Assistive Detect and Avoid for Pilots in the Cockpit

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See and Avoid

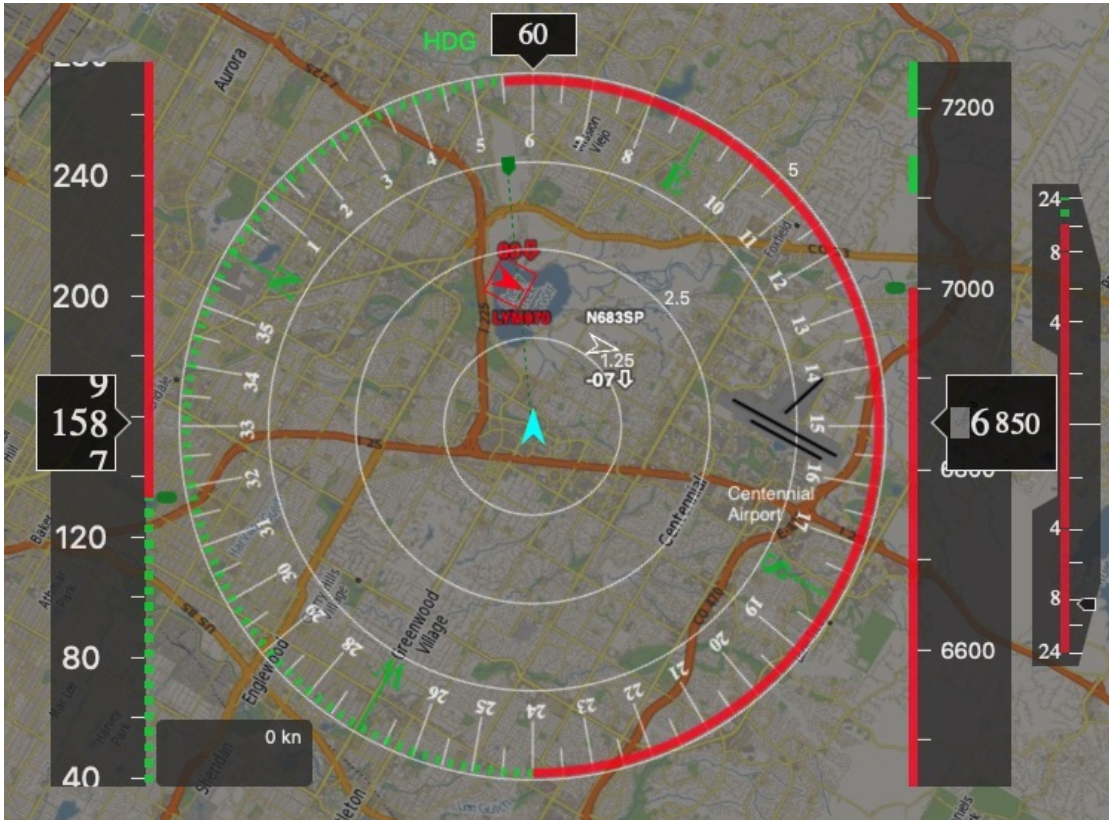
- The Code of Federal Regulations requires that vigilance is maintained by each person operating an aircraft to see and avoid other aircraft, regardless of the type of operation.
- In the vicinity of, and at non-towered airports, aircraft communicate via a Common Traffic Advisory Frequency to report positions and coordinate arrivals and departures with other aircraft
- Many Visual Flight Rules (VFR) operations depend on see and avoid as the only means of remaining well clear of traffic aircraft
- Mid-air collisions continue to occur in the U.S. at a rate of about 10 collisions per year

See and Avoid vs. Detect and Avoid

Centennial mid-air collision recreation, 2021 May 12

Out of window view, SR22 N416DJ (recreation)

