U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Pilots' Role in Collision Avoidance **Date:** 4/19/16 **AC No:** AC 90-48D
Initiated by: AFS-800 **Change:**

1 PURPOSE. This advisory circular (AC) is issued for the purpose of alerting all pilots to the potential hazards of midair collisions and near midair collisions (NMAC), and to emphasize those basic problem areas related to the human causal factors where improvements in pilot education, operating practices, procedures, and improved scanning techniques are needed to reduce midair conflicts.

2 CANCELLATION. AC 90-48C, Pilots' Role in Collision Avoidance, dated March 18, 1983, is cancelled.

3 BACKGROUND.

3.1 Midair Conflicts. From January 2009 through December 2013, a total of 42 midair collisions occurred in the United States. During this same time period, there were 461 reported NMACs. Statistics indicate that the majority of these midair collisions and NMACs occurred in good weather and during daylight hours.

3.2 Collision-Avoidance Programs. The Federal Aviation Administration (FAA) has several significant programs designed to reduce the potential for midair collisions and NMACs. This AC is one of those programs, and is directed towards all pilots operating in the National Airspace System (NAS), with emphasis on the need for recognition of other aircraft and maintaining visual separation, improved workload management, and the human factors associated with midair conflicts, particularly in high-volume traffic areas. While the FAA is engaged in the Next Generation Air Transportation System (NextGen) project to transform the NAS for safer, more efficient air traffic management, pilots must remember that they have a regulatory responsibility to see and avoid other aircraft.

4 ACTION. The following areas warrant special attention and continuing action on the part of all pilots to avoid the possibility of becoming involved in a midair conflict.

4.1 See-and-Avoid Concept.

4.1.1 Regulatory Basis. The flight rules prescribed in Title 14 of the Code of Federal Regulations (14 CFR) part 91 set forth the concept of "See and Avoid." Part 91, § 91.113 prescribes that when weather conditions permit, regardless of whether the operation is conducted under instrument flight rules (IFR) or visual flight rules (VFR), each person operating an aircraft shall maintain vigilance so as to see and avoid other aircraft.

4.1.2 Vigilant Lookout. Pilots should also keep in mind their responsibility for continuously maintaining a vigilant lookout regardless of the type of aircraft being flown. Remember that most midair collision accidents and reported NMAC incidents occurred during good VFR weather conditions and during the hours of daylight.

4.1.3 Preflight Planning. Pilots are encouraged to include the use of http://www.seeandavoid.org in their preflight planning. The SeeAndAvoid.org portal is a valuable resource for civilian and military pilots. It provides information and education on airspace, visual identification of various aircraft, aircraft performance, and mutual hazards to safe flight, with the ultimate goal of reducing close calls and eliminating midair collisions.

4.2 Visual Scanning.

4.2.1 Attention and Response to Traffic Movement. The pilot's responsibility is to fly the aircraft safely. All other duties should be secondary while flying. Pilots should remain constantly alert to all traffic movement within their field of vision, as well as periodically scanning the entire visual field outside of their aircraft to ensure detection of conflicting traffic. Remember that the performance capabilities of many aircraft, in both speed and rates of climb/descent, result in high closure rates limiting the time available for detection, decision, and evasive action. Research has shown that the average person has a reaction time of 12.5 seconds. This means that a small or high-speed object could pose a serious threat if some other means of detection other than see and avoid were not utilized, as it would take too long to react to avoid a collision. This is particularly important with small Unmanned Aircraft Systems (sUAS).

Table 1. Aircraft Identification and Reaction Time Chart

Event	Seconds
See Object	0.1
Recognize Aircraft	1.0
Become Aware of Collision Course	5.0
Decision to Turn Left or Right	4.0
Muscular Reaction	0.4
Aircraft Lag Time	2.0
TOTAL	12.5

4.2.2 Refocusing Eyes. The probability of spotting a potential collision threat increases with the time spent looking outside, but certain techniques may be used to increase the effectiveness of the scan time. The human eyes tend to focus somewhere, even in a featureless sky. If there is nothing specific on which to focus, your eyes revert to a relaxed intermediate focal distance (10 to 30 feet). This means that you are looking without actually seeing anything, which is dangerous. In order to be most effective, the pilot should shift glances and refocus at intervals. Most pilots do this in the process of scanning the instrument panel, but it is also important to focus outside to set up the visual system for effective target acquisition.

