

# FITS Generic ADS-B, TIS-B and FIS-B Syllabus

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## INTRODUCTION

### How to use this generic FITS Syllabus

This syllabus is an FAA Industry Training Standards (FITS) accepted training method. This generic syllabus is a guide for you to use in developing your specific FITS curriculum. This FITS Syllabus is intended as a guide for aircraft manufacturers, training providers, and flight schools to use in developing a specific FITS curriculum for their aircraft, geographic region, and customer base.

This syllabus is unique in several ways. First, it is a syllabus that uses real-world scenarios as the foundation of the training. Flight maneuvers are still a vital part of flight training and flight maneuvers are a part of this syllabus, but the use of real-world scenarios is used to also enhance the pilot's decision making skills. The syllabus presents situations and circumstances that pilots face everyday as learning experiences and lessons. The primary tenant of FITS training is that you prepare for the real world of flying, by acting as a pilot while in training. Therefore, throughout the syllabus, the pilot in training (PT) will take on different tasks or jobs just as if they were already certificated pilots. The second important unique feature of this syllabus and of FITS training is that it is all competency based. When the pilot in training (PT) masters a particular skill area in the syllabus, he/she moves on regardless of how much time it takes to reach that point of mastery. This means that each lesson does not necessarily equal one flight. It may take several flights before the PT masters the elements of the lesson and is ready to move on to the next lesson. Consequently, the amount of total flight hours a PT has when the syllabus is completed may be more or less than the minimum times under current aviation regulations. Please note that FITS training is conducted under the current FARs. Although philosophically, FITS is competency based, many training organizations must still require their students to meet the FAA minimum training hours. Courses under Part 142, section 141.55(d) may be approved to train to competency and not require an hours minimum.

### Applicable Regulations

This generic syllabus is adaptable to 14 CFR Parts 142, 141, or 61. Please refer to the appropriate regulations for your specific curriculum requirements.

### FITS Acceptance

FITS acceptance is achieved by developing your specific curriculum and submitting it to your local Flight Standards District Office for operations under 14 CFR Part 61, 141, and 142. If you are an OEM (Original Equipment Manufacturer, you should submit your curriculum to the FAA FITS Program Manager, AFS-800, Federal Aviation Administration, 800 Independence Ave. SW, Washington, DC 20591. A cover letter explaining what courses you are requesting FITS acceptance and under what regulations should accompany the curriculum. *Use of the FITS logo.* Once accepted,

you are free to use the FITS Logo on all accepted curriculums and in advertising about this particular curriculum. The FITS logo cannot be used in relationship to non-FITS products.

There are four levels of FITS acceptance:

1. Accepted FITS Flight Syllabus: Will contain all the tenets of FITS and will include flight in an aircraft or at least an Advanced Training Device. Examples of this type of syllabus include initial, transition, and recurrent training syllabi.
2. Accepted FITS Syllabus (No flight): It is not intended to teach the pilot in training (PT) psychomotor pilot skills or full cockpit/aircraft integration in a specific aircraft. It's intended to enhance certain skill sets of the PT. Application of this level of acceptance may be to teach the PT how to use a new glass cockpit display or develop better Single Pilot Resource Management (SRM) skills. A FITS Accepted Syllabus will also contain all the tenets of FITS. A live instructor will lead the training.
3. Accepted FITS Self-Learning Program: This acceptance is between the FITS Accepted Syllabus and FITS Supporting Material. It may be either an interactive CD or on-line course on a specific application or subject. The purpose of this training is to learn a specific piece of equipment or enhance a specific higher order thinking skill. Scenario training and/or testing is required. Since a live instructor is not required, Learner Centered Grading may not be applicable.
  - a. If the program is for a piece of equipment (i.e., GPS), the equipment should act like the actual piece of equipment during the interaction with the equipment as much as feasible. After basic training on the equipment, scenarios should be used to demonstrate PT proficiency and knowledge.
  - b. For non equipment programs (i.e., ADM development) scenarios with multi-string testing should be used.
4. Accepted FITS Supporting Material: These products do not meet the training tenets of FITS (i.e. may not be scenario based), but the subject is integral to FITS. These products could be accepted on their own technical merit, but only as a part of an Accepted FITS Flight Syllabus or FITS Syllabus. For example, a CBI on risk management could be accepted as and used as a Lesson in a FITS accepted transition syllabus. Original equipment manufacturers (Cessna, Cirrus, Eclipse, etc.) or developers of training materials (Sporty's, Jeppesen, King Schools, etc.) normally develop Accepted FITS Supporting Material.

## FITS TERMINOLOGY

**Automation Bias** – The relative willingness of the pilot to trust and utilize automated systems.

**Automation Competence** – The demonstrated ability to understand and operate the automated systems installed in the aircraft.

**Automation Management** – The demonstrated ability to control and navigate an aircraft by means of the automated systems installed in the aircraft.

**Automated Navigation leg** – A flight of 30 minutes or more conducted between two airports in which the aircraft is controlled primarily by the autopilot and the on board navigation systems.

**Automation Surprise** – Occurs when the automation behaves in a manner that is different from what the operator is expecting.

**Candidate Assessment** – A system of critical thinking and skill evaluations designed to assess a pilot in training's readiness to begin training at the required level.

**Critical Safety Tasks/Events** – Those mission related tasks/events that if not accomplished quickly and accurately may result in damage to the aircraft or loss of life.

**Data link Situational Awareness Systems** – Systems that feed real-time information to the cockpit on weather, traffic, terrain, and flight planning. This information may be displayed on the PFD, MFD, or on other related cockpit displays.

**Emergency Escape Maneuver** – A maneuver (or series of maneuvers) performed manually or with the aid of the aircraft's automated systems that will allow a pilot to successfully escape from an unanticipated flight into Instrument Meteorological Conditions (IMC) or other life-threatening situations.

**IFR Automated Navigation Leg** – A leg flown on autopilot beginning from 500 ft AGL on departure (unless the limitations of the autopilot require a higher altitude, then from that altitude) until reaching the decision altitude or missed approach point on the instrument approach (unless the limitations of the autopilot require a higher altitude, then from that altitude). If a missed approach is flown, it will also be flown using the autopilot and on-board navigation systems.

**Light Turbine TAA** – is a jet or turboprop Technically Advance Aircraft (TAA) certified for single-pilot operations, weighing 12,500 lbs or less, that may be equipped with cabin pressurization, and may be capable of operating in Class A airspace on normal mission profiles.

**Mission Related Tasks** – Those tasks required for safe and effective operations within the aircraft's certificated performance envelope.

**Multi-Function Display MFD** – Any display that combines primarily navigation, systems, and situational awareness information onto a single electronic display.

**Pilot in Training (PT)** – The person receiving the training in a FITS course.

**Primary Flight Display (PFD)** – Any display that combines the primary six flight instruments, plus other related navigation and situational awareness information into a single electronic display.

**Proficiency-Based Qualification** – Aviation task qualification based on demonstrated performance rather than other flight time or experience.

**Scenario Based Training** – A training system that uses a highly structured script of real-world experiences to address flight-training objectives in an operational environment. Such training can include initial training, transition training, upgrade training, recurrent training, and special training. The appropriate term should appear with the term "Scenario Based," e.g., "Scenario Based Transition Training," to reflect the specific application.

**Simulation Training Only** – Any use of animation and/or actual representations of aircraft systems to simulate the flight environment. Pilot in training interaction with the simulation and task fidelity for the task to be performed are required for effective simulation.

**Single Pilot Resource Management (SRM)** – The art and science of managing all resources (both on-board the aircraft and from outside sources) available to a single pilot (prior and during flight) to ensure the successful outcome of the flight is never in doubt.

**Technically Advanced Aircraft (TAA)** – A General Aviation aircraft that contains the following design features: Advanced automated cockpit such as MFD or PFD or other variations of a Glass Cockpit, or a traditional cockpit with GPS navigation capability, moving map display and autopilot. It includes aircraft used in both VFR and IFR operations, with systems certified to either VFR or IFR standards. TAA's may also have automated engine and systems management.

**VFR Automated Navigation Leg** – A leg flown on autopilot from 1,000 ft AGL on the departure until entry to the 45-degree leg in the VFR pattern.

## TRAINING PHILOSOPHY

FITS Training is a scenario-based approach to training pilots. It emphasizes the development of critical thinking and flight management skills, rather than solely on traditional maneuver-based skills. The goal of this training philosophy is the accelerated acquisition of higher-level decision-making skills. Such skills are necessary to prevent pilot-induced accidents.

### FITS Training Goals

- Higher Order Thinking Skills
- Aeronautical Decision Making (ADM)
- Situational Awareness
- Pattern Recognition (Emergency Procedures) and Judgment Skills
- Automation Competence
- Planning and Execution
- Procedural Knowledge
- Psychomotor (Hand-Eye Coordination) Skills
- Risk Management
- Task Management
- Automation Management
- Controlled Flight Into Terrain (CFIT) Awareness

Previous training philosophies assumed that newly certified pilots generally remain in the local area until their aviation skills are refined. This is no longer true with the advent of Technically Advanced Aircraft (TAA). Offering superior avionics and performance capabilities over legacy general aviation training aircraft, these aircraft travel faster and further than their predecessors. As a result, a growing number of entry-level pilots are suddenly capable of long distance/high speed travel—and its inherent challenges. Flights of this nature routinely span diverse weather systems and topography requiring advanced flight planning and operational skills. Advanced cockpits and avionics, while generally considered enhancements, require increased technical knowledge and finely tuned automation competence. Without these skills, the potential for an increased number of pilot-induced accidents is daunting. A different method of training is required to accelerate the acquisition of these skills during the training process.

Research has proven that learning is enhanced when training is realistic. In addition, the underlying skills needed to make good judgments and decisions are teachable. Both the military and commercial airlines have embraced these principles through the integration of Line Oriented Flight Training (LOFT) and Crew Resource Management (CRM) training into their qualification programs. Both LOFT and CRM lessons mimic real-life scenarios as a means to expose pilots to realistic operations and critical decision-making opportunities. The most significant shift in these programs has been the movement from traditional maneuver-based training to incorporate training that is scenario-based.