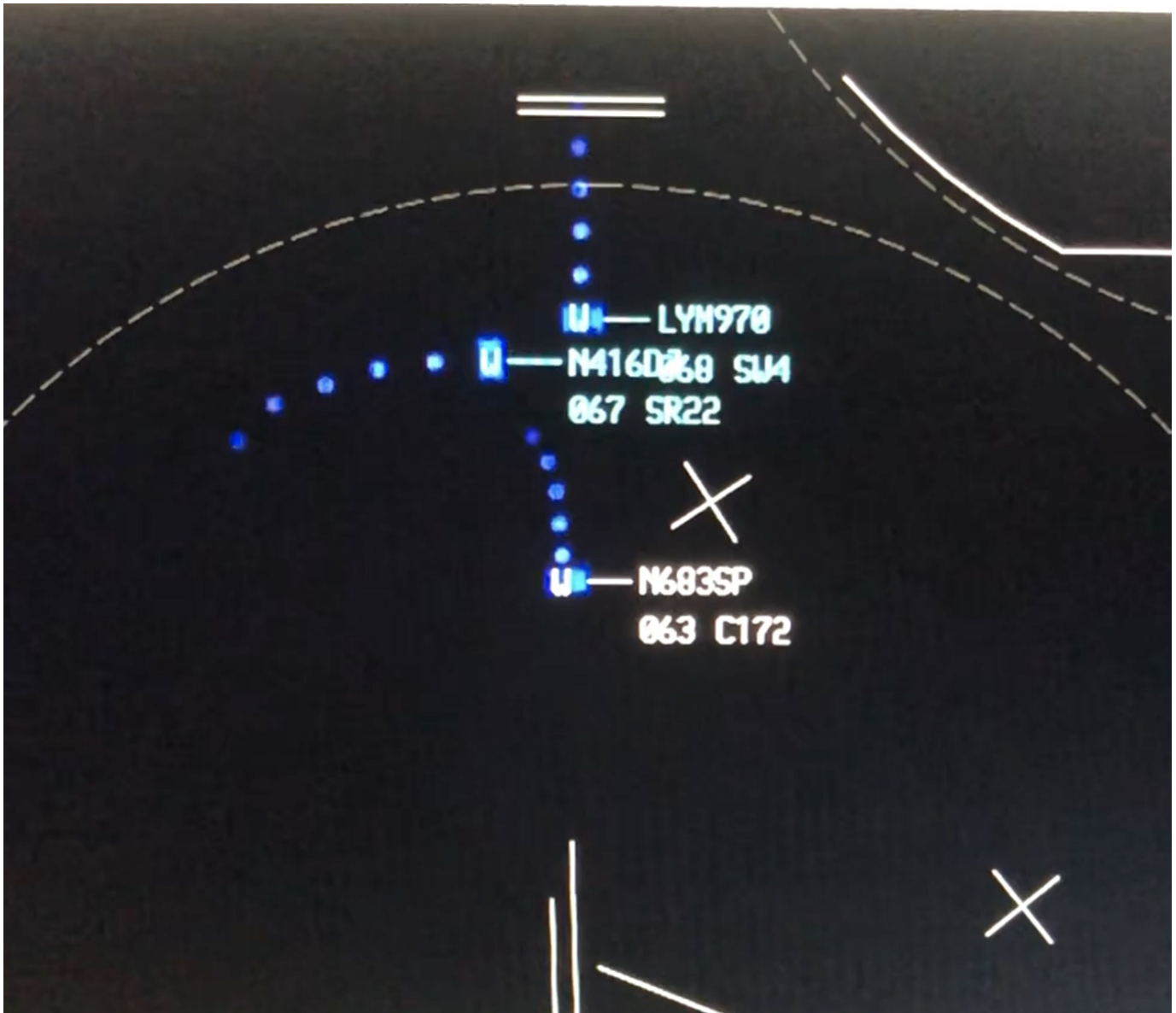
DANTi Detect and Avoid traffic display
From SR22 N416DJ perspective