4.2.3 Refocusing When Switching Views. Pilots should also realize that their eyes may require several seconds to refocus when switching views between items in the cockpit and distant objects. Proper scanning requires the constant sharing of attention with other piloting tasks; thus, it is easily degraded by psychophysiological conditions, such as fatigue, boredom, illness, anxiety, or preoccupation.

4.2.4 Eye Movements. Effective scanning is accomplished with a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field. Each movement should not exceed 10 degrees, and each area should be observed for at least 1 second to enable detection. Although most pilots seem to prefer horizontal back-and-forth eye movements, each pilot should develop a scanning pattern that is most comfortable and then adhere to it to assure optimum scanning.

4.2.5 Spotting Threats. Peripheral vision can be most useful in spotting collision threats from other aircraft. Each time a scan is stopped and the eyes are refocused, the peripheral vision takes on more importance because it is through this element that movement is detected. Apparent movement is almost always the first perception of a collision threat, and probably the most important, because it is the discovery of a threat that triggers the events leading to proper evasive action. It is essential to remember, however, that if another aircraft appears to have no relative motion, it is likely to be on a collision course with you. If the other aircraft shows no lateral or vertical motion, but is increasing in size, take immediate evasive action.

4.2.6 Nighttime Searches. Visual search at night depends almost entirely on peripheral vision. This is due in part to the night blind spot that involves an area between 5 and 10 degrees wide in the center of the visual field. By looking approximately 10 degrees below, above, or to either side of an object, “off center” viewing can compensate for this night blind spot. In order to perceive a very dim lighted object in a certain direction, the pilot should not look directly at the object, but scan the area adjacent to it. Short stops of a few seconds in each scan will help to detect the light and its movement. Lack of brightness and color contrast in daytime and conflicting ground lights at night increase the difficulty of detecting other aircraft. Modern aircraft lighting and light pulse systems present a noticeable improvement toward detecting other aircraft in flight over previous legacy systems. Many of these systems and light-emitting diode (LED) bulbs use less power, last longer, and are brighter than minimum operating equipment, improving aircraft safety in poor lighting conditions or reduced visibility (see paragraph 4.5). Operators should consider installing these systems to improve operational safety. Pilots utilizing Night Vision Imaging Systems (NVIS), such as night vision goggles (NVG), must be aware that some LED obstruction and aircraft anticollision lighting may not be visible through the NVGs. When flying with NVGs, pilots should also be looking around the binocular assembly frequently, outside of the NVG view, to detect lighting that may not be visible through the NVGs.

4.2.7 Physical Obstructions. Pilots are reminded of the requirement to move one’s head in order to search around the physical obstructions, such as door and window posts. The doorpost can cover a considerable amount of sky, but a small head movement may uncover an area which might be concealing a threat. This is especially important for

pilots utilizing NVIS, since there can be a tendency to reduce head movement and only scan the view through the device looking straight ahead.

4.2.8 Assistance and Additional Equipment. Pilots should consider the assistance of other crewmembers or passengers to help in looking for hazards and notifying the pilot immediately when they are concerned. This is particularly important in high-traffic areas, low-altitude flights, or when the pilot's workload is high. If the aircraft is to operate in these environments for any length of time, operators are encouraged to install and use additional equipment (as described in paragraph 4.5) to assist the pilot in minimizing impact risks to other aircraft, terrain, and/or obstacles.

Note: Additional information related to vision in flight can be found in the Aeronautical Information Manual (AIM), chapter 8, Medical Facts for Pilots, paragraph 8-1-6.

4.3 Clearing Procedures.

4.3.1 Pilots' Responsibilities. Pilots should:

1. Prior to taxiing onto a runway or landing area for takeoff, scan the approach areas for possible landing traffic by maneuvering the aircraft to provide a clear view of such areas. It is important that this be accomplished even though a taxi or takeoff clearance has been received.
2. During climbs and descents in flight conditions which permit visual detection of other traffic, execute gentle banks left and right at a frequency which permits continuous visual scanning of the airspace about them.
3. Execute appropriate clearing procedures before all turns, abnormal maneuvers, or acrobatics.
4. Following the AIM, chapter 4, Air Traffic Control, section 3, execute pattern entries and departures for the runway in use appropriate to the airport configuration and information depicted.