Maneuver-based training emphasizes the mastery of individual tasks or elements. Regulations, as well as Practical Test Standards (PTS), drive completion standards. Flight hours and the ability to fly within specified tolerances determine competence. The emphasis is on development of motor skills to satisfactorily accomplish individual maneuvers. Only limited emphasis is placed on decision-making. As a result, when the newly trained pilot flies in the real-world environment, he or she is inadequately prepared to make crucial decisions. Scenario Based Training (SBT) and Single Pilot Resource Management (SRM) are similar to LOFT and CRM training. However, each is tailored to the pilot's training needs. These techniques use the same individual tasks that are found in Maneuver Based Training, but script them into scenarios that mimic real-life cross-country travel. By emphasizing the goal of flying safely, the pilot in training correlates the importance of individual training maneuvers to safe mission accomplishment. In addition, the instructor continuously interjects "What If?" discussions as a means to provide the trainee with increased exposure to proper decision-making. Because the "What If?" discussions are in reference to the scenario, there is a clear connection between decisions made and the final outcome. The "What If?" discussions are designed to accelerate the development of decision-making skills by posing situations for the pilot in training to consider. Once again, research has shown these types of discussions help build judgment and offset low experience.

Questions or situations posed by the instructor must be open-ended (rather than requiring only rote or one-line responses). In addition, the instructor guides the pilot in training through the decision process by: 1) Posing a question or situation that engages the pilot in training in some form of decision-making activity. 2) Examining the decisions made. 3) Exploring other ways to solve the problem. 4) Evaluating which way is best. For example, when the pilot in training is given a simulated engine failure, the instructor might ask questions such as: "What should we do now?" Or, "Why did you pick that place to land?" Or, "Is there a better choice?" Or, "Which place is the safest?" Or, "Why?" These questions force the pilot in training to focus on the decision process. This accelerates the acquisition of improved judgment, which is simply the decision-making process resulting from experience. It is not innate. All of our life experiences mold the judgment tendencies we bring to our flight situations. By introducing decision-making opportunities into routine training lessons, we speed-up acquisition of experience, thus enhancing judgment.

For further information, please reference "Aeronautical Decision Making" in the FAA Aviation Instructor Handbook.

## TEACHING METHODS

### Scenario Based Training

For Scenario Based Training (SBT) to be effective there must be a purpose for the flight and consequences if it is not completed as planned. It is vital that the pilot in training and the Instructor communicate the following information well in advance of every training flight:

- Purpose of flight
- Scenario destination(s)
- Desired pilot in training learning outcomes
- Desired level of pilot in training performance
- Desired level of automation assistance
- Possible in-flight scenario changes (during later stages of the program)

With the guidance of the Instructor, the pilot in training should make the flight scenario as realistic as possible. This means the pilot in training will know where they are going and what will transpire during the flight. While the actual flight may deviate from the original plan, it allows the pilot in training to be placed in a realistic scenario.

**Scenario Planning** – Prior to the flight, the Instructor will brief the scenario to be planned. The Instructor will review the plan and offer guidance on how to make the lesson more effective. Discussion, in part, will reflect ways in which the Instructor can most effectively draw out a pilot in training's knowledge and decision processes. This enables the Instructor to analyze and evaluate the pilot in training's level of understanding. After discussion with the Instructor, the pilot in training will plan the flight to include:

- Reason to go flying
- Route
- Destination(s)
- Weather
- NOTAMS
- Desired pilot in training learning outcomes
- Possible alternate scenarios and emergency procedures

### Example of Scenario Based Training

Consider the following example: During traditional maneuvers based training (MBT), the Instructor provides a detailed explanation on how to control for wind drift. The explanation includes a thorough coverage of heading, speed, angle of bank, altitude, terrain, and wind direction plus velocity. The explanation is followed by a demonstration and repeated practice of a specific flight maneuver, such as turns around a point or S turns across the road until the maneuver can be consistently accomplished in a safe and effective manner within a specified limit of heading, altitude, and airspeed. **At the**

***end of this lesson, the pilot in training is only capable of performing the maneuver.***

Now, consider a different example: The pilot in training is asked to plan for the arrival at a specific uncontrolled airport. The planning should take into consideration the possible wind conditions, arrival paths, airport information and communication procedures, available runways, recommended traffic patterns, courses of action, and preparation for unexpected situations. Upon arrival at the airport the pilot in training makes decisions (with guidance and feedback as necessary) to safely enter and fly the traffic pattern using proper wind drift correction techniques. This is followed by a discussion of what was done, why it was done, the consequences, and other possible courses of action and how it applies to other airports. ***At the end of this lesson the pilot in training is capable of explaining the safe arrival at any uncontrolled airport in any wind condition.***

The first example is one of traditional learning, where the focus is on the maneuver. The second is an example of scenario-based training, where the focus is on real world performance. Many course developers in flight training have built on the former option. Traditional training methods in many instances are giving way to more realistic and fluid forms of learning. The aviation industry is moving from traditional knowledge-related learning outcomes to an emphasis on increased internalized learning in which learners are able to assess situations and appropriately react. Knowledge components are becoming an important side effect of a dynamic learning experience.

Reality is the ultimate learning situation and scenario-based training attempts to get as close as possible to this ideal. In simple terms, scenario-based training addresses learning that occurs in a context or situation. It is based on the concept of situated cognition, which is the idea that knowledge cannot be known and fully understood independent of its context. ***In other words, we learn better when the situation is more realistic and the more we are counted on to perform real tasks.***

Michael Hebron, a well-known golf instructor, suggests that there is little the expert can do in the way of teaching the learner particular motions of the golf swing. Instead, learning has to be experiential and feedback based; only a handful of basic principles are involved. The same goes, he says, for any and all kinds of learning. ***“It’s about learning, not about golf.”***

Scenario-based training (SBT) is similar to the experiential model of learning. The adherents of experiential learning are fairly adamant about how people learn. ***They would tell us that learning seldom takes place by rote.*** Learning occurs because we immerse ourselves in a situation in which we are forced to perform. We get feedback from our environment and adjust our behavior. We do this automatically and with such frequency in a compressed timeframe that we hardly notice we are going through a learning process. Indeed, we may not even be able to recite particular principles or describe how and why we engaged in a specific behavior. Yet, we are still able to replicate the behavior with increasing skill as we practice. If we could ask Mark

MacGuire to map out the actions that describe how he hits a home run, he would probably look at us dumbfounded and say, “I just do it.” On the other hand, I am sure Mark MacGuire could describe in detail the size and characteristics of every one of the baseball diamonds he was playing in as well as the strengths, weaknesses and common practices of every one of the pitchers he faced.

### Developing Scenario-Based Training

Scenario-based training best fits an open philosophy of blended and multiple learning solutions in which change and experience are valued and the lines between training and performance improvement are blurred. For scenario-based training to be effective it must generally follow a performance improvement imperative. The focus is on improved outcomes rather than the acquisition of knowledge and skills. Success requires a blended, performance-based, and reinforced solution.

An athletic exercise such as basketball might prove to be a very good example. Clearly, the team’s objective is to win, which means scoring more points than the other team. That’s the performance objective. Each member of the team also has personal performance goals. The coach can stand at a blackboard and explain defensive and offensive diagrams with players, the rules of the game, and so forth. By doing that, he has identified a set of learning subjects (rules and play patterns) that are best delivered in a traditional fashion.

On the other hand, the application of these subjects and the level of proficiency required in their use can only be learned on the court. The scenario in this example is a scrimmage. During a typical scrimmage, experienced players are mixed with non-experienced players and matched against a similarly constituted practice team. The two teams play a game, and the coaches stop the action at appropriate intervals to offer feedback. Learning takes place in a highly iterative fashion often without the player realizing that specific bits of learning are taking place. The scrimmage provides a player with the opportunity to make several decisions, engage in complex and fast-paced behaviors, and immediately see impact. The coach may have some general ideas of basketball in mind and perhaps some specific learning objectives for the day, but in most cases does not know precisely which of them will be addressed during the scrimmage – that depends on the flow of practice.

Similarly, most flight training consists of both kinds of subjects: those amenable to traditional instructional design techniques and those better approached through scenario-based training. Neither is all that useful without the other. Before a learner can engage in a scenario, he or she needs some basic subject knowledge and skill. However, the strongest adherents of the scenario-based approach suggest very little subject knowledge is needed in order to take advantage of SBT. **The main point is that knowledge without application is worth very little.**

The first step in the scenario design process is to engage a number of subject matter experts in a series of discovery sessions and interactive meetings for the purpose of

identifying issues and learning objectives including higher-level and performance objectives. With clearly identified learning objectives, appropriate techniques and where to use them can be specified. In the basketball example, players need some rudimentary knowledge of the game and basic skill in order to make the practice session efficient and effective. Consequently, the required knowledge and skill objects need to be integrated into the actual sessions of practice. So, like a train pulling a number of boxcars, a traditional piece of learning precedes or is integrated into a scenario, with the scenario dictating what information is covered in the traditional piece. If, as described in the scrimmage session above, you don't precisely know what will come up in the practice, you shouldn't waste time in the traditional preparation. It's more efficient to share very basic principles and devote your resources to preparing to teach any situation that may arise. What is important, however, is to establish the boundaries of the scenarios. These are done using performance-based learning objectives (Internalized Responses) as opposed to knowledge-based learning objectives, and are worded as performance objectives rather than skill-based behavior objectives.

For example, in the traditional, more repetitive, intensive flight training sessions, objectives are knowledge-based and tend to be specific and limited. On the other hand, in scenario-based training we are simply trying to determine whether the learner has the minimum necessary knowledge/skill to qualify for the scenario. With scenario-based objectives, we are looking for performance behaviors and indicators of internalized responses, which are usually situational recognition indicators.

We can see this clearly illustrated in an automobile driver-training example (Table 1). The traditional Behavior (skill) objective is knowledge based and the SBT Performance objective is performance-based (responses which are situational recognition indicators).

Table 1: Driving Learning Objectives

Knowledge		Behavior (Skill)
<b>Traditional</b>	<p>Know what a STOP sign and a Railroad crossing sign look like and what they mean.</p> <p>Describe the correct parallel parking procedure.</p>	<p>Drive an automatic shift car on a county road over a 2-mile route with one RR crossing and 2 full stops.</p> <p>Maneuver the automobile into a normal parallel parking space between 2 other cars.</p>
Internalized Response		Performance
<b>Scenario-Based</b>	<p>Appropriately apply the rules of the road for driving in the local area in moderate traffic.</p> <p>Determine the shortest route and apply the appropriate procedures for driving in heavy and complex traffic conditions.</p>	<p>Drive from your garage to the Shopping Center on the same side of town.</p> <p>Drive from your garage to a specified address in another town over 50 miles away on the Interstate and an Expressway system.</p>

Scenario design sessions should resemble focus groups in which participants work through a series of issues, from broad scenario outlines to very specific scenario details. Direct participants to address two general areas: content and style.

Sessions to determine content usually ask participants to:

- Share experiences about the subject event
- Describe desirable outcomes
- Share best practices or known instances of consistent achievement of the desired outcomes
- Create indicators of successful outcomes
- Create strategies expected to lead to successful outcomes
- Establish descriptions of successful and unsuccessful performance behaviors related to these strategies (note that outcome measures and performance behaviors will constitute the evaluative criteria for assessing performance in the scenario).

