Ground and mid-air collisions account for 72 percent of US F-16 Operations Related Flight Losses, excluding losses due to engine failures. Controlled Flight into Terrain (CFIT), Spatial Disorientation (SDO) & G-Induced Loss of Consciousness (G-LOC) account for 75 percent of US F-16 fatalities. The majority of these losses/fatalities can be eliminated by equipping fighter aircraft with Automatic Collision Avoidance Technology (ACAT).

**System Requirements**

The system has three high-level requirements, listed in order of priority:

- **Do No Harm**
  The system shall not cause the aircraft to depart controlled flight, automatically maneuver outside aircraft or pilot limits or put the aircraft or pilot in a dangerous situation.

- **Do Not Interfere**
  The system shall operate in the background, allowing the pilot to fly low-level missions, employ air-ground weapons, perform air combat maneuvers, and fly in close formation. It should only activate when required to prevent ground or mid-air collisions.

- **Prevent Collisions**
  The system shall automatically maneuver the aircraft to prevent ground and mid-air collisions.

**Why ACAT?**

Midair Collisions 24%
Controlled Flight into Terrain (CFIT) 25%
Spatial Disorientation (SDO) 12%
G Induced Loss of Consciousness (GLOC) 11%

**Total US F-16 Operations Related Aircraft Losses Excluding Losses Due To Engine Failures**

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VIRTUALLY ELIMINATE GROUND AND MID-AIR MISHAPS.
THE NEED IS CRITICAL, AND THE TIME IS NOW.
Automatic Ground Collision Avoidance System (Auto GCAS)

Auto GCAS is designed to protect fighter pilots from Controlled Flight into Terrain (CFIT), Spatial Disorientation (SDO) and G-Induced Loss of Consciousness (G-LOC).

System Capabilities
- Allows nuisance-free, low-level operation and weapons deliveries including low-angle strafe
- Essentially eliminate losses due to CFIT, SDO, and G-LOC

System Description
- Passive system that uses highly accurate GPS position information relative to an onboard Digital Terrain Elevation Database (DTED) to determine ground proximity
- Based on modeled aircraft performance, Auto GCAS will take control of the aircraft via its digital flight control system to avoid ground collision if a collision is imminent
- Uses a roll-to-wings-level, 5-g recovery maneuver for ground collision avoidance
- System is time-based versus altitude-based
- Extensive flight testing showed that nominal pilot recoveries were initiated no later than 1.5 seconds prior to where a 5-g recovery would result in ground impact; nominal Auto GCAS recoveries occur between 0.25 and 0.8 seconds prior to this point of no return, well after an aware pilot would have recovered
- System returns aircraft control to the pilot after the collision has been avoided

Fielding and Performance
- In 2010 AFRL finished testing the system at NASA Armstrong including 1670 automatic fly-up activations, 103 flights and 141 flight hours
- The F-16 program office further tested Auto GCAS and fielded it on more than 600 USAF F-16 Block 40/50 aircraft in the fall of 2014
- Auto GCAS has saved 4 aircraft and pilots as of May 2016
- AFRL has a program underway that will enable Auto GCAS implementation on more than 300 ANG/AFRC/ACC F-16 Block 10 to 32 aircraft, with projected fielding in 2020

Automatic Air Collision Avoidance System (Auto ACAS)

Auto ACAS is designed to protect fighter pilots from mid-air collisions.

System Capabilities
- Does not interfere with air combat training, rejoins or close-in formation flight
- Adapts to quickly changing collision geometries from multiple threats

System Description
- F-16 initial integration uses modified Air Combat Maneuvering Instrumentation (ACMI) pods for aircraft-to-aircraft communication
- Aircraft fire control radar can also be used if ACMI data is not available
- If a collision avoidance maneuver is required, Auto ACAS takes control of the aircraft via its digital flight control system
- Auto ACAS-equipped aircraft on a potential collision course with other aircraft select three top avoidance maneuvers from nine possible options:
  1) Maintain current maneuver
  2) Bunt
  3) Roll and pull to one of 7 different bank angles
- Maneuvers are selected based on aircraft state, collision geometry, and accepted pilot “rules of the road”

For non-Auto ACAS equipped aircraft, the system generates a track file from ACMI pod or radar data and the Auto ACAS equipped aircraft alone will maneuver to avoid the threat aircraft
- System returns aircraft control to the pilot when flight paths are clear

Fielding and Performance
- Initially flight tested through a Test Pilot School Test Management Project in September 2015
- Two phases of flight testing with more than 100 total sorties will be completed in the FY16-FY17 time period at Edwards Air Force Base to further mature Auto ICAS
- Transition target platforms are the F-16, F-22 & F-35
- By adding Auto ICAS to the F-16 & F-35 there is the Potential to save through 2040:
  - Pilots = 40
  - Aircraft = 57
  - Dollars = $6.76B

Automatic Integrated Collision Avoidance System (Auto ICAS)

Auto ICAS combines Auto GCAS and Auto ACAS into one integrated system.

System Capabilities
- Full flight envelope Auto GCAS and Auto ACAS prioritized protection
- Does not interfere with low-level operations, air combat training, rejoins, or close-in formations
- Will essentially eliminate CFIT, SDO, G-LOC and the majority of mid-air collisions

System Description
- Integrated Collision Avoidance System combines Auto GCAS and Auto ACAS algorithms
- System will use appropriate Auto GCAS or Auto ACAS maneuver to avoid the ground and other aircraft
- System returns aircraft control to the pilot after executing an automatic avoidance maneuver

Fielding and Performance
- Initially flight tested through a Test Pilot School Test Management Project in September 2015
- Two phases of flight testing with more than 100 total sorties will be completed in the FY16-FY17 time period at Edwards Air Force Base to further mature Auto ICAS
- Transition target platforms are the F-16, F-22 & F-35
- By adding Auto ICAS to the F-16 & F-35 there is the Potential to save through 2040:
  - Pilots = 40
  - Aircraft = 57
  - Dollars = $6.76B

Time Aligned Escape Trajectories

Uncertainty Sphere

Predicted