4.4 Airspace, Flight Rules, and Operational Environment. Pilots should be aware of the type of airspace in which they intend to operate in order to comply with the flight rules applicable to that airspace. Aeronautical information concerning the NAS is disseminated by three methods: aeronautical charts (primary); the AIM; and the Notices to Airmen (NOTAM) system. The general operating and flight rules governing the operation of aircraft within the United States are contained in part 91.

4.4.1 Use of Resources. Pilots should:

1. Use currently effective aeronautical charts for the route or area in which they intend to operate.
2. Note and understand the aeronautical legend and chart symbols related to airspace information depicted on aeronautical charts.

3. Use a current Airport/Facility Directory (A/FD). The A/FD is designed to be used in conjunction with charts and is published every 56 days. The A/FD also contains the Aeronautical Chart Bulletin. The purpose of the bulletin is to provide major changes in aeronautical information that have occurred since the last publication date of each VFR Sectional, Terminal Area, and Helicopter Route Chart listed.
4. Develop a working knowledge of the various airspace segments, including the vertical and horizontal boundaries.
5. Develop a working knowledge of the specific flight rules governing operation of aircraft within the various airspace segments.
6. Use the AIM. Chapter 3, Airspace, describes the current NAS and airspace classifications. Chapter 4, Air Traffic Control, and chapter 5, Air Traffic Procedures, provide information on pilot and controller responsibilities depending on the airspace. Chapter 7, Safety of Flight, contains additional information pertaining to safe flight operations, avoiding unmanned balloons and UASs, and scanning for other aircraft.
7. Contact the nearest FAA Flight Service Station (FSS) for any pertinent NOTAMs pertaining to their area of operation, including temporary flight restrictions (TFR) in the area of their intended operation.

4.4.2 Special Operational Environments. Pilots should also be familiar with, and exercise caution in, those operational environments where they may expect to find a high volume of traffic or special types of aircraft operation. This includes the need to be aware of various features and airspace contained on a VFR chart that might not be depicted on an IFR chart, particularly when operating in visual meteorological conditions (VMC). These areas include airport traffic patterns, particularly at airports without a control tower in Class G airspace and also Class E surface areas; Class B, Class C, and Class D surface areas, including any Class E extensions; VFR practice areas associated with local area flight training schools; Federal airways; the vicinity of very high frequency omni-directional range stations (VOR); restricted areas; warning areas; alert areas; Military Operations Areas (MOA); intensive student jet training areas; military low-level high-speed training routes; instrument approach areas; areas of high density jet arrival/departure routings, especially in the vicinity of major terminals and military bases; VFR helicopter routes; and Gulf of Mexico offshore operations areas, particularly near the shoreline. Pilots should be alert to temporary areas of high volume generated by events such as air shows or a news media event, scenic areas of interest to air tour operations, areas designated by Special Federal Aviation Regulations (SFAR), or areas indicated on an aeronautical chart as urban due to population density. Special care should be taken when operating in these areas, and pilots should consider the benefits of installing and using equipment noted in paragraph 4.5. Electronic News Gathering (ENG) aircraft and air tour aircraft should also have established communication procedures when operating in the vicinity of other aircraft at the same location or on the same route.

4.5 Aircraft Systems and Technologies.

4.5.1 Recommended Safety Equipment. For improved safety and to aid in collision avoidance, the following safety equipment is recommended:

1. High-intensity anticollision white strobe lights visible from all directions.
2. Pulse light (collision avoidance) systems for the aircraft landing lights.
3. Dual very high frequency (VHF) aircraft communications radios.
4. Traffic advisory systems (TAS), Traffic Alert and Collision Avoidance System (TCAS) I, TCAS II, or those aircraft equipped with Automatic Dependent Surveillance-Broadcast (ADS-B) In and display capability.
5. High-visibility propeller tip markings (includes main and tail rotor blades for rotorcraft).
6. Appropriate instrumentation to recover from inadvertent entry into instrument meteorological conditions (IMC). The installed equipment should meet or exceed 14 CFR part 135, § 135.159 night VFR instrumentation standards.
7. Weather avoidance system (such as satellite weather mapping).
8. Altitude hold monitoring/alerting equipment.
9. Cockpit/flight data recording systems.
10. Satellite tracking systems to track the flight path of aircraft.
11. Terrain awareness and/or ground proximity warning systems (Terrain Awareness and Warning Systems (TAWS), radar altimeter with audible alerts).

