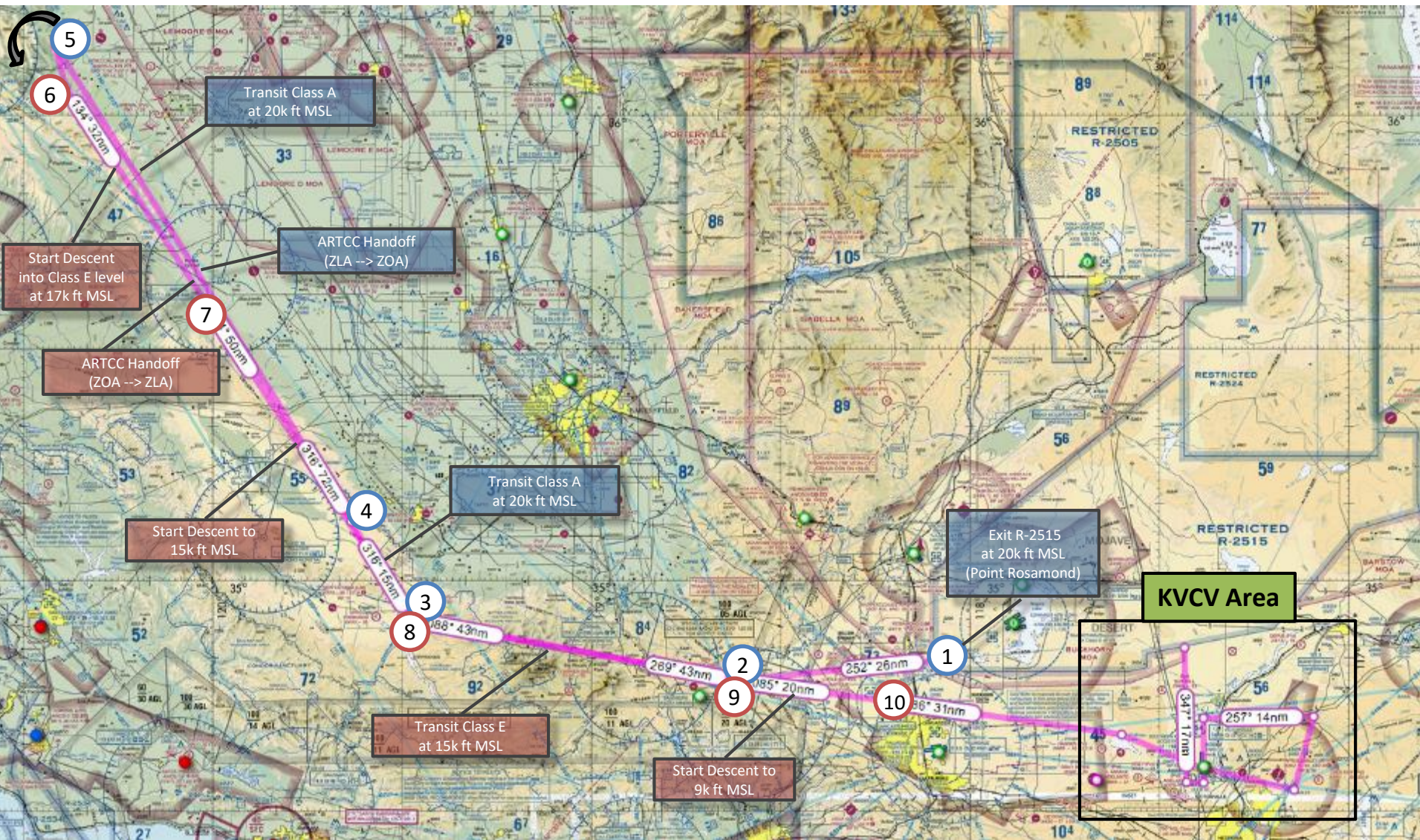
HUD



COA Process



No Chase Aircraft COA Flight Demonstration Route



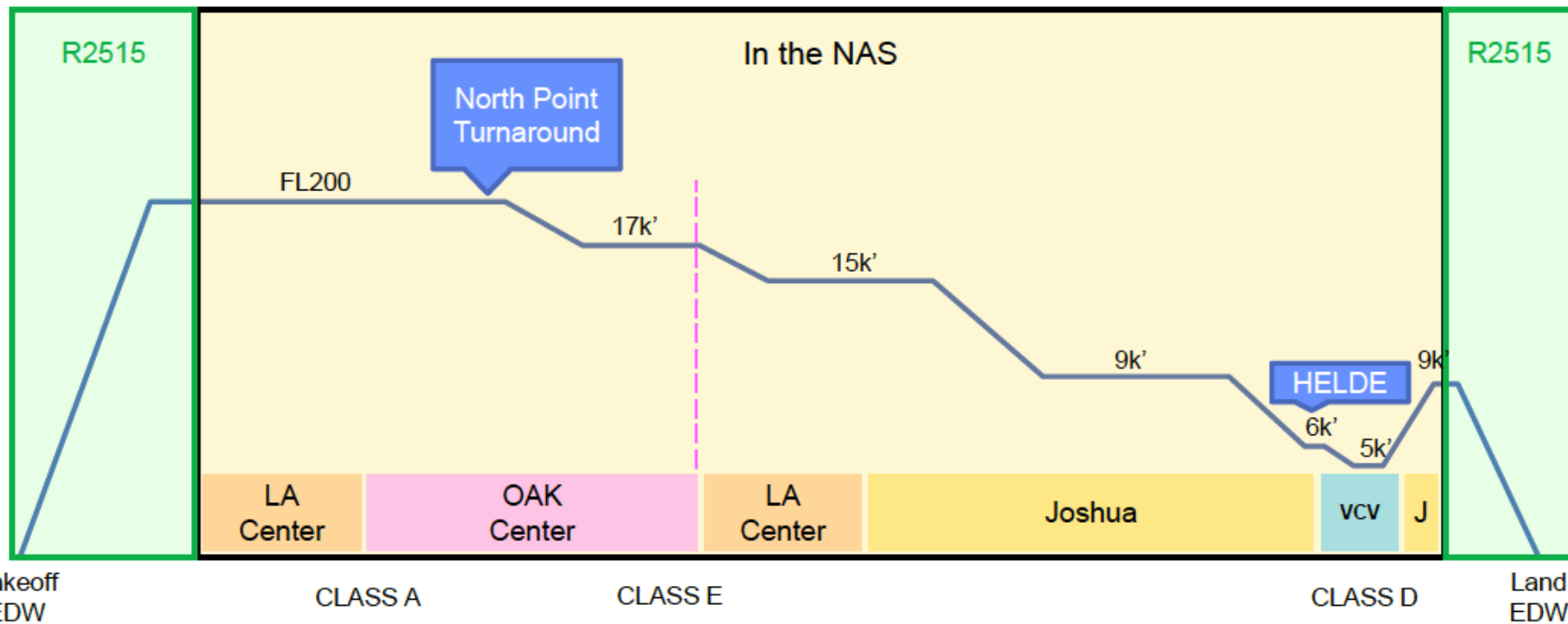
No Chase Aircraft COA Flight Demonstration Route