After the content discussion, ask participants to review the look, feel, and flow of the scenario. This is much like the process used for instructional design. Develop a storyboard with a general beginning and end, using the boundaries established earlier. Talk through the scenario in the session and, through iteration, create a flow script from the results.

With these two elements in place, you can begin the actual construction of the scenario. A subcommittee of Flight Instructors and subject matter experts (SME's) should review and revise the scenario to fit into the whole course of instruction.

Scenarios are meant to be real situations. In an ideal world, an assessment team would evaluate behavior and agree on several critical performance dimensions. The key indicators should come from the initial SME's, in which they also create strategies expected to lead to successful outcomes and establish descriptions of successful and unsuccessful performance behaviors. Outcome measures and performance behaviors will constitute the evaluative criteria for assessing performance in the scenario.

Examples of indicators of successful outcomes are whether an airplane arrived and was secured at the destination airport and how safe were all aspects of the flight or were there any regulatory violations. Strategies are clusters of internally consistent behaviors directed toward the achievement of a goal. Performance behaviors are the key behaviors in those strategies. Establishing these dimensions should be a group process and is usually completed in the subject matter expert design session.

Review, obtain learner feedback, and revise. All learning, even the most traditional, is iterative. The key to creating a useful scenario is to see it as a learning experience for the designers as well as the learners. This means that results and comments about the learning experience are shared with the SME's and the designer so that they can review and modify the scenarios as necessary. Obtain open –ended qualitative data from the learner and the Flight Instructor about the experience and review the data with the SME's and the designer.

Based on this kind of feedback, scenarios can be revised to better target the learner population. That process mirrors the original design steps. There are some cautions, however, in the revision process. First, there is an old saying: “It doesn’t take a cannon to blow away a tin can.” Basically, revisions should not needlessly complicate the scenario or the technology needed to employ it. It is crucial to weigh the risks of complication against the genuine learning needs. Before any revision, affirm the original purpose statement and the categorization of learning elements.

Also, do not let principles and main points become diluted by revisions. It is tempting to add more items and nuances in a scenario, but doing so further complicates the learning process. Save complexity for a full-scale “capstone” experience. Remember, adding an item in traditional learning complicates the learning process in a linear fashion. In scenarios, complication grows non-linearly with the addition of learning items. So, beware. A rule of thumb is to reduce rather than increase principles and main points in a revision.

Always review success and failure paths for realism. Remember that any change in a scenario item complicates all items on the path following it. Any time a decision node is altered, chances are that the decision nodes and information items following it must change. With every revision, follow and ensure the consistency of associated paths.

Finally, remember that traditional learning elements should service the scenario-based learning elements, which are situated in a real context and based on the idea that knowledge cannot be known and fully understood independent of its context. It is essential to place boundaries around scenarios to make the transitions between scenarios and traditional learning as efficient as possible.

Table 2: The Main Points

- Scenario-based training (SBT) is situated in a real context and is based on the idea that knowledge cannot be known and fully understood independent of its context.
- SBT accords with a performance improvement and behavior change philosophy of the learning function.
- SBT is different from traditional instructional design and one must be aware of the differences to successfully employ SBT.
- All learning solutions should employ both traditional and scenario-based training.
- Traditional learning elements should service the scenario-based training elements.
- It is essential to place boundaries around scenarios to make the transitions between scenarios and traditional learning as efficient as possible.
- Use interactive discovery techniques with subject matter experts (SME's) and designers to establish the purpose and outcomes of scenarios create the scenarios and appropriate strategies and performance behaviors, and develop learner evaluation criteria.
- SBT occurs by following success and failure paths through a realistic situation. Typically, these paths must be limited to stress the main learning objective. Otherwise the scenario can become too complex and unwieldy.
- Open-ended qualitative learner feedback is key to successful scenario revision, but revisions should not further complicate the scenario unless highly justified.

Kindley, R. (2002). *Scenario-Based E-Learning: A Step Beyond Traditional E-Learning*. Retrieved 02/02/05 from <http://www.learningcircuits.org/2002/may2002/kindley.html>

## Single Pilot Resource Management

Single Pilot Resource Management (SRM) is defined as the art and science of managing all the resources (both on-board the aircraft and from outside sources) available to a single-pilot (prior and during flight) to ensure that the successful outcome of the flight is never in doubt. Most of us remember a favorite Instructor from our past that showed us the best way to solve in-flight problems and unforeseen circumstances. The FITS team has combined much of this collective CFI body of knowledge with some innovative teaching methods to give pilots practical tools to teach aeronautical decision-making and judgment. SRM includes the concepts of Aeronautical Decision Making (ADM), Risk Management (RM), Task Management (TM), Automation Management (AM), Controlled Flight Into Terrain (CFIT) Awareness, and Situational Awareness (SA). SRM training helps the pilot maintain situational awareness by managing the automation and associated aircraft control and navigation tasks. This enables the pilot to accurately assess and manage risk and make accurate and timely decisions. ***This is what SRM is all about, helping pilots learn how to gather information, analyze it, and make decisions.***

Teaching pilots to identify problems, analyze the information, and make informed and timely decisions is one of the most difficult tasks for Instructors. By way of comparison, the training of specific maneuvers is fairly straightforward and reasonably easy to understand. We explain, demonstrate, and practice a maneuver until proficiency is achieved. We are teaching the pilot in training **“what to think”** about each maneuver, and sign them off when they demonstrate proficiency. Teaching judgment is harder. Now we are faced with teaching the pilot in training **“how to think”** in the endless variety of situations they may encounter while flying out in the “real world.” Often, they learn this by watching Instructors. They observe reactions, and more importantly, actions, during flight situations and they often adapt the styles of the Instructor to their own personalities.

Pilots in training may range from 100-hour VFR-only pilots, all the way to multi-thousand hours ATP’s. The strength of this format is that the participants learn not only from their Flight Instructor, but from each other as well. The collective knowledge of many pilots, when guided by an experienced CFI, is much greater than the knowledge of each participant, including the Flight Instructor. In these scenarios, there are no right answers, rather each pilot is expected to analyze each situation in light of their experience level, personal minimums, and current physical and mental readiness level, and make their own decision.

The SRM scenarios, developed by the FITS team, incorporate several maneuvers and flight situations into realistic flight scenarios. The scenarios are much like the Line Oriented Flight Training (LOFT) employed by the major corporate and airline training organizations for years. Table 3 gives an example of the performance, standards and conditions using SRM.

Table 3: Single Pilot Resource Management (SRM)

<b>Performance</b> The training task is:	<b>Standards</b> The pilot in training will:	<b>Conditions</b> The training is conducted during:
1. Task Management (TM)	Prioritize and select the most appropriate tasks (or series of tasks) to ensure successful completion of the training scenario.	Note: All tasks under SRM will be embedded into the curriculum and the training will occur selectively during all phases of training. SRM will be graded as it occurs during the training scenario syllabus.
2. Automation Management (AM)	Program and utilize the most appropriate and useful modes of cockpit automation to ensure successful completion of the training scenario.	Note: All tasks under SRM will be embedded into the curriculum and the training will occur selectively during all phases of training. SRM will be graded as it occurs during the training scenario syllabus.
3. Risk Management (RM) and Aeronautical Decision-Making (ADM)	Consistently make informed decisions in a timely manner based on the task at hand and a thorough knowledge and use of all available resources. It is in this area that ADS-B, TIS-B and FIS-B data link products will be used to assess and manage risks and to aid in making strategic (weather and airspace) and tactical decisions (collision avoidance, spacing, sequencing, and merging) to insure the safe outcome of a flight.	Note: All tasks under SRM will be embedded into the curriculum and the training will occur selectively during all phases of training. SRM will be graded as it occurs during the training scenario syllabus.
4. Situational Awareness (SA)	Be aware of all factors such as traffic, weather, fuel state, aircraft mechanical condition, and pilot fatigue level that may have an impact on the successful completion of the training scenario. It is in this area that ADS-B, TIS-B and FIS-B data link products and services will be used by pilots to enhance their situational awareness.	Note: All tasks under SRM will be embedded into the curriculum and the training will occur selectively during all phases of training. SRM will be graded as it occurs during the training scenario syllabus.
5. Controlled Flight Into Terrain (CFIT) Awareness	Understand, describe, and apply techniques to avoid CFIT encounters: a. During inadvertent encounters with IMC during VFR flight. b. During system and navigation failures and physiological incidents during IFR flight.	Note: All tasks under SRM will be embedded into the curriculum and the training will occur selectively during all phases of training. SRM will be graded as it occurs during the training scenario syllabus.

## The “5P” Check

SRM sounds good on paper, however, it requires a way for pilots to understand and deploy it in their daily flights. This practical application is called the “Five P’s (5P’s)” The 5P’s consist of “the Plan, the Plane, the Pilot, the Passengers, and the Programming”. Each of these areas consists of a set of challenges and opportunities that face a single pilot. And each can substantially increase or decrease the risk of successfully completing the flight based on the pilot’s ability to make informed and timely decisions. The 5P’s are used to evaluate the pilot’s current situation at key decision points during the flight, or when an emergency arises. These decision points include, pre-flight, pre-takeoff, hourly or at the midpoint of the flight, pre-descent, and just prior to the final approach fix or for VFR operations, just prior to entering the traffic pattern.

The 5P’s are based on the idea that the pilots have essentially five variables that impact his or her environment and that can cause the pilot to make a single critical decision, or several less critical decisions, that when added together can create a critical outcome. These variables are the Plan, the Plane, the Pilot, the Passengers, and the Programming. The authors of the FITS concept felt that current decision-making models tended to be reactionary in nature. A change has to occur and be detected to drive a risk management decision by the pilot. For instance, many pilots ascribe to the use of risk management sheets that are filled out by the pilot prior to takeoff. These catalog risks that may be encountered that day and turn them into numerical values. If the total exceeds a certain level, the flight is altered or cancelled. Informal research shows that while these are useful documents for teaching risk factors, they are almost never used outside of formal training programs. The number of pilots who use them before each and every flight approaches zero. The 5P concept is an attempt to take the information contained in those sheets and in the other available models and operationalize it.

The 5P concept relies on the pilot to adopt a “scheduled” review of the critical variables at points in the flight where decisions are most likely to be effective. For instance, the easiest point to cancel a flight due to bad weather is before the pilot and passengers walk out the door and load the aircraft. So the first decision point is Pre-Flight in the flight planning room, where all the information is readily available to make a sound decision, and where communication and FBO services are readily available to make alternate travel plans.