ATC Radar Display

Approach from the North to KAPA runways 17L and 17R

Centennial mid-air collision



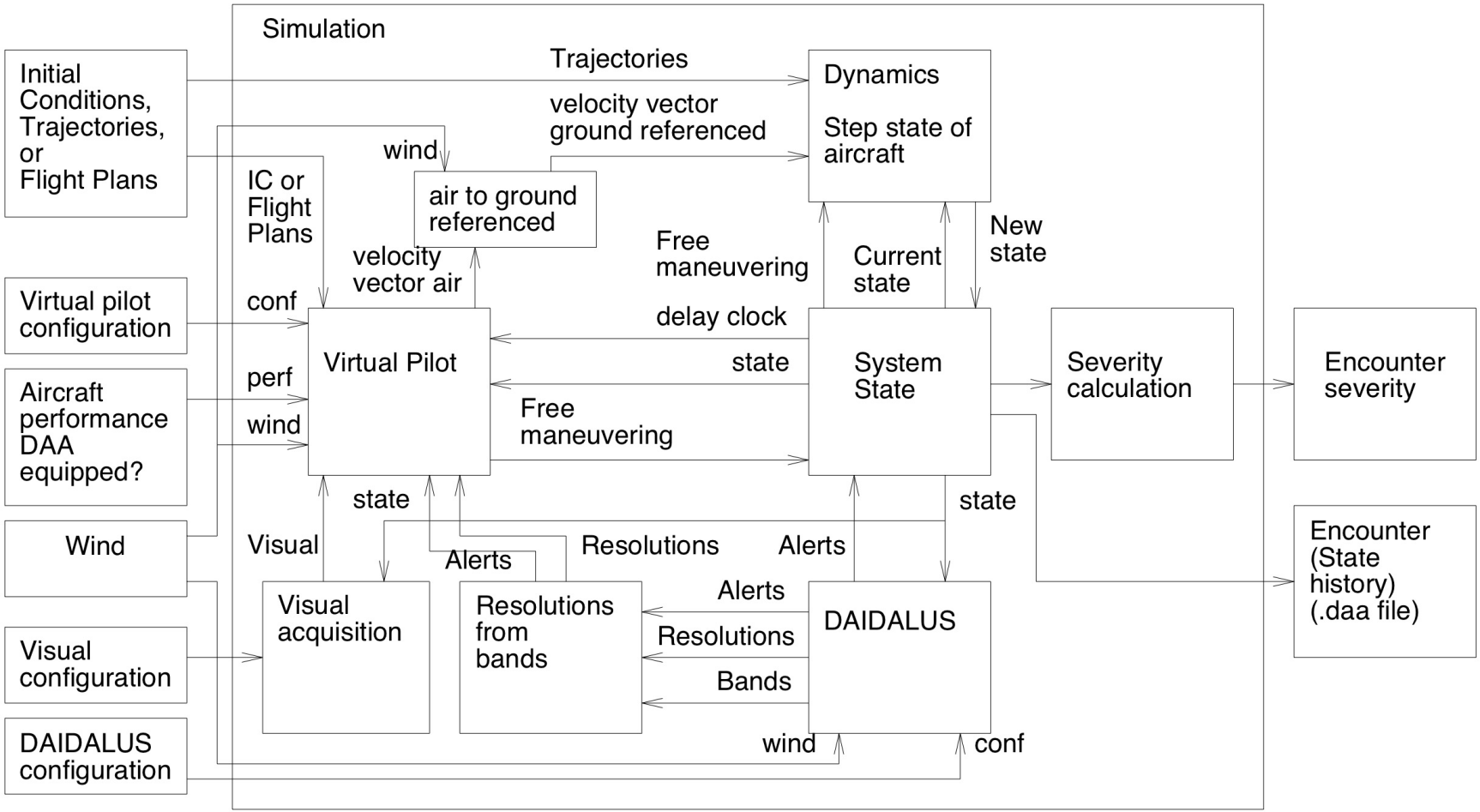
The DANTi Detect and Avoid Prototype

1. Ownship
2. Traffic
3. Ground speed
4. Heading
5. Heading or Track
6. Altitude
7. Vertical speed
8. Scale
9. North or Track up
10. Call sign on traffic
11. Type of moving map
12. Peripheral band
13. Peripheral band