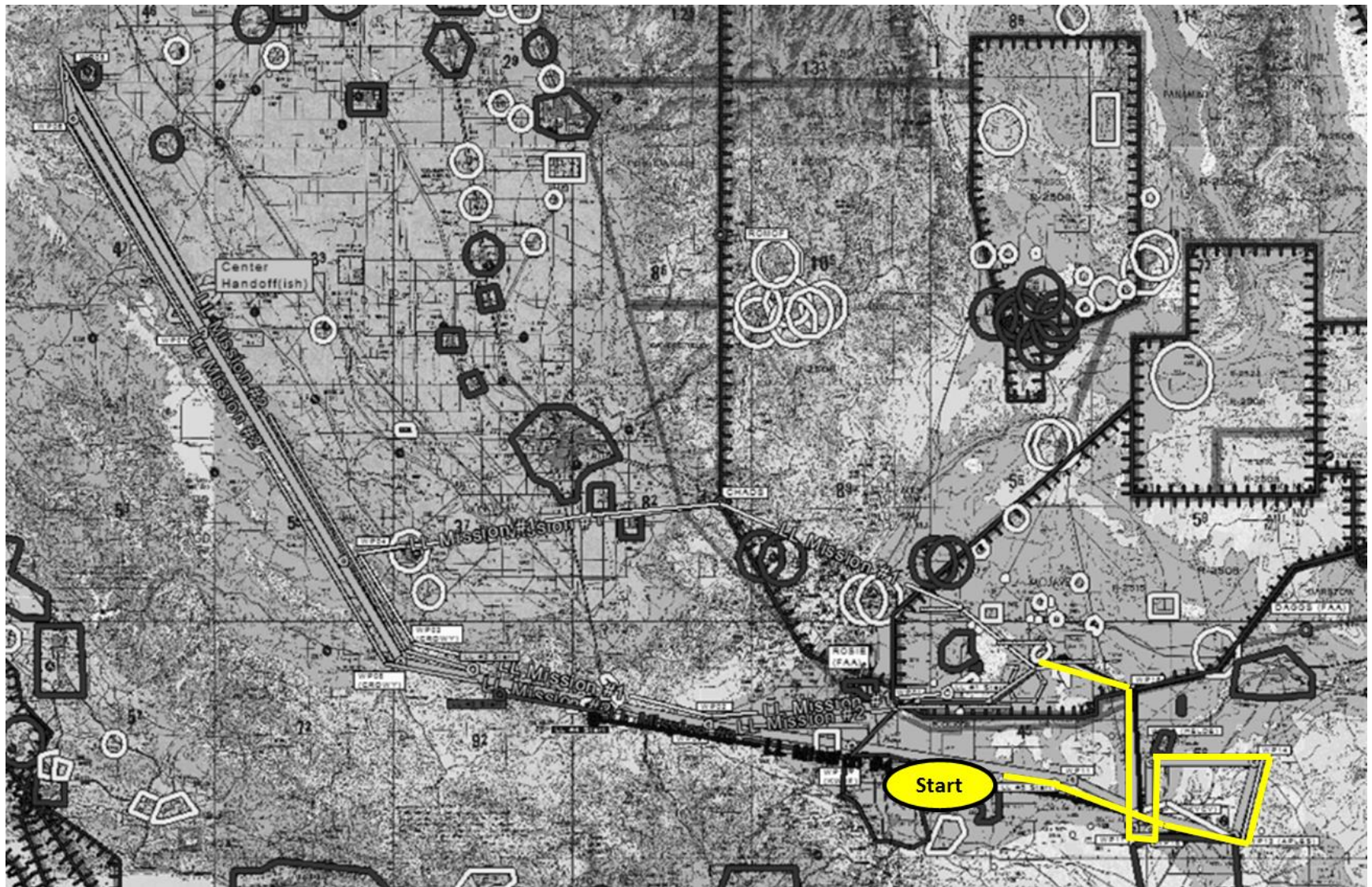
Zoom in of KVCV Area. At or above Min. Vectoring Altitude (MVA) at all times, WPT 11-18.





Mission Altitude Profile







Ikhana Flight #250
Thursday, 24 May 2018
Mission in the NAS with Photo Chase
(Mission Rehearsal)
IAW COA 2017-WSA-148



NASA Prepares to Fly a Large Unmanned Aircraft in Public Airspace without Chase Plane for First Time using DAA Technology





Mission Timeline



- **Mission Events: 05-24-2018**

- **0624L Ikhana Takeoff and climb to FL200 within R-2515**
- **0654L Enter NAS Class A at Point Rosamond (WP01) FL200**
- **0707L Brief DAA Corrective Alert on SWA462 (Southwest Airlines 737 descending out of FL350 to FL210)**
- **0721L Check-in with ZOA-11**
- **0735L Descent to 17,000 ft MSL**
- **0736L Check-in with ZLA-15**
- **0742L Start of descent to 15,000 ft MSL**
- **0809L Start of descent to 9,000 ft MSL**
- **0832L Start of descent to 6,000 ft MSL**
- **0836L Start of descent to 5,000 ft MSL and cleared transit through KVCV Class D**
- **0845L Entry into R-2515 9,000 ft MSL (WP18)**
- **0900L Ikhana landing**

Brief DAA Corrective Alert

Southwest Airlines 462



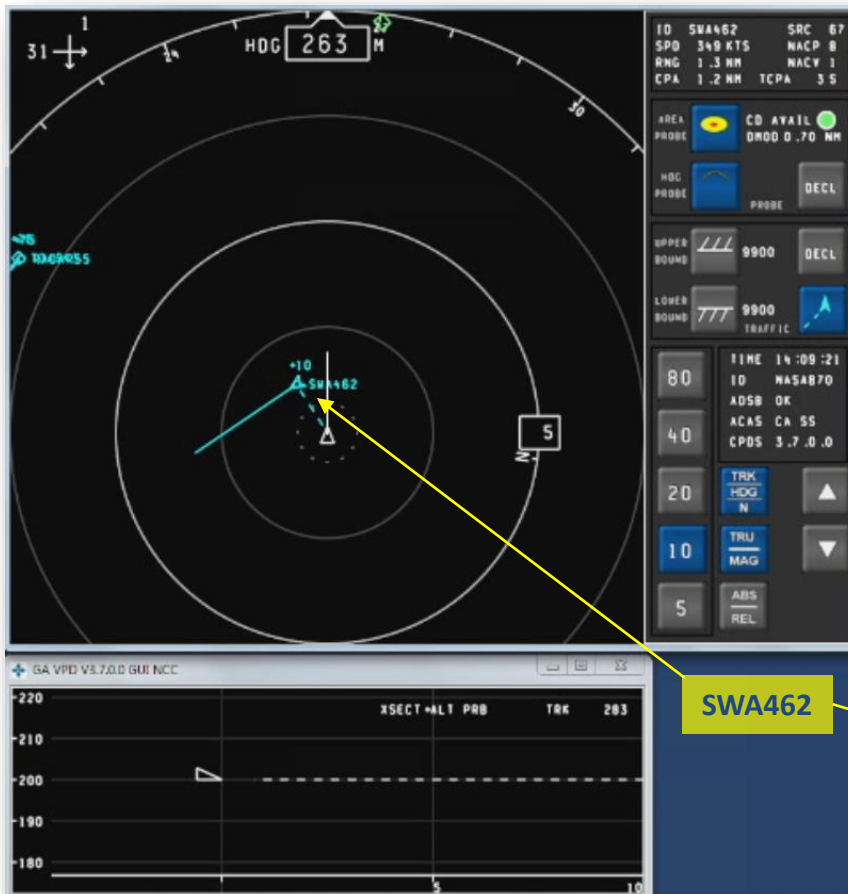
- Ikhana NASA 870 cruising at FL200
- 0707L, DAA corrective alert on SWA462 B737 descending out of FL310 to FL220 headed to Burbank. SW462 was 14.7 nmi away at time of alert
- SWA462 surveilled by ATAR and ADS-B with sensor fused target report. TCAS was using extended hybrid surveillance mode and was not actively interrogating
- DAA corrective alert cleared as SWA462 leveled off at FL220 11.7 nmi away