The second easiest point in the flight to make a critical safety decision is just prior to takeoff. Few pilots have ever had to make an “emergency take-off”. While the point of the 5P check is to help you fly, the correct application of the 5P before takeoff is to assist in making a reasoned go-no-go decision based on all the information available. That decision will usually be to “go”, with certain restrictions and changes, but may also be a “no-go”. The key point is that these two points in the process of flying are critical go-no go points on each and every flight.

The third place to review the 5Ps is at the mid point of the flight. Often, pilots may wait until the ATIS is in range to check weather, yet at this point in the flight many good options have already passed behind the aircraft and pilot. Additionally, fatigue and low altitude hypoxia serve to rob the pilot of much of their energy by the end of a long and tiring flight day. This leads to a transition from a decision-making mode to an acceptance mode on the part of the pilot. If the flight is longer than 2 hours, the 5P check should be conducted hourly.

The last two decision points are just prior to descent into the terminal area and just prior to the final approach fix, or if VFR just prior to entering the traffic pattern, as preparations for landing commence. Most pilots execute approaches with the expectation that they will land out of the approach every time. A healthier approach requires the pilot to assume that changing conditions (the 5Ps again) will cause the pilot to divert or execute the missed approach on every approach. This keeps the pilot alert to all manner of conditions that may increase risk and threaten the safe conduct of the flight. Diverting from cruise altitude saves fuel, allows unhurried use of the autopilot, and is less reactive in nature. Diverting from the final approach fix, while more difficult, still allows the pilot to plan and coordinate better, rather than executing a futile missed approach. Now lets look in detail at each of the “Five P’s”.

### The Plan

The “Plan” can also be called the mission or the task. It contains the basic elements of cross country planning, weather, route, fuel, publications currency, etc. Unlike risk management sheets that pilot fill out before a flight, the “Plan” should be reviewed and updated several times during the course of the flight. A delayed takeoff due to maintenance, fast moving weather, and a short notice Temporary Flight Restriction (TFR) may all radically alter the plan. Several excellent flight planning software packages are available that automate this process, allowing the pilot additional time to evaluate and make decisions. Some include real time and graphical TFR depictions. The “plan” is not just about the flight plan, but the entire days events surrounding the flight and allowing the pilot to accomplish the mission. The plan is always being updated and modified and is especially responsive to changes in the other four remaining P’s. If for no other reason, the 5P check reminds the pilot that the day’s flight plan is real life and subject to change at any time.

Obviously the weather is a huge part of any “plan.” The addition of real time data link weather information give the TAA pilot a real advantage in inclement weather, but only if the pilot is trained to retrieve, and evaluate the weather in real time without sacrificing situational awareness. And of course, weather information should drive a decision, even if that decision is to continue on the current “plan.” Pilots of aircraft without datalink weather should get updated weather in-flight through a Flight Service Station and/or Flight Watch.

## The Plane

Both the “plan” and the “plane” are fairly familiar to most pilots. The “plane” consists of the usual array of mechanical and cosmetic issues that every aircraft pilot, owner, or operator can identify. For example, Is everything working properly? Is the fuel situation where you expected it to be at that point? Are you using anti-ice equipment? However, with the advent of the Technically Advanced Aircraft (TAA), the “plane” has expanded to include database currency, automation status, and emergency backup systems that were unknown a few years ago. Much has been written about single pilot IFR flight both with, and without, an autopilot. While this is a personal decision, it is just that, a decision. Low IFR in a non-autopilot equipped aircraft may depend on several of the other “P’s” we will discuss. Pilot proficiency, currency, and fatigue are among them. The TAA offers many new capabilities and simplifies the basic flying tasks, but only if the pilot is properly trained and all the equipment is working as advertised.

## The Pilot

This is an area all pilots are learning more and more about each day. Flying, especially when used for business transportation, can expose the pilot to high altitude flying, long distance and endurance, and more challenging weather. Technically Advance Aircraft (TAA), simply due to their advanced capabilities can expose a pilot to even more of these stresses. The traditional “IMSAFE” checklist is a good start. However, each of these factors must be taken in consideration of the cumulative effect of all of them together and the insidious effects of low altitude hypoxia. The authors informal survey of TAA pilots show that almost half fly with pulse oxymeters to display the effects of low altitude hypoxia in a graphic manner.

The combination of late night, pilot fatigue, and the effects of sustained flight above 5,000 feet may cause pilots to become less discerning, less critical of information, less decisive and more compliant and accepting. Just as the most critical portion of the flight approaches (for instance a night instrument approach, in the weather, after a four hour flight) the pilot’s guard is down the most. The “5P” process emphasizes that pilot recognize the physiological situation they are placing themselves in at the end of the flight, before they even takeoff, and continue to update their condition as the flight progresses. Once identified, the pilot is in an infinitely better place to make alternate plans that lessen the effect of these factors and provide a safer solution.

## The Passengers

One of the key differences between CRM and SRM is the way passengers interact with the pilot. In the airline industry the passengers have entered into a contractual agreement with the pilots company with a clearly defined set of possible outcomes. In corporate aviation, the relationship between crew and passengers is much closer, yet is still governed by a set of operating guidelines and the more formal lines of corporate authority. However, the pilot of a highly capable one engine inoperative aircraft has

entered into a very personal relationship with the passengers, in fact, they sit within an arms reach all of the time.

It may be easy, especially in business travel, for the desire of the passengers to make airline connections or important business meetings to enter into the pilot's decision-making loop. If this is done in a healthy and open way, it is a very positive thing. However, this is not always the case. For instance, imagine a flight to Dulles Airport and the passengers, both close friends and business partners, need to get to Washington D.C. for an important meeting. The weather is VFR all the way to southern Virginia then turns to low IFR as the pilot approaches Dulles. A pilot employing the 5P approach might consider reserving a rental car at an airport in northern North Carolina or southern Virginia to coincide with a refueling stop. Thus, the passengers have a way to get to Washington, and the pilot has an out to avoid being pressured into continuing the flight if the conditions do not improve.

Passengers can also be pilots. The old joke says that when four Certified Flight Instructors (CFI) board a light general aviation aircraft, a NOTAM should be posted. There is some truth to this. If no one is designated as pilot in command and unplanned circumstances arise, the decision-making styles of four self confident CFI's may come into conflict. Another situation arises when an owner pilot flies with a former CFI in the right seat on a business trip. Unless a clear relationship is defined and briefed prior to the flight, the owner pilot may feel some pressure to perform for the Individual Learning Manager (possibly beyond his or her capability), and the Individual Learning Manager may feel inhibited from intervening in small decisions until it is clearly evident that the pilot is making poor decisions. This is actually a CRM situation and requires clear pre-flight understanding of roles, responsibilities, and communication. Non-Pilots can also cause the pilot to review the SRM process.

Pilots need to understand that non-pilots may not understand the level of risk involved in the flight. There is an element of risk in every flight. That's why SRM calls it risk management not risk elimination. While a pilot may feel comfortable with the risk present in a night IFR flight, the passengers may not and may manifest this during the flight. The human reaction to fear and uncertainty is as varied as the shapes of our ears. Some become quiet, some talk incessantly, and in extreme cases anger and fear are strongly manifested. This may be the last thing the pilot needs to deal with while shooting the ILS to 400 feet and a mile visibility at midnight.

.A pilot employing SRM should ensure that the passengers are involved in the decision-making and given tasks and duties to keep them busy and involved. If, upon a factual description of the risks present, the passengers decide to buy an airline ticket or rent a car, then a good decision has generally been made. This discussion also allows the pilot to move past what he or she "thinks" the passengers want to do and find out what they "actually" want to do. This removes a load of self-induced pressure from the pilot.

## The Programming

The TAA adds an entirely new dimension to the way General Aviation aircraft are flown. The Glass Cockpit, GPS, and Autopilot are tremendous boons to reduce pilot workload and increase pilot situational awareness. And frankly, the programming and operation of these devices is fairly simple and straightforward. However, unlike the analog instruments they replace, they tend to capture the pilot's attention and hold it for long periods of time (like a desktop computer). To avoid this phenomenon, the pilot should plan in advance when and where the programming for approaches, route changes, and airport information gathering should be accomplished...as well as times it should not. Pilot familiarity with the equipment, the route, the local air traffic control environment, and their own capabilities vis-à-vis the automation should drive when, where, and how the automation is programmed and used.

The pilot should also consider what his or her capabilities are in response to last minute changes of the approach (and the reprogramming required) and ability to make large-scale changes (a re-route for instance) while hand flying the aircraft. Since formats are not standardized, simply moving from one manufacturer's equipment to another should give the pilot pause and require more conservative planning and decisions.

## The SRM Decision Process

The SRM process is simple. At least five times, before and during the flight, the pilot should review and consider the "Plan, the Plane, the Pilot, the Passengers, and the Programming" and make the appropriate decision required by the current situation. It is often said that failure to make a decision is a decision. Under SRM and the 5P's, even the decision to make no changes to the current plan, is made through a careful consideration of all the risk factors present.

## Example of Single Pilot Resource Management

The teaching of SRM is best accomplished in a seminar environment. Recently, the authors conducted a set of classroom seminars that presented real time flight scenarios to a room full of qualified pilots of varied experiences. The first scenario presented was a night MVFR/IFR flight from St Augustine Florida to Washington Dulles Airport. The original "**Plan**" called for a non-stop flight with a 45-minute fuel reserve. The "**Plane**" was a well-equipped TAA with a minor navigation light problem that delayed departure by an hour. The "**Passengers**" were one pilot and one non-pilot. The non-pilot seemed nervous about the trip and a little ill. Both passengers needed to get to Washington DC for an important meeting the next day. The "**Pilot**" had spent a full day at a flight refresher clinic, including a two-hour flight and a three-hour class, and felt reasonably refreshed at the 5 PM departure time. And finally, the GPS/MFD, the "**Programming**," combination looked like it would make the flight a snap. However, there were questions about the currency of the database that required the pilot's attention.

The discussion that followed revolved around the reliability of the weather data, the fatigue of the pilot landing at Dulles at 9 PM, alternate ways to get the passengers to their meeting, minimum requirements for aircraft night flight, and a more complete understanding of the benefits and challenges posed by GPS programming and database currency. The 5p's ensured that each pilot looked at the entire picture prior to making the critical decisions that would lay the groundwork for success or failure over four hours later in Washington.

Predictably, the destination weather deteriorated slowly as the flight proceeded northbound. The pilot's fatigue level, low altitude/long duration hypoxia, a succession of minor annoyances caused by the airplane and the passengers, began to become a factor. Again, the pilots applied the 5p's, and many decided to land short of Washington Dulles, check the weather, and secure a rental car as a backup for the Monday morning meeting (in fact many decided this prior to takeoff).