Effectiveness of See and Avoid

- To estimate the effectiveness of See and Avoid and determine the benefits of Assistive Detect and Avoid, a visual acquisition program is used together with Monte Carlo simulation
- The DANTi prototype, developed at NASA Langley Research Center, is used as the Assistive Detect and Avoid system for comparison to see and avoid
- Three scenarios are used in the simulation runs
  - Head-on
  - Crossing
  - Overtaking

Simulation

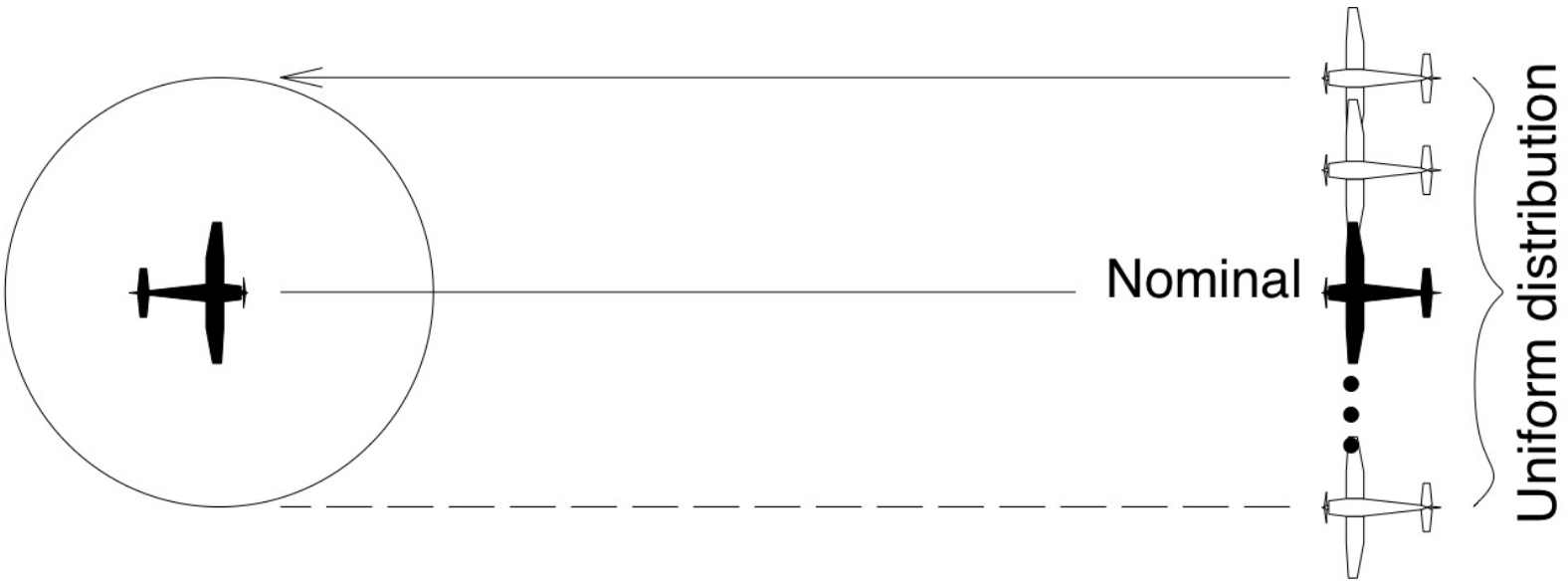

Simulation
Initial Conditions, Trajectories, or Flight Plans
Trajectories
Dynamics
Step state of aircraft
velocity vector ground referenced
wind
IC or Flight Plans
air to ground referenced
velocity vector air
Free maneuvering
Current state
New state
Virtual pilot configuration
conf
delay clock
Virtual Pilot
state
System State
Severity calculation
Encounter severity
Aircraft performance DAA equipped?
perf
wind
Free maneuvering
state
state
Wind
Visual
Resolutions
Alerts
Alerts
Encounter (State history) (.daa file)
Visual acquisition
Resolutions from bands
Alerts
DAIDALUS
Visual configuration
Resolutions
Bands
DAIDALUS configuration
wind
conf

Severity Classification