Zeus Situation Awareness Display

Brief DAA Corrective Alert (con't)

Southwest Airlines 462



CPDS Traffic Display

- Subsequent descent and level-off at FL210 by SWA462 at 5 nmi triggered TCAS TA and “Traffic Traffic” alert (audio and head-up display)
- SWA462 surveilled by ATAR, ADS-B, and TCAS with sensor fused target report
- SWA462 CPA = 1.3 nmi with 1000 ft altitude separation



Zeus Situation Awareness Display

Traffic Enroute to KVCV



CPDS Traffic Display

Conflict space depicted on Vertical Profile Display of VFR traffic

- TCAS surveillance on VFR aircraft landing at Fox Field (8.7 nmi, 75 KGS, 2,300 ft MSL)
- TCAS surveillance on VFR aircraft at 12.3 nmi, 5,500 ft MSL later becoming sensor fused (TCAS and ATAR) surveillance (6.1 nmi, 5,500 ft MSL)



Zeus Situation Awareness Display

Traffic Around Apple Valley Airport



CPDS Traffic Display

- TCAS surveillance on VFR aircraft in the traffic pattern (3.2 - 4.8 nmi, 57- 60 KGS, 2,800 - 3,800 ft MSL)



Zeus Situation Awareness Display

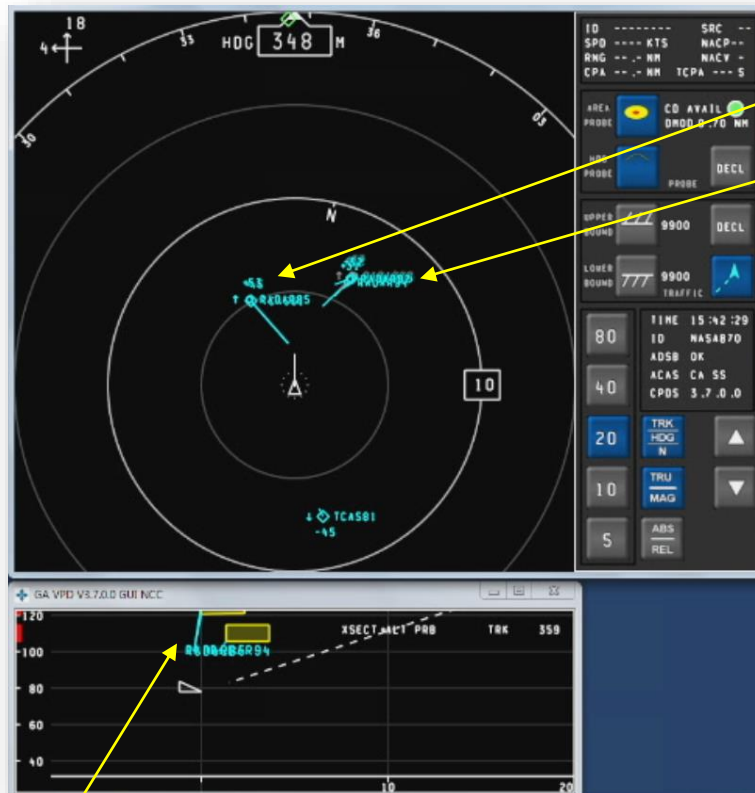


CPDS Traffic Display

- Ikhana level at 5,000 ft MSL, inside the KVCV Class D
- TCAS surveillance on VFR aircraft in the traffic pattern (3.2 nmi, 59 KGS, 3,400 ft MSL and climbing at ~500 fpm)



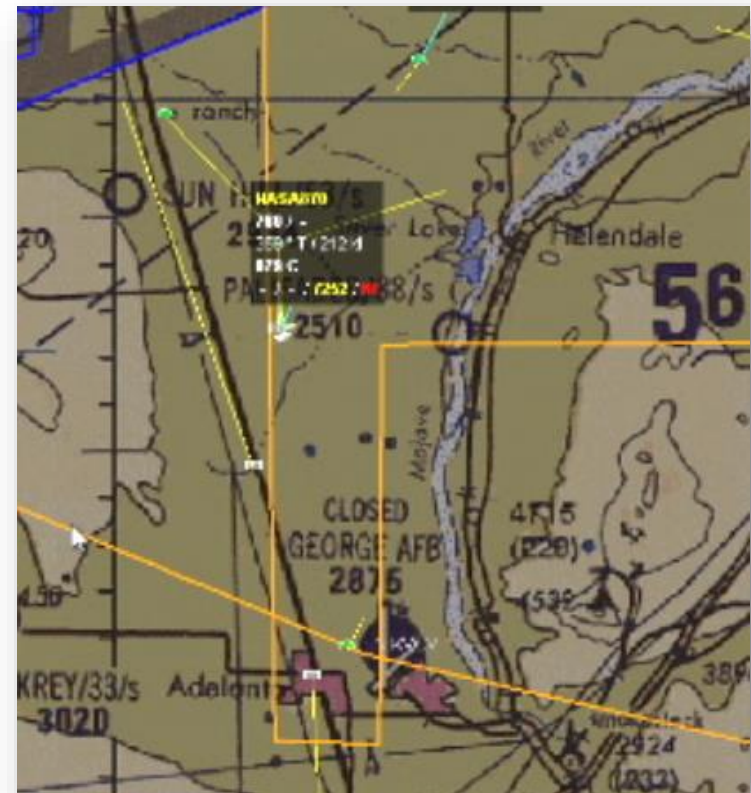
Zeus Situation Awareness Display



CPDS Traffic Display

Conflict space depicted on Vertical Profile Display of VFR traffic

- TCAS and ATAR surveillance on fast mover leaving R-2515 (5.1 nmi, 361 KGS, 12,400 ft MSL)
- Sensor Fused surveillance on MQ-9 orbiting south of R-2515 (6.5 nmi, 11,000 ft MSL)



Zeus Situation Awareness Display



Ikhana Flight #251
Tuesday, 12 June 2018
No Chase Flight Demonstration
IAW COA 2017-WSA-148



Sharing Air: Integrating Unmanned Aircraft with Manned Aircraft in the National Airspace System