For the purposes of the discussion, this aircraft was equipped with a ballistic parachute system. For those that proceeded to Dulles, the scenario ended with a spatial disorientation incident at 1500 feet, 10 miles short of the airport caused by pilot fatigue, latent hypoxia, and failure to use the autopilot. For many, it was the first time they had considered all the options available, and the criticality of quick and accurate decisions. In the background, another instructor began calling out altitudes and speeds as the aircraft descended to the ground, providing an added dose of realism and pressure. Should the class initiate an unusual attitude recovery, and if it did not work should they attempt another? How much will the passengers help or hinder the pilots thought processes? When, and how, should the ballistic parachute system be deployed, and what are its limitations. This scenario sparked questions about the capabilities and limitations of the autopilot, cockpit automation, and the parachute system. More importantly, it caused the pilots in the room to examine how they should gather critical information, assess the risks inherent in the flight, and take timely action. All agreed that a few accurate decisions before and during the early part of the flight reduced the risk to pilot and passengers.

All these questions were discussed in a lively thirty-minute session following the scenario. In this type of Scenario Based Training, the group discussion is just as important as the actual situation, for it is during the discussion that the pilots are most ready to learn, and begin to develop a mental model of how they might react to situations. Instead of encountering a once in a lifetime, life or death, situation alone on the proverbial dark and stormy night, the participants could examine how the situation had developed, understand the options available to them, and begin to develop a general plan of action well ahead of time.

## Learner Centered Grading

The third component of the FITS training method, following each flight scenario, is to use the concept of “learner-centered grading.” Learner centered grading includes two parts: learner self assessment and a detailed debrief by the instructor. The purpose of the self assessment is to stimulate growth in the learner’s thought processes and, in turn, behaviors. The self-assessment is followed by an in-depth discussion between the instructor and the pilot in training which compares the instructor ratings to the pilot in training’s self-assessment.

To improve learning, it is recommended that learners prepare to learn from their experiences both before and after key events. This preparation should increase learning and enhance future performance. Pre-briefs are essential for setting goals. During key events, especially those that require high levels of attention, there may be little time for learning; most individuals allocate the bulk of their cognitive resources to performing the actual task; however, they may also dedicate some cognitive resources to self-monitoring, learning, and correction.

How facilitation and feedback occur is important to the learning process. In order for feedback to be useful for both informational and motivational purposes, it should be designed systematically. For example, the facilitator (Flight Instructor) should avoid lecturing the learner, and should withhold their observations and opinions of the exercise until the learner has given their opinion. The use of closed-ended questions may stymie the usefulness of the feedback process as well, as they encourage one-word/yes/no types of answers that do not elicit opinions of performance or suggestions for improvement. It is more effective to use open-ended questions that probe the learner to assess their own performance. Allotting enough time for the feedback is also important. Debriefs that are rushed often turn into one-way “lectures” due to time constraints.

Referring to prior pre-briefs when conducting subsequent debriefs provides a sense of continuity, reliability, and consistency, all of which are desirable attributes of a feedback source. Reminding learners of goals and lessons learned from prior exercises helps them plan for future events. Learners may also be more receptive to feedback during a debrief if they were appraised of the goal criteria in a pre-brief.

The FITS approach utilizes scenarios to teach Single Pilot Resource Management (SRM) while simultaneously teaching individual tasks such as landings and takeoffs. The authors quickly realized that this required a new approach to the pilot in training's performance measurement. Traditional grading approaches are generally teacher centered and measure performance against an empirical standard. The following example of a traditional flight syllabus demonstrates.

Table 4: A Traditional Grading Scale

<ul style="list-style-type: none"> <li>. Excellent - the pilot in training has performed in an excellent manner</li> <li>. Good – the pilot in training has exceeded basic requirements</li> <li>. Satisfactory – the pilot in training has met basic standards</li> <li>. Marginal – the pilot in training has failed to perform the task standards</li> <li>. Unsatisfactory – the pilot in training has demonstrated significant performance difficulties</li> </ul>
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Table 5: A Traditional Lesson

Lesson Tasks	Lesson Sub Tasks	Lesson Grading
<ul style="list-style-type: none"> <li>. Flight Planning</li> </ul>	<ul style="list-style-type: none"> <li>. Flight Planning</li> <li>. Weight and Balance and Aircraft Performance Calculations</li> </ul>	<ul style="list-style-type: none"> <li>. U, M, S, G, E</li> <li>. U, M, S, G, E</li> </ul>
<ul style="list-style-type: none"> <li>. Normal Preflight and Cockpit Procedures</li> </ul>	<ul style="list-style-type: none"> <li>. Normal Pre-Takeoff Checklist Procedures</li> <li>. GPS/Avionics Programming</li> <li>. MFD /PFD Setup</li> </ul>	<ul style="list-style-type: none"> <li>. U, M, S, G, E</li> <li>. U, M, S, G, E</li> <li>. U, M, S, G, E</li> </ul>

This type of grading scale (See Table 4), or something similar, is in wide use throughout the aviation training industry. While it appears to be based on published standards, in reality it is often used as a tool to determine pilot in training progress and provide motivation. Thus, on the first lesson a pilot in training may receive an “Excellent” grade for attempting to plan the flight and accomplishing the weight and balance with a few minor errors. However, by the third flight, that same performance may only earn a “Satisfactory” grade due to lack of pilot in training progress (***note that while performance remained the same, the grade changed***). Additionally, the Flight Instructor awards the grade based on his or her observation of the pilot in training's performance. This observation, while accurate, may not be based on an understanding of the pilot in training's level of knowledge and understanding of the task. Lastly, the pilot in training has been conditioned since grade school to look at grades as a reward for performance and may feel that there is a link between grades earned and their self-esteem. In reality, none of this aids pilot in training performance in any meaningful way.

The learner centered grading approach addresses these the above concerns. First, the grade is now a “Desired Scenario Outcome.” These outcomes describe pilot in training-learning behavior in readily identifiable and measurable terms. They reflect the pilot in training’s ability to see, understand, and apply the skills and tasks that are learned to the scenario.

For instance, a pilot in training who can “explain” a successful landing has achieved the basic level of competence to begin the learning process. Once the pilot in training can “explain” the effect of crosswind and speed reduction on rudder effectiveness, they have achieved a level of learning that will allow for meaningful “Practice.” The “Perform” level denotes unsupervised practice and self-correction of errors. These grades are equally applicable to the first scenario to the last since they are not lesson dependent.

The grade of “Manage/ Decide” is used solely for SRM grading and the grade of “Perform” is used solely for task grading. A pilot in training who is becoming proficient at aeronautical decision-making and risk management would be graded first at the “Explain” level, then at the “Practice”, and finally at the “Manage/Decide” level. A Manage/Decide or Perform grade does not describe perfection. Rather, these grades simply show a proficient pilot who corrects their own errors so that the outcome of the flight is never in doubt. Realistically, this is the performance level we desire. All pilots make mistakes, it is in learning to identify and correct mistakes that they become proficient pilots.

#### Desired Outcomes

The objective of scenario-based training is a change in the thought processes, habits, and behaviors of the pilot in training during the planning and execution of the scenario. Since the training is learner centered, the success of the training is measured in the following desired pilot in training outcomes.

##### (a) Maneuver Grades (Tasks)

- Describe – at the completion of the scenario, the PT will be able to describe the physical characteristics and cognitive elements of the scenario activities. *Instructor assistance is required to successfully execute the maneuver.*
- Explain –at the completion of the scenario the PT will be able to describe the scenario activity and understand the underlying concepts, principles, and procedures that comprise the activity. *Significant instructor effort will be required to successfully execute the maneuver.*
- Practice – at the completion of the scenario the pilot in training will be able to plan and execute the scenario. *Coaching, instruction, and/or assistance from the CFI will correct deviations and errors identified by the CFI.*

- Perform – at the completion of the scenario, the PT will be able to perform the activity without assistance from the CFI. Errors and deviations will be identified and corrected by the PT in an expeditious manner. At no time will the successful completion of the activity be in doubt. (“Perform” will be used to signify that the PT is satisfactorily demonstrating proficiency in traditional piloting and systems operation skills)
- Not Observed – Any event not accomplished or required

(b) Single Pilot Resource Management (SRM) Grades

- Explain – the pilot in training can verbally identify, describe, and understand the risks inherent in the flight scenario. *The pilot in training will need to be prompted to identify risks and make decisions.*
- Practice –the pilot in training is able to identify, understand, and apply SRM principles to the actual flight situation. *Coaching, instruction, and/or assistance from the CFI will quickly correct minor deviations and errors identified by the CFI.* The pilot in training will be an active decision maker.
- Manage/Decide - the pilot in training can correctly gather the most important data available both within and outside the cockpit, identify possible courses of action, evaluate the risk inherent in each course of action, and make the appropriate decision. *Instructor intervention is not required for the safe completion of the flight.*
- Not Observed – Any event not accomplished or required

Grading will be conducted independently by the pilot in training and the instructor, and then compared during the post flight critique.

Learner centered grading (outcomes assessment) is a vital part of the FITS concept. Previous syllabi and curriculum have depended on a grading scale designed to maximize pilot in training management and ease of instructor use. Thus the traditional: “excellent, good, fair, poor” or “exceeds standards, meets standards, needs more training” often meet the instructor’s needs but not the needs of the pilot in training. The learner centered grading described above is a way for the instructor and pilot in training to determine the pilot in training’s level of knowledge and understanding. “Perform” is used to describe proficiency in a skill item such as an approach or landing. “Manage-Decide” is used to describe proficiency in the SRM area such as ADM. Describe, explain, and practice are used to describe pilot in training learning levels below proficiency in both.

Grading should be progressive. During each flight, the pilot in training should achieve a new level of learning (e.g. flight one, the automation management area, might be a “describe” item by flight three a “practice” item, and by flight five a “manage-decide” item.

## An Example of Learner Centered Grading

Immediately after landing, and before beginning the critique, Flight Instructor Linda asks her pilot in training Brian to grade his performance for the day. Being asked to grade himself is a new experience but he goes along with it. The flight scenario had been a two-leg IFR scenario to a busy class B airport about 60 miles to the east. Brian had felt he had done well in keeping up with programming the GPS and the MFD until he reached the approach phase. He had attempted to program the ILS for runway 7L and had actually flown part of the approach until ATC asked him to execute a missed approach.

When he went to place a grade in that block he noticed that the grades were different. Instead of satisfactory or unsatisfactory he found, “Describe, Explain, Practice, and Perform”. He decided he was at the Perform level since he had not made any mistakes.