4.5.2 Collision-Avoidance Technologies. Understanding the differences between TAS, TCAS, and ADS-B is an important part of using such technologies to minimize workload and aid in collision avoidance. Pilots should make every effort to communicate with other aircraft and coordinate activities whenever practical, particularly in areas known to contain traffic related to air tour operations, low-level sightseeing, operations over congested areas, or news-gathering operations. Pilots should respond to traffic advisories (TA) by attempting to establish visual contact with the alerting aircraft and other aircraft which may be in the vicinity.

4.5.2.1 A TAS independently interrogates nearby transponder-equipped aircraft and determines bearing and range from the replies within a given range (depending on the power of the system installed). TAS is not radar-coverage limited. It is important to recognize this system *will not* see aircraft that are not currently using a transponder that is not transmitting in the “ON” or “ALT” modes. Depending on the system, it may provide TAs in addition to displaying nearby traffic.

4.5.2.2 ADS-B is a system for air traffic surveillance. The FAA has mandated ADS-B Out by 2020 on all aircraft operating in current Mode C airspace

(around Class B and C airspace and above 10,000 feet). With ADS-B, each aircraft broadcasts its own Global Positioning System (GPS) position along with other information like heading, ground track, groundspeed, and altitude (ADS-B Out). To see other aircraft, you must be equipped with ADS-B In to process the data signals. Depending on the system, it may provide TAs in addition to displaying nearby traffic.

4.5.2.3 There are two types of TCAS, TCAS I and TCAS II. TAS systems are almost identical to TCAS I systems; in fact, they use the same set of requirements or Minimum Operational Performance Standards (MOPS). Both systems actively interrogate nearby Mode A, C, and S transponders and issue TAs ("TRAFFIC, TRAFFIC"). The difference is that TCAS I systems can detect the number of nearby TCAS systems and thus send a more powerful interrogation when fewer aircraft are nearby. TCAS II systems are intended for turbine-powered aircraft and go beyond TCAS I systems by issuing TAs and Resolution Advisories (RA). RAs recommend maneuvers that will either increase or maintain the existing separation from an alerting aircraft. If the alerting aircraft is TCAS II-equipped, the RAs will be coordinated to ensure that complementary RAs are selected (e.g., "CLIMB, CLIMB" for one aircraft, "DESCEND, DESCEND" for the other aircraft). Further information concerning TCAS operation can be found in the current edition of AC 120-55, Air Carrier Operational Approval and Use of TCAS II.

4.5.3 Active Traffic Systems. Active traffic systems (including TAS and TCAS) use Mode A, C, or S transponder interrogations to determine aircraft bearing and distance. Altitude is determined by reported Mode C altitude. After 2020, aircraft will be required to broadcast ADS-B Out and this data can be interpreted by aircraft with ADS-B In, but aircraft will still be required to have a Mode C or S transponder in airspace where it is currently required; thus, active traffic systems will continue to function. Most TAS systems will have ADS-B In capability available as an upgrade so these systems can interpret signals from either source.

4.5.4 Active Traffic Systems in an ADS-B Environment. Active traffic systems are valuable for three reasons in an ADS-B environment. First, even after January 1, 2020, not all aircraft will have ADS-B Out, particularly in airspace which does not require it. Thus, without an active traffic system, those unequipped aircraft would not display on a cockpit traffic display even if you had ADS-B In. Second, an active traffic system will display all aircraft independent of the type of ADS-B Out, since all aircraft will still be required to have a Mode C or Mode S transponder. Third, ADS-B is dependent on GPS signals, so during periods of poor satellite geometry or solar storms, GPS position and thus ADS-B could be disrupted and less reliable, meaning an active traffic system can act as a backup to ADS-B in the cockpit.

4.5.5 Maintaining Vigilance. Traffic information equipment does not relieve a pilot's responsibility to see and avoid other aircraft. Managing distractions caused by the use of technology in the cockpit is critical to the safety of the flight. While new aircraft systems can provide pilots with a wealth of information, they can also cause fixation on the

displays and draw a pilot's attention inside the cockpit and away from the outside environment. Any newly installed technology and its limitations should be thoroughly learned and understood on the ground first as much as possible. For all pilots using advanced technologies in the cockpit, extra vigilance is required to avoid excessive heads-down time.