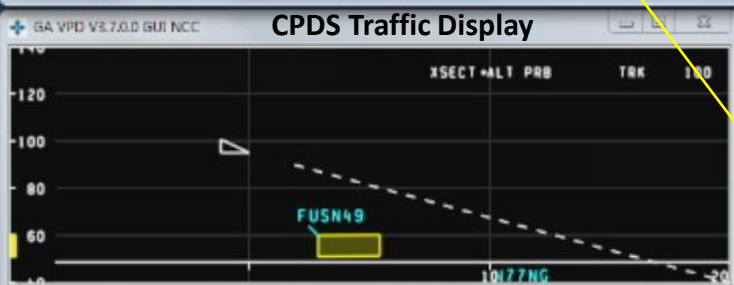
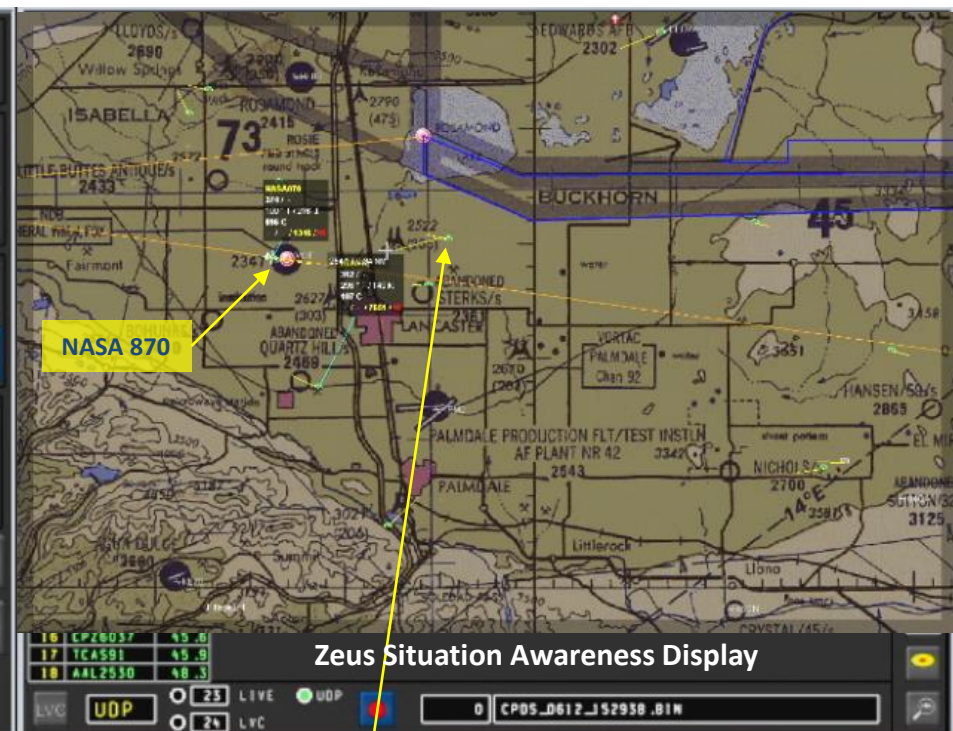
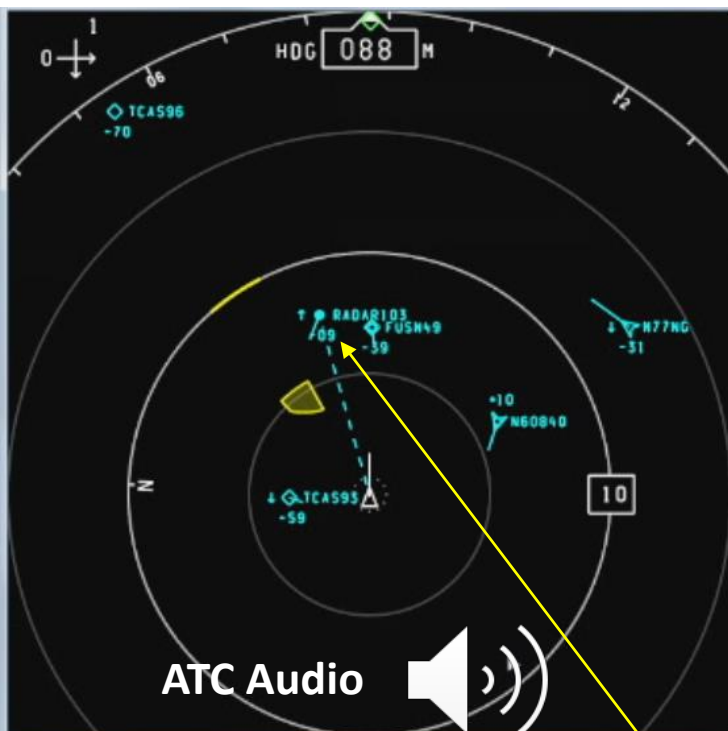




Mission Timeline



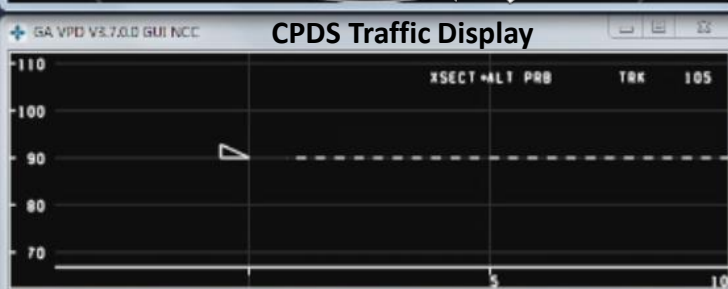
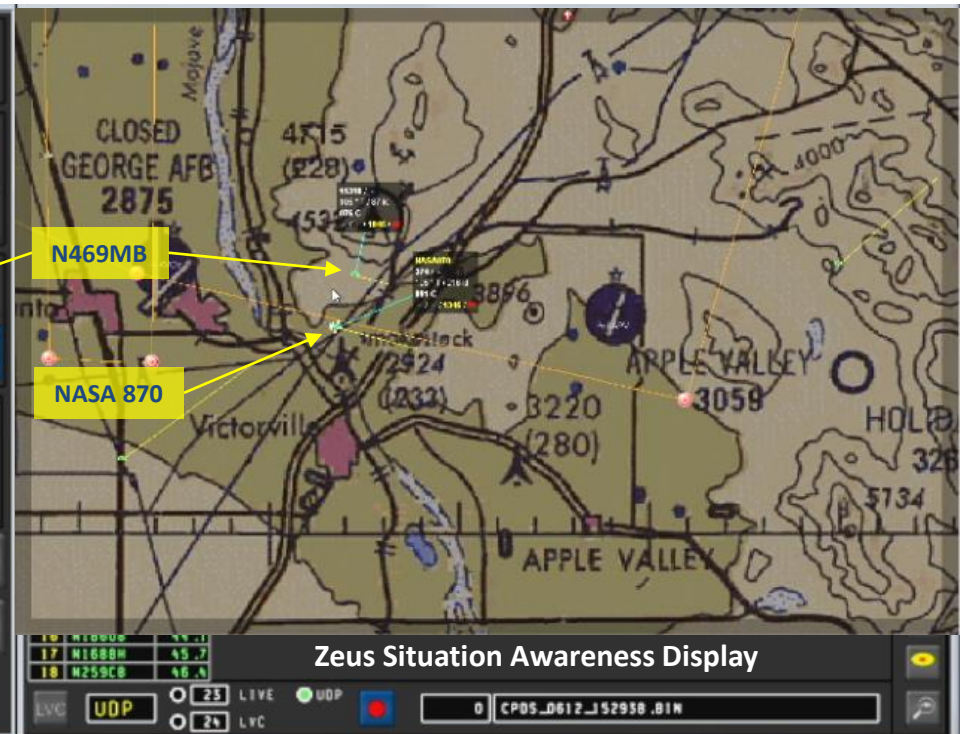
- **Mission Events: 06-12-2018**
 - **0604L Ikhana Takeoff and climb to FL200 within R-2515**
 - **0628L Enter NAS Class A at Point Rosamond (WP01) FL200**
 - **0659L Check-in with ZOA-11**
 - **0711L Descent to 17,000 ft MSL**
 - **0715L Check-in with ZLA-15**
 - **0718L Start of descent to 15,000 ft MSL**
 - **0743L Start of descent to 9,000 ft MSL**
 - **0747L ATC interaction (first of its kind) where ATC provides traffic advisory on an opposite direction VFR traffic with an intermittent transponder and unverified altitude. Ikhana responds with “Traffic Detected” and ATC acknowledges. No further traffic advisories are provided on that VFR traffic since Ikhana has the traffic detected**
 - **0801L ATC/Pilot interaction where a C-172 is provided an advisory of a UAS overtaking it to the right and 1,500 ft above. C-172 pilot reports “Traffic in Sight”**
 - **0806L Start of descent to 6,000 ft MSL**
 - **0810L Start of descent to 5,000 ft MSL and cleared transit through KVCV Class D**
 - **0818L Entry into R-2515 9,000 ft MSL (WP18)**
 - **0846L Ikhana landing**
- **Route of Flight outside R-2515: 415 nm**
- **Time outside of R-2515: 1.8 hrs**