When Linda returned Brian discovered that she had graded his flight as well, with a similar grade sheet. Most of their grades appeared to match until the item labeled “programming the approach”. Here, where he had placed a “Perform” Linda had placed a “Explain”. This immediately sparked a discussion. As it turned out, Brian had selected the correct approach, but he had not activated it. Before Linda could intervene, traffic dictated a go around. Her explain grade told Brian that he did not really understand how the GPS worked and he agreed. Now, learning could occur.

In Table 6 on the following page, the desired outcome table denotes a pilot in training near the beginning of training and the grades reflect proficiency of the pilot in training to an expected level of performance in each of these areas. These grades are not self-esteem related since they do not describe a recognized level of prestige (such as A+ or “Outstanding”), rather a level of performance. You can’t flunk a lesson. However, you can fail to demonstrate the required flight and SRM skills. By reflecting on the lesson and grading their own performance, the pilot in training becomes actively involved in the critique process. Pilot in training participation in the process also reduces the self-esteem issue. But most importantly, this establishes the habit of healthy reflection and self-criticism that marks most competent pilots.

Table 6: Learner Centered Scenario Grading-Desired Outcome Table

Scenario Activities	Scenario Sub Activities	Desired Scenario Outcome
Flight Planning	<ol style="list-style-type: none"> <li>1. Scenario Planning</li> <li>2. Weight and Balance and Aircraft Performance Calculations</li> <li>3. Preflight SRM Briefing</li> <li>4. Decision making and Risk management</li> </ol>	<ol style="list-style-type: none"> <li>1. Perform</li> <li>2. Perform</li> <li>3. Perform</li> <li>4. Explain/Practice</li> </ol>
Normal Preflight and Cockpit procedures	<ol style="list-style-type: none"> <li>1. Normal Pre-Takeoff Checklist Procedures</li> <li>2. GPS Programming</li> <li>3. MFD Setup )</li> <li>4. PFD Setup</li> </ol>	<ol style="list-style-type: none"> <li>1. Perform</li> <li>2. Explain/Practice</li> <li>3. Practice</li> <li>4. Explain/Practice</li> </ol>
Engine Start and Taxi Procedures	<ol style="list-style-type: none"> <li>1. Engine Start</li> <li>2. Taxi</li> <li>3. SRM/Situational Awareness</li> </ol>	<ol style="list-style-type: none"> <li>1. Perform</li> <li>2. Perform</li> <li>3. Explain/Practice</li> </ol>
Before Takeoff Checks	<ol style="list-style-type: none"> <li>1. Normal and Abnormal Indications</li> <li>2. Automation Management</li> <li>3. Aeronautical Decision Making and Risk management</li> </ol>	<ol style="list-style-type: none"> <li>1. Perform</li> <li>2. Explain/Practice</li> <li>3. Manage/Decide</li> </ol>

# FITS ADS-B, TIS-B and FIS-B Syllabus

## Preface

This course prepares the Pilot in Training (PT) to fully use the capability of ADS-B and associated FIS-B information to make timely decisions in order to ensure a safe and successful flight. This course is designed for all levels of pilot certification levels, with a primary focus on developing SRM skills to take full advantage of the capabilities of ADS-B, TIS-B and FIS-B. The course focuses on maneuvers that can be associated with a typical cross-country flight. The scenario will be done as a VFR cross country, but if the PT is instrument rated, the scenario can be done as an IFR flight if conditions and airport facilities allow. In either case, the scenarios should be appropriate to the PT's certification and ratings.

This course does not intend for any complex emergencies to be conducted within its context. If emergencies are introduced into a scenario, they should be of the type requiring the PT to appropriately use the ADS-B, TIS-B, and FIS-B equipment and information to achieve a solution through skillful use of SRM.

A description of ADS-B, TIS-B, and FIS-B, including definitions and abbreviations is contained in the Appendix.

## Disclaimer

This course should be conducted in those areas where the ADS-B, TIS-B, FIS-B service is operational and the aircraft is equipped with the avionics necessary to both transmit and receive ADS-B signals. **An aircraft that is equipped with ADS-B equipment that only transmits ADS-B out solely for ATC purposes is not suitable for this course.**

Because TIS-B is part of the ADS-B ground system, this syllabus assumes that the equipment is capable of displaying TIS-B and ADS-R information as well as ADS-B In traffic information. Additionally, a multifunction display will also have the capability to display FIS-B data if the UAT link is used.

A Multi-function Display (MFD) information display is dependent upon what types of data linked information is being received from sensors onboard the aircraft. With the data link options available today, not all information shown on an MFD may be standardized. For example, one aircraft may have the ability to display approach charts from a data linked source whereas another may only to display data from a database source. Also, as each new generation of equipment comes on to the market, new capabilities may be available that are not found on older generations or models of the same equipment.

If using an aircraft supplied by the PT, it is very important to gain an understanding of what equipment and features are installed, in addition to the ADS-B avionics. It is possible that multiple sensors are installed that can provide similar functions. As the instructor, you need to know functions, capabilities, and limitations of the equipment. See the Approved Flight Manual for the aircraft for information regarding this equipment.

Ensure the airplane used for completing the scenario is capable of using the ADS-B systems. The aircraft should have a GPS navigator, an ADS-B position source, and ADS-B data link such as the Universal Access Transceiver (UAT) or 1090ES data link, and an MFD capable of displaying ADS-B, TIS-B, and FIS-B information. Other equipment, such as a satellite receiver for subscription weather services (FIS / FIS-B) could be used as a source of data linked FIS products. Also, the aircraft could be capable of displaying traffic from other sensors, such as TCAD, or TIS. Again, for training purposes, be sure that these sensors are inhibited and not used as a substitute for TIS-B. While all of these systems can be used to provide additional information, the focus of this course is on ADS-B, TIS-B and FIS-B. ADS-B systems using the 1090ES datalink are not expected to be capable of displaying FIS-B products.

### **Completion Standards**

This course objectives are met when the PT can operate the ADS-B / TIS-B and FIS-B equipment and use all information to the point where all SRM skills are at the Manage/Decide level of proficiency, and the flight is completed safely. Those maneuvers and procedures used during the flight should be at the perform level of proficiency. Because pilots of varying levels of certification can take this course, PT's are expected to demonstrate a level of proficiency appropriate to their certification established in the appropriate PTS. For example, a non-instrument rated private pilot would be expected to demonstrate those maneuvers necessary to complete the scenario to the standards set forth in the Private Pilot PTS.

# Flight Training

## Lesson 01

### Scenario:

You have just taken delivery of your airplane after getting new avionics installed capable of taking advantage of ADS-B technology. You've been reading the manual that came with the avionics as well as reading the literature available on ADS-B, TIS-B, and FIS-B products, so you're ready to begin using your new avionics. You've asked an instructor who is familiar with the ADS-B Out / In avionics to take you on a short cross-country flight so you can learn how to fully integrate ADS-B and its capabilities in your everyday flying. You decide to take a trip to another airport that is approximately 60-80 miles away. After reaching your destination, you and your instructor plan to have lunch during which you plan to discuss the outbound leg and also plan the return leg.

NOTE: This flight can be accomplished as either a VFR or IFR cross-country flight as appropriate to the PT's level of certification and experience. In order to minimize distractions during this first flight, it may be prudent to consider conducting a VFR flight even though the PT may be instrument rated. Then conduct the second leg under IFR. If an IFR flight is conducted, it may also be prudent to consider conducting the flight in VMC conditions.

### Lesson Objectives:

The primary objective of this flight is to help the PT learn to properly operate the ADS-B avionics. To accomplish this, the PT should be able to identify that the ADS-B avionics are operating properly and also to identify and make proper reports to ATC when they are determined not to be operating properly. The PT should also be able to navigate the menus available on the MFD to display FIS-B products, such as NEXRAD radar weather images, textual weather information, airspace information, NOTAMS, and other information available via FIS-B. The PT should be able to use the displayed information to assist in locating and identifying potential traffic conflicts via ADS-B and TIS-B. The PT should be able to use the weather, airspace, and other information received via FIS-B for improved situational awareness, and to enhance SRM skills. The PT is expected to make appropriate use of automation to handle routine flying skills (i.e., autopilot, navigator) while attention is focused on the ADS-B, TIS-B, and FIS-B information.

### **Pre-Briefing:**

The instructor will discuss ADS-B, TIS-B, and FIS-B, avionics, displays, and products to determine the PT's level of knowledge. The PT should be able to describe details of the ADS-B avionics installed in the airplane to be flown, and explain how to determine if the equipment is properly installed and working.

The PT should be able to explain how to use ADS-B and TIS-B to enhance their ability to see and avoid other traffic. The PT should be able to explain how to set the appropriate ADS-B code, and explain the relationship between the ADS-B code and the transponder code (4096, Mode A/C/S, 1090ES). The PT should be able to explain the difference between 1090MHz transponders and the 1090ES data link.

The PT should be able to describe and explain the menu options and functions of the MFD and how to display the various FIS-B products. In addition, The PT should describe and explain how to properly use the automation available in the aircraft to manage the aircraft control workload so that situational awareness is maintained at all times while using the ADS-B avionics.

The PT should be able to explain how to use ADS-B as an aid to prevent runway incursions and situational awareness during ground operations.

The PT should be able to explain how to use ADS-B and TIS-B as an aid to spacing during arrival, approach, and traffic pattern operations, including spacing, sequencing, and merging as the case may be. (Future uses of ADS-B by ATC may include delegated separation, self-separation, and other spacing applications. By having the PT use current ADS-B and TIS-B information, awareness of and practice in the use of this technology can help prepare for the future growth of capabilities in these areas.)

The PT should also be able to describe and explain how to use the information provided by the various FIS-B products to make strategic decisions regarding the flight using proper SRM skills. The PT should also be able to explain why FIS-B at its current level of technical maturity can not be used for tactical use purposes.

The PT should be able to explain how to recognize and compensate for malfunctions of the ADS-B equipment and describe how to report malfunctioning equipment to ATC.

### **Completion Standards:**

This lesson will be complete when the PT successfully demonstrates operation the ADS-B avionics to properly display the various options and FIS-B products while flying the aircraft to the appropriate levels of proficiency. The PT must be able to use ADS-B and TIS-B to aid in the visual identification of potential or conflicting traffic, and take appropriate action based upon the intended function of the equipment. (Note, if more advanced ADS-B avionics is being used, its functionality must be demonstrated, also.) .

The PT must be able to display the various FIS-B products and use the information appropriately to identify and manage risks and make proper decisions to ensure a safe flight outcome. Proper SRM skills should be demonstrated to maintain situational awareness, apply proper decision-making to minimize risks, all while using proper automation management skills.

The PT must be able to use ADS-B displays, including TIS-B displays to help maintain situational awareness during ground operations, including prevention of runway incursions and for sequencing and spacing from other traffic during departures and arrivals.