4.6 Use of Communications Equipment and Air TA Services. One of the major factors contributing to the likelihood of NMAC incidents in surface areas that have an operating air traffic control (ATC) system has been the mix of known arriving and departing aircraft with unknown traffic. The known aircraft are generally in radio contact with the controlling facility (local, approach, or departure control) and the other aircraft are neither in two-way radio contact nor identified by ATC at the time of the NMAC. This precludes ATC from issuing TA information to either aircraft. Although pilots should adhere to the necessary communications requirements when operating VFR, they are also urged to take advantage of the air TA services available to VFR aircraft. Pilots should:

4.6.1 Use the AIM. Chapter 4, sections 1–4, and chapter 5, sections 2–4, contain additional information on services available to pilots, including information on VFR advisory services, radar traffic information services for VFR pilots, recommended TA practices at nontowered airports, and radio communication techniques.

4.6.2 Use the A/FD. The A/FD contains a list of all major airports showing the services available to pilots and the applicable communication frequencies.

4.6.3 Develop a Working Knowledge of Those Facilities Providing TA Services and the Area in Which They Give These Services. In some cases, this should include talking with local operators about their own or other local procedures in effect.

4.6.4 Initiate Radio Contact. Initiate radio contact with the appropriate terminal radar or nonradar facility when operating within the perimeters of the advertised service areas or within 15 miles of the facility when no service area is specified.

4.6.5 Monitor the Appropriate Facility Communication Frequencies. When it is not practical to initiate radio contact for traffic information, at least monitor the appropriate facility communication frequency, particularly when operating in or through arrival/departure routes and instrument approach areas.

4.6.6 Self-Announce Position. Utilize established frequencies to self-announce position regularly when operating in VFR practice areas, VFR routes established for air tour operations, and high-volume traffic environments.

4.6.7 Remember Controller Limitations. Remember that controller observation of aircraft in the surface area is often limited by distance, depth perception, aircraft conspicuity, and other normal visual acuity problems. Limitations of radar (when available), traffic volume, controller workload, unknown traffic, etc., may prevent the controller from providing timely TA information. TAs are secondary to the controllers' primary duties (which are separating aircraft under their control and issuing safety advisories when aware of safety conflicts). Therefore, the pilot is responsible for seeing and avoiding

other traffic. TAs should be requested and used when available to assist the pilot to see and avoid other traffic by assisting, but not substituting in any way, the pilot's own visual scanning. This is especially true while operating under flight following. It is important to remember that advisories which ATC may provide are not intended to lessen in any manner the pilot's obligation to properly scan to see and avoid traffic.

4.7 Airport Traffic Patterns. A significant number of midair collisions, as well as NMACs, have occurred within the traffic pattern environment. Pilots should:

4.7.1 Maintain Contact with the Tower. When operating at tower-controlled airports, maintain two-way radio contact with the tower while within the surface area. Make every effort to see and properly avoid any aircraft pointed out by the tower, or any other aircraft which may be in the area and unknown to the tower.

4.7.2 Look for Other Aircraft. When entering a known traffic pattern at a nontowered airport, keep a sharp lookout for other aircraft in the pattern. Enter the pattern in level flight and allow plenty of spacing to avoid overtaking or cutting any aircraft out of the pattern.

4.7.3 Observe the Airport Layout and Local Traffic. When approaching an unfamiliar airport, fly over or circle the airport at least 500 feet above traffic pattern altitude (usually at 2,000 feet or more above the surface) to observe the airport layout, any local traffic in the area, and the wind and traffic direction indicators. Never descend into the traffic pattern from directly above the airport.

4.7.4 Use Extra Caution when Landing. Be particularly alert before turning to the base leg, during the final approach course, and during the final approach to landing. At nontowered airports, avoid entering the traffic pattern on the base leg or from a straight-in approach to the landing runway. Per the AIM, chapter 4, section 3, make all traffic pattern turns to the left unless the A/FD, other approved light signals, or visual marking indicate turns should be made to the right per §§ 91.126 and 91.127.

4.7.5 Compensate for Blind Spots. Compensate for blind spots due to aircraft design and flight attitude by moving your head or maneuvering the aircraft.