In a first of its kind ATC interchange, NASA 870 is advised of an opposite direction VFR traffic (not talking to ATC) with an intermittent transponder resulting in an unverified altitude. This traffic was surveilled by the ATAR at 7.7 nmi during Ikhana's descent to 9,000 ft MSL. NASA 870 responds with "Traffic Detected". ATC acknowledges the traffic detected call and does not provide any further advisories since Ikhana has now resumed separation responsibilities with its DAA capabilities

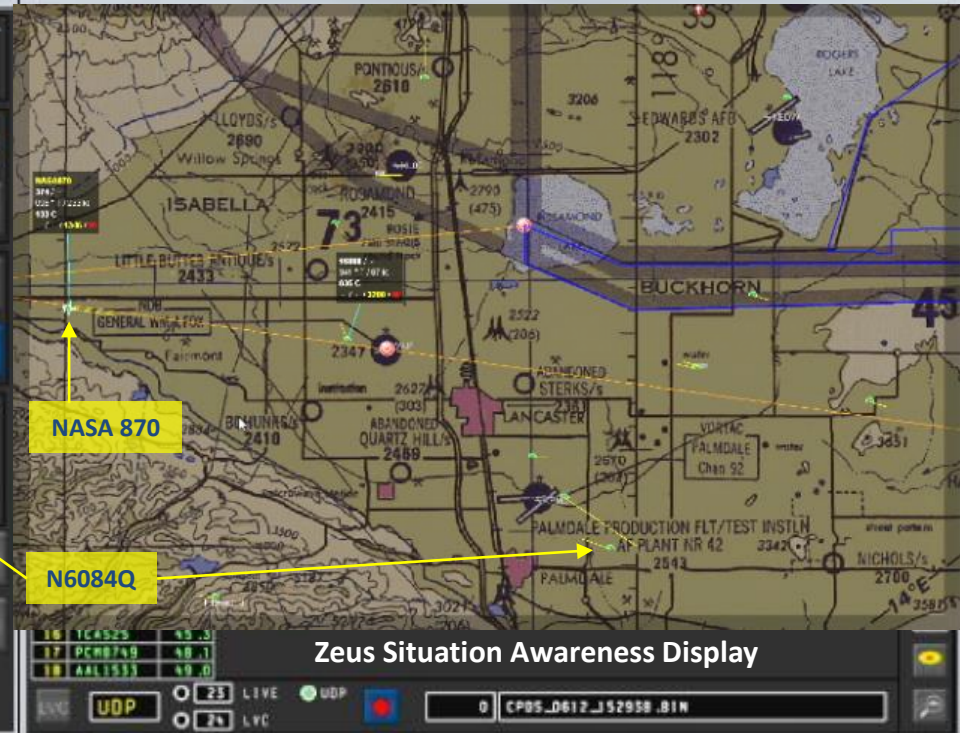


ATC Advisory to C-172 of Overtaking UAS (Ikhana) Traffic



ATC advises a C-172 that a UAS is overtaking it to its right and 1,500 ft above. C-172 pilot reports "Traffic in Sight". The C-172 was surveilled by the ATAR and TCAS

ATC Interaction Mooney N6084Q

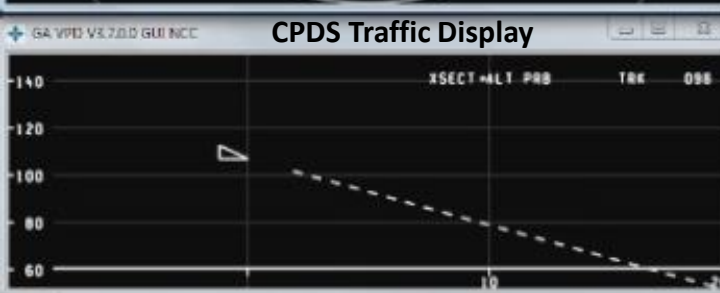
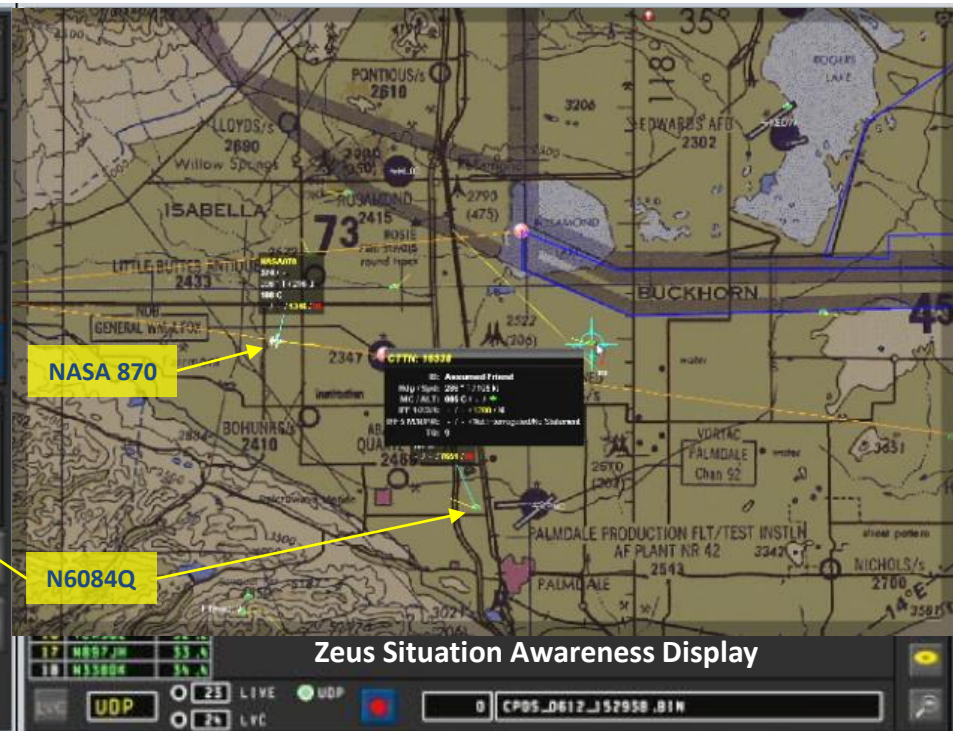