RTCA SC-228 Severity for Well Clear for Unmanned Aerial Systems*	FAA Safety Management System (SMS) Severity Classification
0%-17%	5, Minimal
>17%-33%	4, Minor
>33%-47%	3, Major
>47%-94%	2, Hazardous
>94%-100%	1, Catastrophic

* Three components are used in the determination of severity percentage:
1. Horizontal Proximity (tau MOD)
2. Horizontal miss-distance projection
3. Vertical distance

Initial Conditions and Distribution



- Initial conditions are selected from a uniform distribution
- All initial trajectories are in conflict
- If no action is taken, encounter results in a Loss of Well Clear
- After visual acquisition or detection, the virtual pilot performs an evasive maneuver

Configuration for Visual

- Visibility: 20 statute miles (32.2 km)
- Aircraft speed: 120 knots (both) head-on, crossing
- Aircraft speed: 140 and 100 knots, overtaking
- Traffic aircraft: Piper PA28, four seat single engine piston
- Crew: single pilot

Results, Head-on

	Severity					
Condition	No LoWC	5	4	3	2	1
Unmitigated	0%	17.32%	16.26%	13.67%	46.52%	6.23%
Visual unaided	0.15%	19.15%	17.43%	14.29%	46.66%	2.32%
Visual aided	1.62%	28.23%	22.52%	16.89%	30.74%	0%
Assistive DAA tau=0	71.08%	28.92%	0%	0%	0%	0%
Assistive DAA tau=35	100%	0%	0%	0%	0%	0%