4.8 Flying in Formation. Several midair collisions have occurred which involved aircraft on the same mission, with each pilot aware of the other's presence. Pilots who are required, by the nature of their operations, to fly in pairs or in formation are cautioned to:

1. Recognize the high statistical probability of their involvement in midair collisions.
2. Make sure that adequate preflight preparations are made and the procedures to be followed are understood by all pilots intending to participate in the mission.
3. Always keep the other aircraft in sight despite possible distraction and preoccupation with other mission requirements.

4. Avoid attempting formation flight without having obtained instruction and attained the skill necessary for conducting such operations.

4.9 Flight Instructors, Pilot Examiners, and Persons Acting as Safety Pilots. The importance of flight instructors training pilot applicants to devote maximum attention to collision avoidance, while conducting flight operations in today's increasing air traffic environment, cannot be overemphasized. Flight instructors should set an example by carefully observing all regulations and recognized safety practices, since students consciously and unconsciously imitate the flying habits of their instructors.

4.9.1 Flight Instructors' and Safety Pilots' Responsibilities. Flight instructors and persons acting as safety pilots should:

1. Guard against preoccupation during flight instruction to the exclusion of maintaining a constant vigilance for other traffic.
2. Be particularly alert during the use of advanced cockpit technology and the conduct of simulated instrument flight where there is a tendency to "look inside" excessively and forget see-and-avoid responsibilities.
3. Take the time to teach new and advanced cockpit technology on the ground. Thoroughly review features as well as limitations of the equipment and the pitfalls of fixation and overreliance on technology.
4. Place special training emphasis on those basic problem areas of concern mentioned in this AC where improvements in pilot education, operating practices, conflicts, procedures, and techniques are needed to reduce midair conflicts.
5. At tower-controlled airports, notify the control tower operator of students' first solo flights.
6. Explain the availability of and encourage the use of expanded radar services for arriving and departing aircraft at terminal airports where this service is available, as well as the use of radar TA services for transiting terminal areas or flying between en route points.
7. Understand and explain the limitations of radar that may frequently limit or prevent the issuance of radar advisories by air traffic controllers (refer to the AIM).
8. Understand and explain the benefits and limitations of collision avoidance technologies installed on the aircraft.

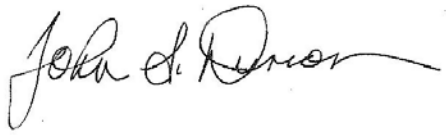
4.9.2 Pilot Examiners' Responsibilities. Pilot examiners should:

1. During any flight test, direct attention to the applicant's vigilance of other air traffic and an adequate clearance of the area before performing any flight maneuver.
2. Direct attention to the applicant's knowledge of the airspace, available FAA air traffic services and facilities, essential rules, good operating practices,

procedures, and techniques that are necessary to achieve high standards of air safety.

4.10 Collision Avoidance Educational Resources. For further information on training courses, documents, and events related to collision avoidance and visual scanning techniques, please visit http://www.faasafety.gov. Additional information can also be obtained from the FAA Safety Team (FAASTeam) Program Manager at any FAA Flight Standards District Office (FSDO).

5 WHERE YOU CAN FIND THIS AC. You can find this AC on the FAA's Web site at http://www.faa.gov/regulations_policies/advisory_circulars. You can view Federal Aviation Regulations at http://www.faa.gov/regulations_policies/faa_regulations/.



John S. Duncan
Director, Flight Standards Service

Advisory Circular Feedback Form

If you find an error in this AC, have recommendations for improving it, or have suggestions for new items/subjects to be added, you may let us know by contacting the General Aviation and Commercial Division (AFS-800) at 9-AFS-800-Correspondence@faa.gov or the Flight Standards Directives Management Officer at 9-AWA-AFS-140-Directives@faa.gov.

Subject: AC 90-48D, Pilots' Role in Collision Avoidance

Date: _____

Please check all appropriate line items:

☐ An error (procedural or typographical) has been noted in paragraph _____ on page _____.

☐ Recommend paragraph _____ on page _____ be changed as follows:

_____

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☐ In a future change to this AC, please cover the following subject:
(Briefly describe what you want added.)

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☐ Other comments:

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☐ I would like to discuss the above. Please contact me.

Submitted by: _____ Date: _____