ATC is overly cautious and directs heading change to a Mooney that is over 25 nmi away of descending UAS traffic. Ikhana is descending to 9,000 ft MSL with the Mooney level at 10,500 ft MSL. The Mooney was surveilled by ATAR and ADS-B. TCAS was using extended hybrid surveillance mode and was not actively interrogating the Mooney



ATC Interaction (con't)

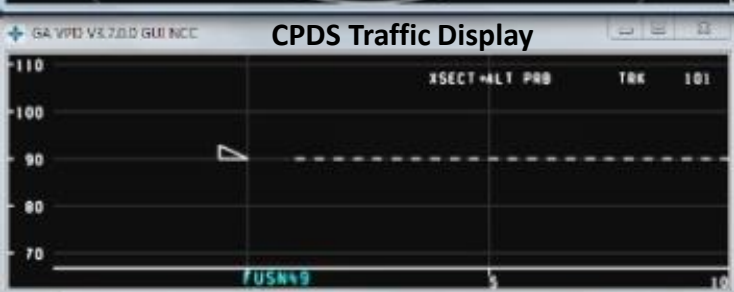
Mooney N6084Q





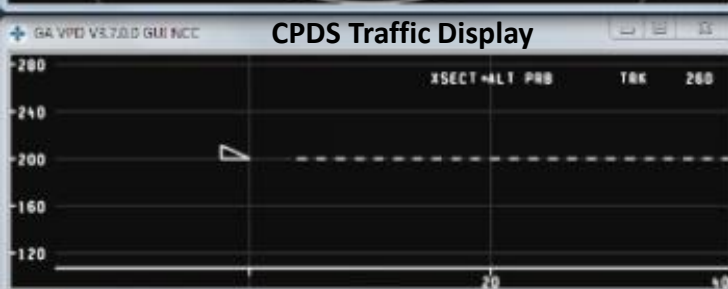
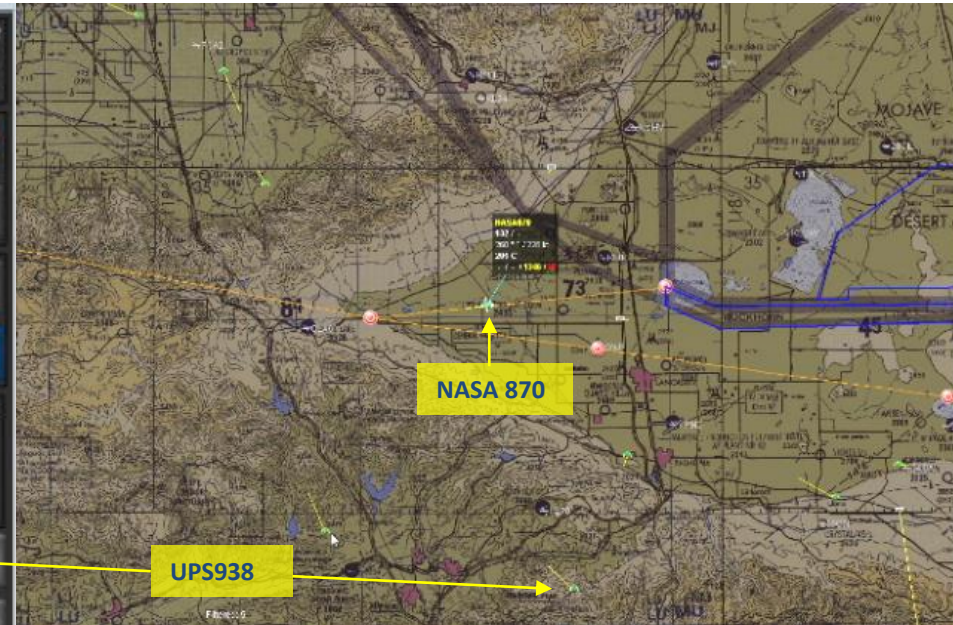
ATC Interaction (con't)

Mooney N6084Q





ATC Interaction UPS938

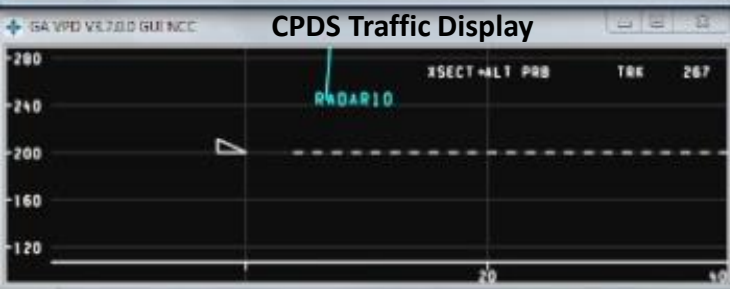


ATC is overly cautious and directs a UPS B757 to climb at or above 1,500 fpm through FL210 for traffic (Ikhana). Ikhana is level at FL200. The UPS B757 was surveilled by ADS-B. Traffic was outside ATAR FOR and TCAS was using extended hybrid surveillance mode and was not actively interrogating the B757



ATC Interaction (con't)

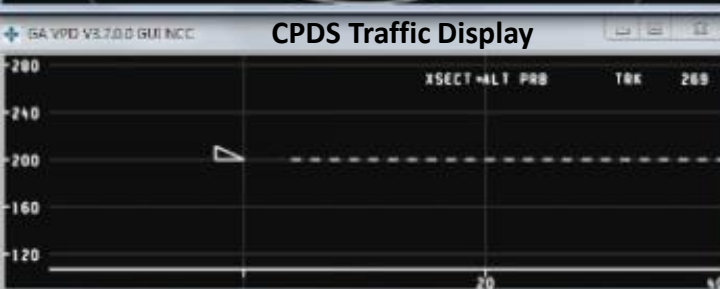
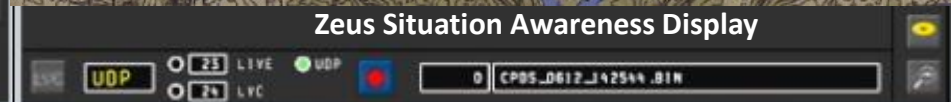
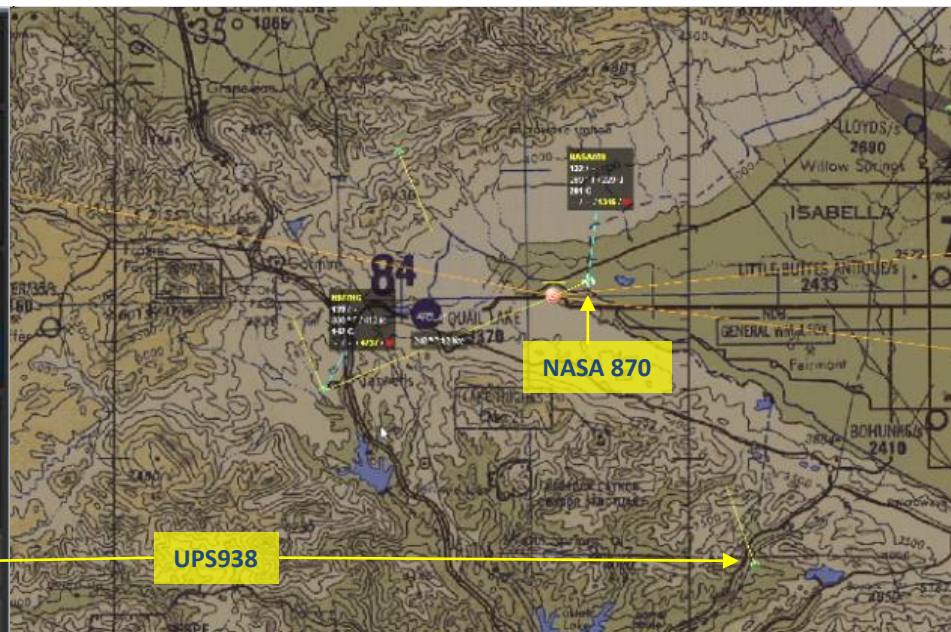
UPS938