Additionally, the PT must be able to identify any errors or unsafe practices during flight, including SRM considerations, and understand why those actions were not optimal and what corrective action should have been taken.

Lesson 01 <b>Desired Outcome Grade Sheet</b>			Task Grades					SRM Grades		
			Not Obs	Describe	Explain	Practice	Perform	Explain	Practice	Manage
Scenario Activity	Task	Desired Performance								
Preflight Preparation	Weather Information	Perform								
	Flight Planning	Perform								
	SRM	Practice								
Preflight Procedures	Aircraft Preflight	Perform								
	ADS-B Equipment Check and Certification	Practice								
	Cockpit Check and Organization	Perform								
	SRM	Practice								
Takeoff and Departure Operations	Use of ADS-B for Taxi Awareness/Runway IncurSION Prevention	Practice								
	Pre-Takeoff Procedures	Perform								
	Normal Takeoff and VFR/IFR Departure Procedures and Navigation	Perform								
	Operation of ADS-B Avionics	Practice								
En route Operations	SRM	Practice								
	VFR/IFR Navigation	Perform								
	Operation of ADS-B Avionics/ADS-B Malfunctions	Practice								
	Use of Automation	Practice								
	Collision Avoidance using ADS-B/TIS-B	Practice								
	Display FIS-B Products	Practice								
Arrival Operations	SRM	Practice								
	Pre-Arrival Procedures	Perform								
	VFR/IFR Navigation and Arrival Procedures	Practice								
	Operation of ADS-B Avionics	Practice								
	Use of ADS-B for Spacing, Sequencing and Merging into Traffic Patterns and Approaches	Practice								
	Display of FIS-B Products	Practice								
Approach and Landing Operations	SRM	Practice								
	VFR Traffic Pattern/ Instrument Approach	Perform								
	Operation of ADS-B Avionics	Practice								
	Display of FIS-B Products	Practice								
	Normal Landing	Perform								
Post Flight Procedures	SRM	Practice								
	Post-Landing Procedures	Perform								

### **De-Briefing:**

The instructor will solicit a self-critique from the student about their personal performance based on the desired outcomes for the flight. The instructor should then compare the student's self-evaluation to their own, then consider why they agree or disagree with the student's assessment and use this information to direct your analysis of the flight. Additionally, discuss the role SRM played in the training activity and why it is critical to consider how a flight or a situation could be better managed to achieve an optimal outcome, if appropriate. Provide guidance on what the tasks and objectives will be for the next training activity and recommend how the PT should prepare them self.

### **Notes to the Instructor:**

During the pre-briefing, the PT should have demonstrated an understanding of ADS-B, TIS-B, and FIS-B services and products. This information is available via various sources, such as the Aeronautical Information Manual, Advisory Circulars, training handbooks, and manufacturer-supplied manuals. All functionality should be in accordance with the Airplane Flight Manual Supplement.

During the flight, the PT is expected to demonstrate appropriate proficiency to the standards prescribed in the PTS, based on level of certification. It is expected that automation be used to the maximum extent possible to allow the PT to focus on the ADS-B, TIS-B and FIS-B equipment and information. Remember the focus of this course is on ADS-B, TIS-B and FIS-B and utilizing the information to enhance SRM skills. At no time should the operation of the ADS-B equipment or managing displays and information detract from the PT's ability to maintain positive and safe aircraft control and demonstrate proper collision avoidance techniques. At no time should the PT use the ADS-B/TIS-B display as the sole means of identifying and avoiding traffic. ADS-B/TIS-B is to use as a tool to aid in the visual acquisition of traffic.

If the instructor determines that the PT is not familiar enough with the avionics, they should consider some practice on the ground prior to flying. If this is done in the aircraft using the installed equipment, consider using an external power source for the aircraft so as to not deplete the battery while conducting this practice. Training should be accomplished in accordance with the aircraft's flight manual.

Regardless of whether the flight is conducted under VFR or IFR, the PT should do all of the planning necessary, as they would for any flight. The PT should perform all preflight, takeoff and departure procedures, en route navigation, arrival and approach procedures, landing and after landing procedures. During flight, especially if an autopilot is not installed or functioning, when the instructor is satisfied that the PT has the appropriate level of proficiency, it is considered appropriate for the instructor to take control of the airplane to allow the PT to focus on the ADS-B, TIS-B and FIS-B avionics and displays.

During the flight, be extra vigilant for traffic as the PT's attention may be focused on manipulating the avionics and displays. This is normal during the initial learning phase, but the instructor should remind the PT not spend too much "heads down" time. The PT should never be allowed to relinquish the requirement to maintain proper collision avoidance to the instructor.

You should ask the PT to point out all traffic displayed on the MFD, explain how to interpret the various type traffic symbols (ADS-B vs. TIS-B) displayed, and to locate and identify the traffic visually. The instructor must be sure to reinforce that if ATC issues a traffic advisory the PT does not acknowledge visual contact solely based on the ADS-B display.

At various times during the flight the instructor should have the PT display the various FIS-B weather and other options and also explain how the weather depicted will impact the flight. Discuss what changes to flight plan, if any, might be appropriate to consider based on the information.

At some point during the flight, the instructor should ask the PT to explain how to identify when the ADS-B avionics are malfunctioning and ask the PT to simulate reporting a malfunction to ATC.

After the first leg of the flight, have the PT debrief you on that leg. Discuss any questions, concerns, or lack of understanding the PT has and incorporate them in the return leg.

# Flight Training

## Lesson 02

### Scenario:

Your instructor needs to get to another airport located about 50 miles away to retrieve a solo student who has been stranded on a cross-country. The instructor will be flying back with the stranded student. You will be flying back alone.

### Lesson Objectives:

On the outbound leg, the PT should demonstrate proper use of the ADS-B avionics and manage the information displays with little or no help while maintaining positive aircraft control at all times. The PT should be able to use the information to make good, sound judgment about the conduct of the flight and to exercise good SRM to ensure a safe outcome.

On the return flight, while acting as the sole occupant of the aircraft, the PT should demonstrate the ability to use the ADS-B avionics, manage displays and information, maintain positive aircraft control, and exercise sound SRM with NO intervention or assistance from the instructor.

### Pre-Briefing:

The instructor will discuss the objective of the lesson and determine whether the student is adequately prepared for the activity. The PT should have a clear understanding of how the training activity will be conducted and what standards will be expected of them for all performance items to be covered.

### Completion Standards:

This lesson will be complete when the PT demonstrates the appropriate level of proficiency for their level of certification during the second leg of the flight.

Additionally, the PT should be able to identify any errors or unsafe practices made during the flight, including SRM considerations, and understand why those actions were not optimal and what corrective action could have been taken.

Lesson 02 <b>Desired Outcome Grade Sheet</b>			Task Grades					SRM Grades		
			Not Obs	Describe	Explain	Practice	Perform	Explain	Practice	Manage
Scenario Activity	Task	Desired Performance								
Preflight Preparation	Weather Information	Perform								
	Flight Planning	Perform								
	SRM	Manage/Decide								
Preflight Procedures	Aircraft Preflight	Perform								
	ADS-B Equipment Check and Certification	Perform								
	Cockpit Check and Organization	Perform								
	SRM	Manage/Decide								
Takeoff and Departure Operations	Use of ADS-B for Taxi Awareness/Runway Incursion Prevention	Manage/Decide								
	Pre-Takeoff Procedures	Perform								
	Normal Takeoff and VFR/IFR Departure Procedures and Navigation	Perform								
	Operation of ADS-B Avionics	Perform								
En route Operations	SRM	Manage/Decide								
	VFR/IFR Navigation	Perform								
	Operation of ADS-B Avionics/ADS-B Malfunctions	Perform								
	Use of Automation	Manage/Decide								
	Collision Avoidance using ADS-B/TIS-B	Perform								
	Display FIS-B Products	Perform								
Arrival Operations	SRM	Manage/Decide								
	Pre-Arrival Procedures	Perform								
	VFR/IFR Navigation and Arrival Procedures	Perform								
	Operation of ADS-B Avionics	Perform								
	Use of ADS-B for Spacing, Sequencing and Merging into Traffic Patterns and Approaches	Manage/Decide								
	Display of FIS-B Products	Perform								
Approach and Landing Operations	SRM	Manage/Decide								
	VFR Traffic Pattern/ Instrument Approach	Perform								
	Operation of ADS-B Avionics	Perform								
	Display of FIS-B Products	Manage/Decide								
	Normal Landing	Perform								
Post Flight Procedures	SRM	Manage/Decide								
	Post-Landing Procedures	Perform								

### **De-Briefing:**

The instructor should ask the PT to perform a self-critique of their performance based on the desired outcomes for the flight. The PT should be able to offer suggestions for self-improvement on subsequent flights, thereby demonstrating the ability to continue learning and improving.

### **Notes to the Instructor:**

During the first leg of the flight, the instructor should interact as little as possible during the flight. Instructor interactions should be limited to asking for certain information to be displayed, asking “what if” questions to prompt the PT to seek certain information, and to ask how that information could be used to make decisions about the remainder of the flight.

The PT is expected to optimize use of aircraft automation to properly manage the flight.

On the return leg, the instructor should remember that the PT is supposed to be the sole occupant of the aircraft. The instructor role is to observe and evaluate the PT’s performance regarding the use of the ADS-B avionics. In addition, observe the PT’s management of the information available to ensure sound SRM skill and judgment.

# Appendix A

Definitions and abbreviations related to FITS can be found in Page 6.

## Abbreviations Used in This Course

1090 ES 1090 MHz extended squitter  
ADM- Aeronautical Decision Making  
ADS-B Automatic Dependent Surveillance – Broadcast  
ADS-R Automatic Dependent Surveillance – Rebroadcast  
AM- Automation Management  
ATC- Air Traffic Control  
CBI- Computer Based Instruction  
CDTI cockpit display of traffic information  
CFI- Certificated Flight Instructor  
CFIT- Controlled Flight Into Terrain  
CRM- Crew Resource Management  
FBO- Fixed Based Operator  
FIS-B Flight Information Service – Broadcast  
FITS-FAA/Industry Training Standards  
GPS- Global Positioning System  
IFR- Instrument Flight Rules  
ILS- Instrument Landing System  
IMC- Instrument Meteorological Conditions  
LCG- Learner Centered Grading  
LOFT- Line Oriented Flight Training  
MBT- Maneuvers Based Training  
MFD- Multi-Function Display  
MVFR- Marginal Visual Flight Rules  
PFD- Primary Flight Display  
PT- Pilot in Training  
PTS- Practical Test Standard  
RM- Risk Management  
SA- Situational Awareness  
SBT- Scenario Based Training  
SME- Subject Matter Expert  
SRM- Single-pilot Resource Management  
TAA- Technically Advanced Aircraft  
TFR- Temporary Flight Restriction  
TIS-B Traffic Information Service – Broadcast  
TM- Task Management  
VFR- Visual Flight Rules  
VMC- Visual Meteorological Conditions

## Appendix B

This appendix contains supplemental information about ADS-B. The information in this appendix comes from the *Aeronautical Information Manual* and the *Report from the ADS-B Aviation Rulemaking Committee to the Federal Aviation Administration*, (September 26, 2008).