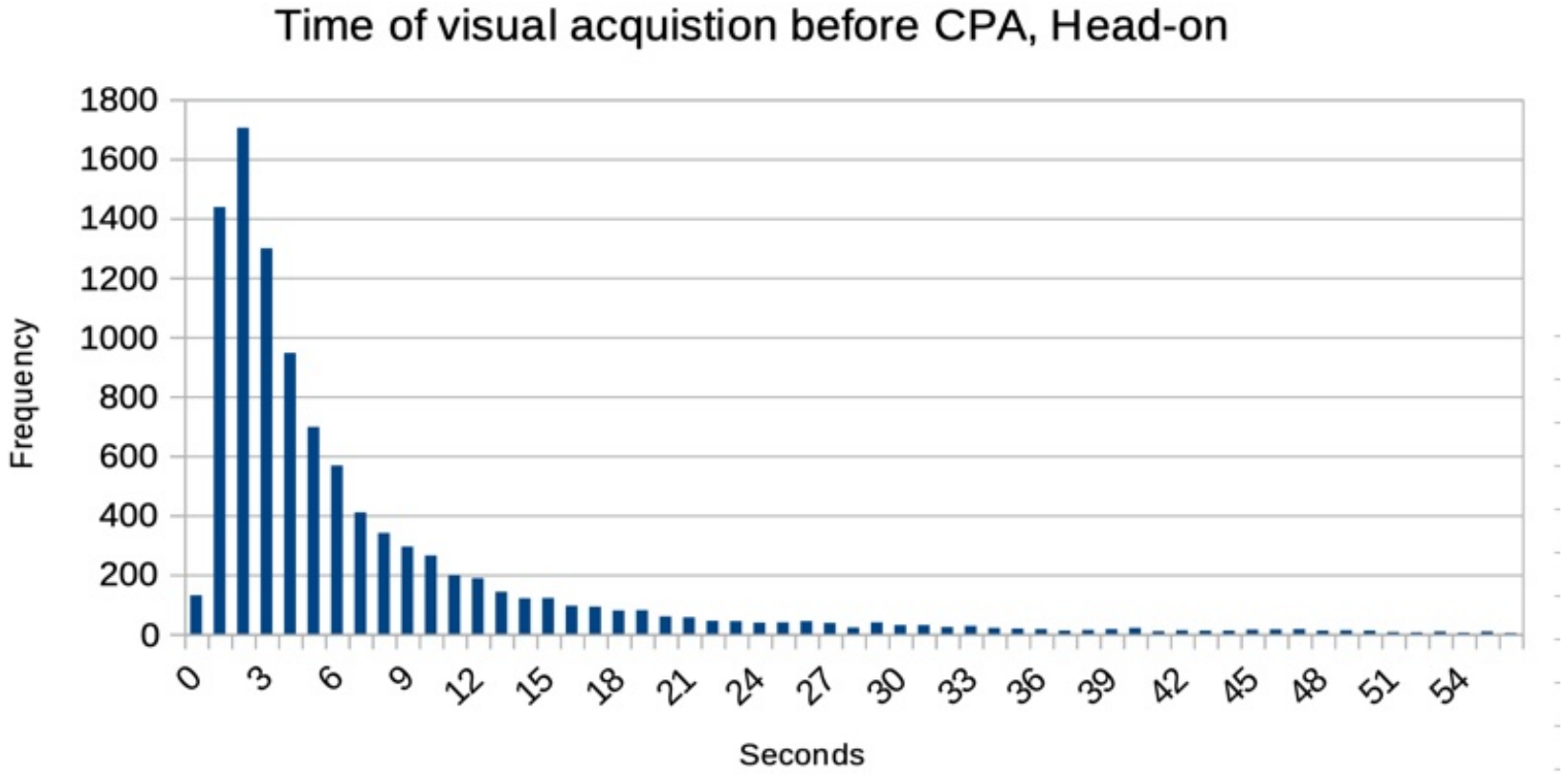
Results, Crossing

	Severity					
Condition	No LoWC	5	4	3	2	1
Unmitigated	0%	0%	5.96%	19.72%	66.01%	8.31%
Visual unaided	7.56%	5.30%	15.00%	21.50%	50.29%	0.35%
Visual aided	45.84%	20.11%	18.30%	10.32%	5.43%	0%
Assistive DAA tau=0	100%	0%	0%	0%	0%	0%
Assistive DAA tau=35	100%	0%	0%	0%	0%	0%

Results, Overtaking

	Severity					
Condition	No LoWC	5	4	3	2	1
Unmitigated	0%	21.06%	17.39%	13.54%	42.43%	5.58%
Visual unaided	77.24%	13.37%	5.74%	2.59%	1.06%	0%
Visual aided	100%	0%	0%	0%	0%	0%
Assistive DAA tau=0	100%	0%	0%	0%	0%	0%
Assistive DAA tau=35	100%	0%	0%	0%	0%	0%