ATC Interaction (con't)

UPS938



- No Chase Flight Demo successfully completed
- DAA Systems worked as expected
 - Extended hybrid surveillance on ADS-B equipped aircraft
 - Sensor fusion
 - ATAR track on VFR traffic with an intermittent transponder
 - DAA Alerting and Guidance
- Some Ku downlink dropouts
- First ever “Traffic Detected” interchange with ATC
- Comments from ZLA, ZOA, JCF
 - Minimum impact to operations – controllers had been provided brief on route, lost link
 - Operation no different than manned aircraft





Lessons Learned



Lessons Learned (1/2)



Spectrum Authorization

- Description: Project and the AFRC Radio Frequency Spectrum Management Office (RFSMO) did not have a good understanding of the Frequency Spectrum allocation/assignment/approval process for operations outside of SUA when developmental equipment interfaces with the operational NAS. Although the COA was approved in March 2018, addressing the spectrum issues caused an additional delay that pushed the flights into the NAS to May and June with chase and without chase, respectively.
- Recommendation: Involve the RFSMO early in project to initiate National Telecommunications and Information Administration (NTIA) certification process (Fed Agency) or FAA licensing (non-Federal).

FAA Operational Approval

- Description: FAA operational approval is independent of spectrum approval. The spectrum approval was an additional process to the COA being approved.
- Recommendation: Involve FAA Spectrum Office early in formulation and Safety Risk Management (SRM) process. This task was missed during initial discussions due to lack of understanding of the process.



Lessons Learned (2/2)



Mission Design

- Description: The final route of flight for NCC was iterative and protracted. Project initiated the development of the mission. Initial consideration focused on meeting the minimum objectives but also there were several options for executing the demonstration dating back to early 2015. As the mission plan got more refined (2017) the project tried to coordinate with the FAA for feedback. Routing was requested in August 2017; however, actual FAA review and recommendations came much later (March 2018) and some recommendations were to abandon early planning and go with a route where traffic was light or were existing COAs permitted operations (i.e. Riverside ANG route). FAA leadership helped ensure that this flight plan was the best to demonstrate DAA.
- Recommendation: Early involvement by the FAA to consider the route of flight and make recommendations is highly desired.

Operational Rehearsal Mission

- Description: Flight into the NAS with photo chase prior to executing full demonstration was beneficial to pilots and all flight crew. Practicing the route provided the crew with expectations for the second flight and allowed them to execute more smoothly. Additionally, the rehearsal mission provided the FAA confidence in the UAS system, as well as showing ATC what the flight without chase would look like in terms of control.
- Recommendation: Operational "rehearsal missions" are beneficial to the team. Any time a similar mission will be executed, a rehearsal is recommended.



Conclusions



Conclusions



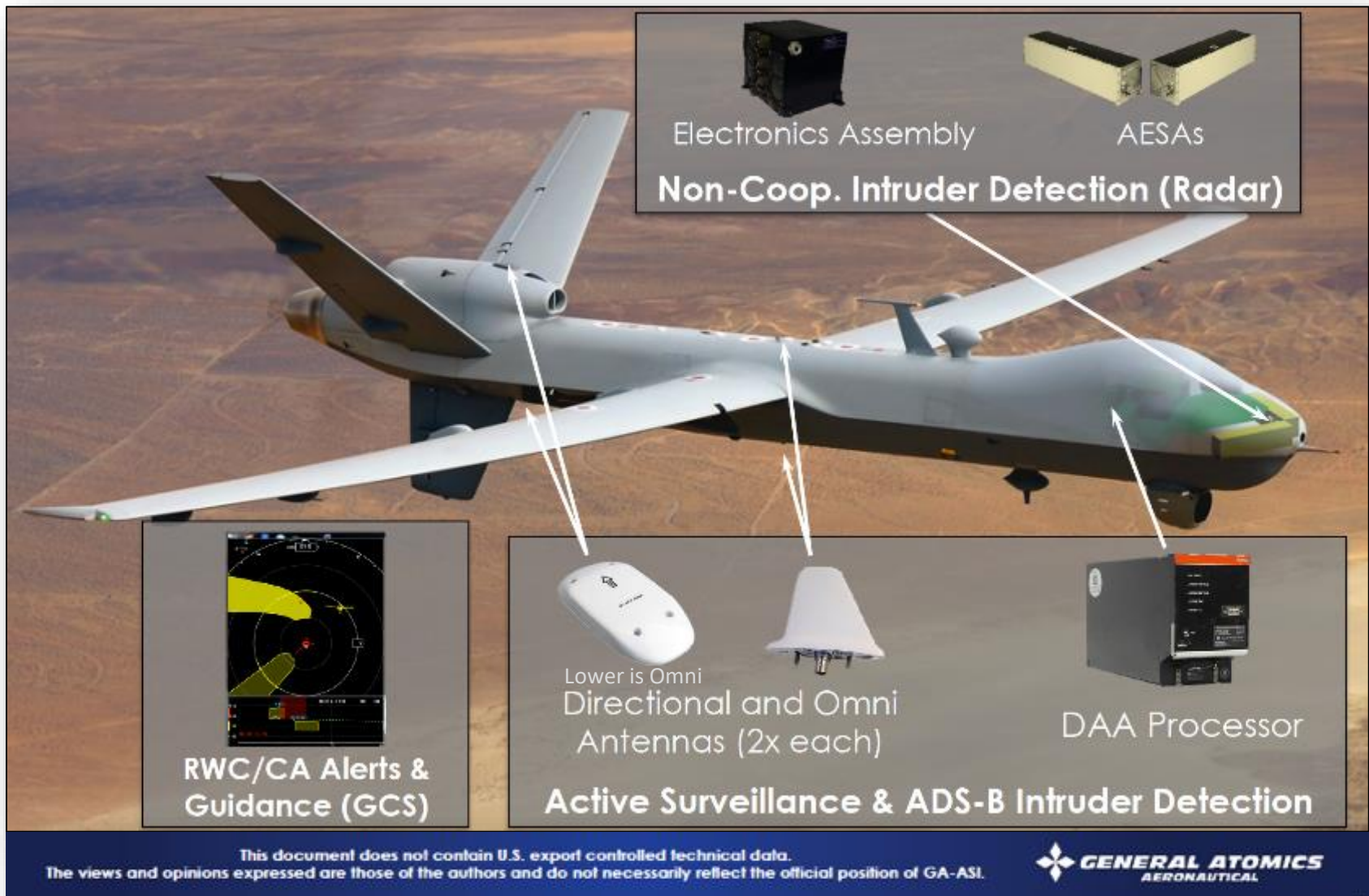
- **All phase 1 project milestones satisfied**
 - Standards from phase 1 MOPS
 - Class A, E, D airspace
 - Multiple ARTCCs
 - DAA technology
- **Experienced test team used to execute mission**
- **Collaborative efforts between NASA, industry partners, and FAA made flight successful**
- **For more information, please refer to:**
 - UAS-NAS NASA 870 Ikhana UAS No Chase COA (NCC) Flights Flight Test Report**
(link to website)