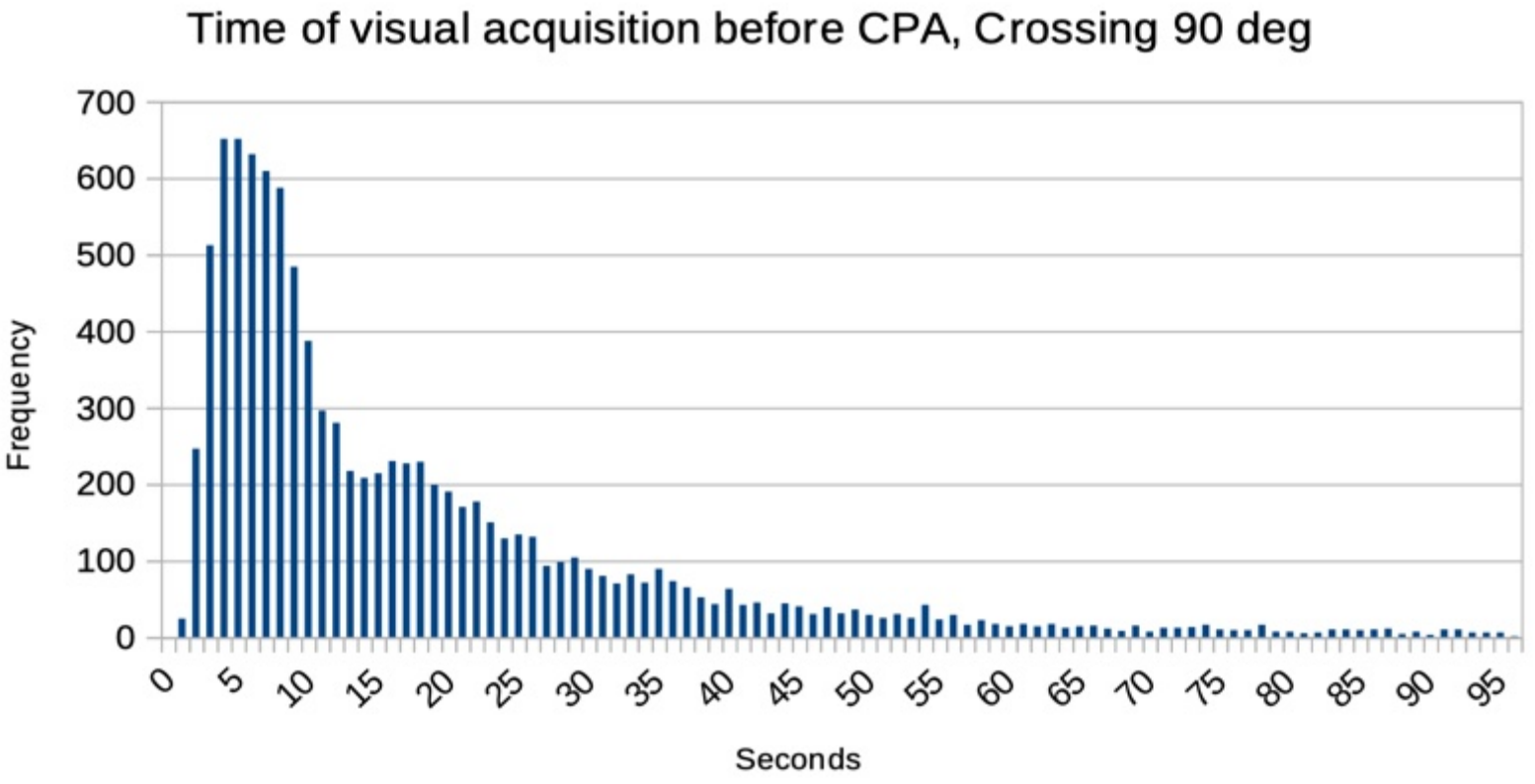
Time to Visual Acquisition, Head-on



Average time: 6.89 sec.

Median time: 3.77 sec.

Time to Visual Acquisition, Crossing



Average time: 17.13 sec.

Median time: 10.68 sec.

Summary and Conclusion

- See and Avoid reduces but does not achieve a desired level of mitigation to remain well clear and avoid collisions
- In head-on encounters, unaided See and Avoid reduces collisions by a factor of 3, but allows 30 percent of the collisions to occur
- Detect and Avoid and the DANTi prototype exhibit a remarkable improvement over See and Avoid to solve conflicts, reduce severity and reduce collisions
- This equipment could be available to General Aviation pilots as Non Required Safety Enhancement Equipment (NORSEE) at relatively low cost