Team photo after successful flight into NAS, 12 June 2018



Backup: DAA System Overview





Backup: Standards Compliance and Safety Case Approach



Safety Case Approach and Rationale



- In order to safely operate UAS in the NAS, it must be shown that the Phase 1 Detect and Avoid (DAA) and Air-to-Air Radar (ATAR) Systems are an alternate means of compliance to 14 CFR §91.111(a) and 14 CFR §91.113(b) “see and avoid/remain well clear” regulations. The approach taken for this safety case entailed the following:
- Performed gap/compliance analysis of the DAA and ATAR systems “as installed” on the Ikhana UAS against published Phase 1 Minimum Operational Performance Standards (MOPS) and Technical Standard Order (TSO) for the DAA and ATAR systems.
 - DO-365 MOPS (dated 31 May, 2017) and TSO-C211 (dated 25 Sep 2017) for DAA Systems.
 - DO-366 MOPS (dated 31 May, 2017) and TSO-C212 (dated 22 Sep 2017) for ATAR for Traffic Surveillance.
 - The majority of the gaps were related to the display of DAA and ATAR system health and status information to the UAS pilot.
 - It was determined that updates to the system software to display this information were not required for this demonstration due to Ikhana’s architecture and flight test operations concept where system health and status telemetry data is downlinked to the Ikhana GCS and displayed not only to Ikhana’s DAA system experienced pilots, but also available to test engineers with subject matter expertise to accurately assess system status.



Safety Case Approach and Rationale



- Performed gap/compliance analysis of the DAA and ATAR systems “as installed” on the Ikhana UAS against DO-178C software certification guidance (dated 13 Dec 2011).
 - Design Assurance Level for all DAA related software can be Level D for overall process/documentation
 - Level C for software testing per DO-178C (full code statement coverage).
 - DAA and ATAR Systems critical DAA functionality will be tested to DAL C rigor requiring full code structural coverage.
 - The only software component of the DAA System not being tested to DAL C full code statement coverage is the Honeywell sensor fusion tracker hosted in the TPA-100 ACAS processor.
 - To address this gap, Honeywell has implemented an I/O crosscheck algorithm, to DAL C standards, that will validate the fusion tracker’s output with TCAS/Extended Hybrid Surveillance.
 - This feature will ensure that the tracker’s output is accurate by validating the fusion tracker output tracks with DO-185B and DO-300A compliant passive and active surveillance techniques



Safety Case Approach and Rationale



- Leveraged the FAA Safety Risk Management Document (SRMD) for UAS DAA System Safety Assessment (SSA) rev 0.5 dated 4 May 2017. Its fault tree influenced NASA's hazard report development and risk mitigation strategy.
- Developed operational mitigations to reduce risk and address performance gaps.
 - ATM Services:
 - The NCC route of flight ensures its mission stays above MVA to leverage the legacy ATM safety systems (primary and secondary surveillance radar coverage)
 - Datalink Management: C2 datalink redundancy during Class E segment <10kft MSL
 - Although the Ku SatCom BRLOS link has been very reliable on the NASA Ikhana UAS, the NCC route of flight was tailored to minimize operations in Class E <10kft MSL until the UAS is within C-Band DLOS range. This is expected to occur prior to WPT 9 before initiating the descent from 15kft MSL to 9,000ft MSL.
 - Route of Flight:
 - The NCC mission plan has been carefully developed to remain off of published airways and away from known flight activity associated with gliders and other small aircraft that NASA has not fully tested the ATAR system against.
 - Flight tests were utilized to validate ATAR performance predictions using RCS modeling and simulations for medium and large aircraft. Modeling and simulation results show sufficient detection and track performance against small RCS aircraft such as gliders; however, to further reduce risk, this flight demonstration is planned to remain clear of areas with known glider activity.



Backup: Mission Information



Mission Waypoints (GPS & VOR Cuts)



WP	LATITUDE (N)	LONGITUDE (W)	VOR	Fix (DD175)	ALT	Remark
1	34° 49' 40.00"	118° 05' 48.00"	Edwards	EDW 233/12	FL200	Exit R2515
2	34° 47' 00.00"	118° 37' 00.00"	Lake Hughes	LHS 330/06	FL200	
3 (CROWY)	34° 54' 54.00"	119° 28' 34.00"	CROWY	CROWY	FL200	Turn North
4	35° 07' 41.38"	119° 38' 09.42"	Fellows	FLW 067/12	FL200	5 min to OAK
5	36° 09' 00.00"	120° 25' 0.00"	Priest	ROM 075/12	FL200	Turnaround/Overfly
6	36° 03' 35.73"	120° 23' 25.22"	Priest	ROM 098/14	FL200	Begin Descend to 17
7	35° 36' 31.31"	120° 01' 36.78"	Avenal	AVE 214/3	17,000	Begin Descend to 15
8 (CROWY)	34° 54' 54.00"	119° 28' 34.00"	CROWY	CROWY	15,000	Turn East
9	34° 47' 00.00"	118° 37' 00.00"	Lake Hughes	LHS 330/06	15,000	Begin Descend to 9
10 (GWF)	34° 44' 19.00"	118° 13' 0.00"	Wm J Fox NDB	GWF	9,000	(PMD 299/10)
11	34° 40' 00.00"	117° 36' 00.00"	Victorville	VCV 282/11	9,000	
12 (VCV)	34° 35' 39.00"	117° 23' 24.00"	Victorville VOR	VCV	9,000	
13 (APLES)	34° 32' 54.48"	117° 08' 58.14"	APLES	APLES	9,000	Turn North
14	34° 42' 20.35"	117° 05' 34.95"	Victorville	VCV 054/16	9,000	Turn W, Descend
15 (HELDE)	34° 42' 16.29"	117° 22' 57.18"	HELDE	HELDE	6,000	Turn S, Descend
16	34° 33' 43.03"	117° 23' 00.88"	Victorville	VCV 159/2	5,000	Turn W, Climb to 6
17	34° 33' 47.96"	117° 25' 43.42"	Victorville	VCV 215/3	6,000	Turn N, Climb to 9
18 (VEGAS)	34° 51' 19.00"	117° 26' 03.00"	Victorville	VCV 341/16	9,000	Enter R2515