The following is from the *Report from the ADS-B Aviation Rulemaking Committee to the Federal Aviation Administration*, (September 26, 2008).

### ADS-B System

ADS-B is a data link system in which aircraft avionics broadcast the position and other information from the aircraft for ground-based receivers and other aircraft with receivers. This data link enables a variety of capabilities on the aircraft and in ATC, as shown in figure 1 below.

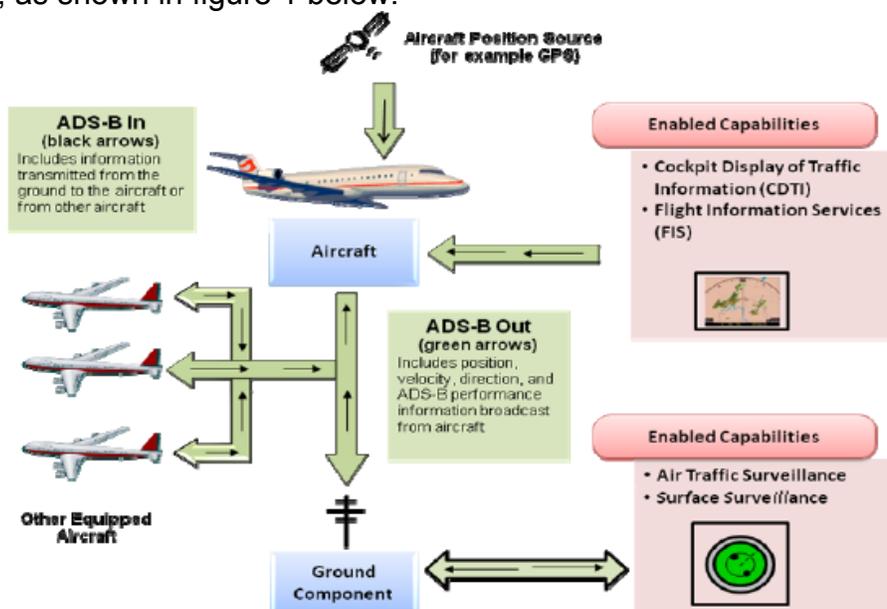


Figure 1—ADS-B System Overview

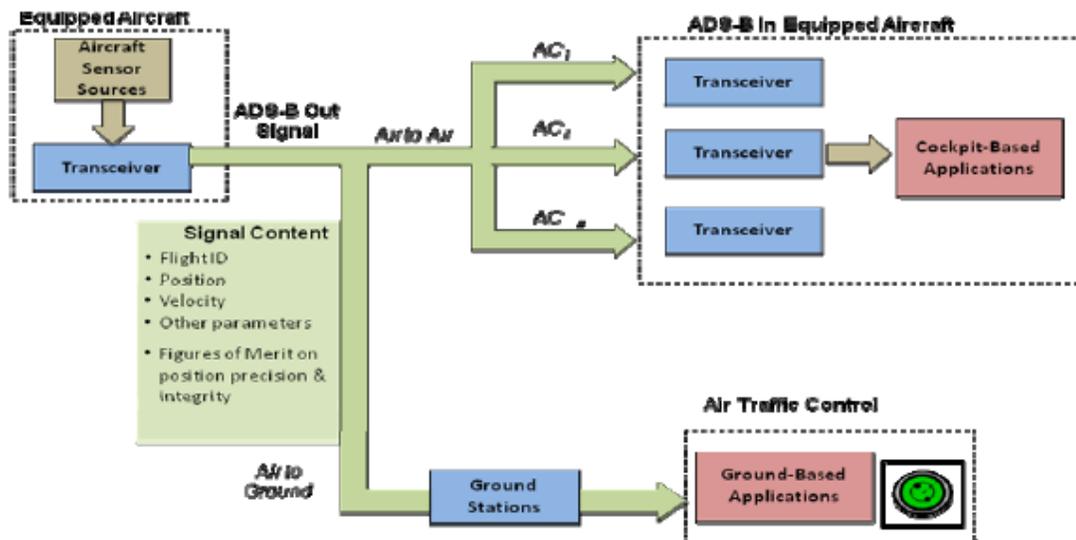
The ADS-B program consists of two different systems: ADS-B Out and ADS-B In. The ability to transmit ADS-B signals or “messages” is referred to as ADS-B Out. The proposed rule requires most operators to equip with ADS-B Out, which would be a prerequisite for any future option or requirement to install ADS-B In avionics.

ADS-B Out allows for more accurate and timely ATC surveillance data as compared to existing primary and secondary radars, but does not provide flightcrews the ability to receive, display, or interpret ADS-B signals. To realize the many benefits of the ADS-B system, including the ability for a flightcrew to have situational awareness of proximate traffic or to use advanced air-to-air applications, aircraft will need to be equipped with an ADS-B display. Applications enabled by ADS-B depend on whether aircraft are equipped with ADS-B Out or ADS-B In. ADS-B In capabilities can be divided into the following two categories: capabilities provided by the ground surveillance component and capabilities added by aircraft equipment.

Surveillance and broadcast services are expected to be provided by the FAA on two different broadcast links: 1090 ES and UAT. High altitude users, including larger air transport category operators, are more likely to equip with 1090 ES. Low altitude users, including most general aviation (GA) operators, are more likely to equip with UAT. For future ADS-B In applications, ground-based automatic dependent surveillance-rebroadcast (ADS-R) equipment allows an aircraft in one link to display aircraft on both links. Aircraft equipped with 1090 ES and UAT could display aircraft on both data links, without the ADS-R system. With respect to broadcast information, flight information service-broadcast (FIS-B) is currently available only on UAT.

### ***ADS-B Out***

As shown in figure 2, an aircraft using ADS-B Out periodically broadcasts its own position and other information through an onboard transceiver. The ADS-B signal can be received by ground stations providing information to ATC and by other aircraft equipped with ADS-B In. Broadcast signals include the aircraft's flight identification, position (horizontal and vertical), velocity (horizontal and vertical), and various performance parameters. Standards for the information provided by ADS-B Out broadcast messages have evolved over time. Aircraft have been equipping with ADS-B Out according to the standards at the time of equipage. The proposed rule establishes and requires specific performance standards, which are projected to enable ADS-B In applications.

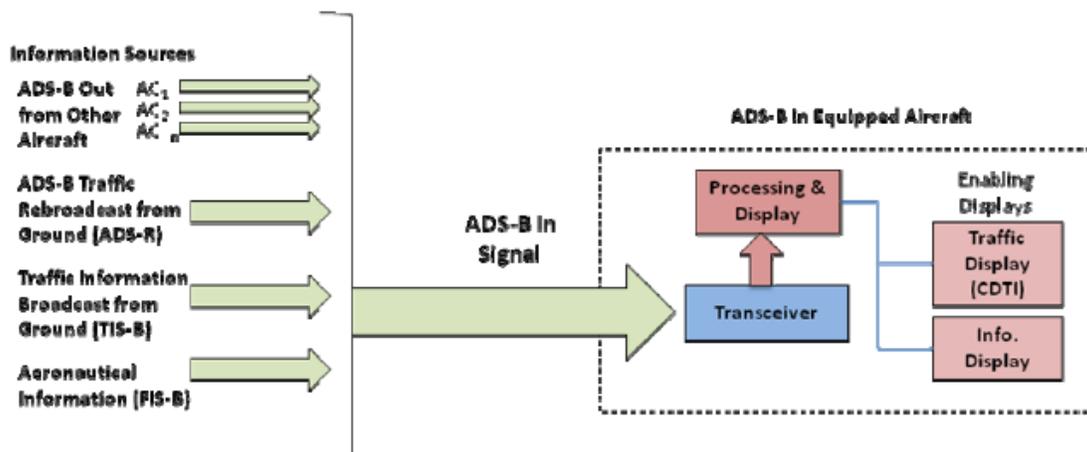


**Figure 2—ADS-B Out Signal and Enabled Capabilities**

ADS-B Out is automatic in the sense that no pilot action is required for the information to be transmitted. It is dependent surveillance in the sense that the surveillance information depends on the positioning and broadcast capabilities of the source. As shown in figure 3, ADS-B Out could be used by ATC for surveillance and traffic separation, in a manner similar to the current radar usage and radar-based separation standards. The broadcast signal can also be received by other aircraft equipped with ADS-B In avionics (as discussed in the next section) to enable cockpit-based applications. Aircraft can be equipped with ADS-B Out without having ADS-B In capability.

### **ADS-B In**

The ability to receive ADS-B signals from the ground and other aircraft, process those signals, and display traffic and information to flightcrews is referred to as ADS-B In, as illustrated in figure 3.



### **Figure 3—ADS-B In Signal Sources and Enabled Capabilities**

As shown in figure 4, an ADS-B In-equipped aircraft can receive information from multiple sources. Achieving benefits from ADS-B In requires onboard processing of the ADS-B signal and integration with aircraft displays. The ADS-B signal processing may be done in terms of a decision logic platform to generate warnings or provide guidance for numerous air-to-air applications, and may be presented on a variety of display platforms. ADS-B In complements ADS-B Out by providing pilots and aircraft navigation systems with highly accurate position and direction information on other aircraft operating nearby.

At the most basic level, ADS-B In enhances the flightcrew's situational awareness of other aircraft operating within their proximity. The full potential of ADS-B In may allow flightcrews to plot the most efficient flight path without ATC instructions. Flightcrews in ADS-B In-equipped aircraft may be able to locate other traffic, identify crossing flight paths, and adjust their flight path to remove any conflicts. ADS-B In also would sustain the level of flight safety provided by radar-based surveillance systems, and may support reduced traffic separation distances and allow for increased traffic volumes. Before implementing ADS-B In, the FAA needs to establish performance standards for each ADS-B In application, establish standards for the subsystems necessary to support the expanded operations, and certificate ADS-B In cockpit display systems. Additionally, the FAA will need to make decisions about electronic flight bags (EFB), as an alternative to integrated cockpit displays. ADS-B In is a major element of the future surveillance technology mix planned by the International Civil Aviation Organization (ICAO) Global Air Navigation Plan.

#### **Automatic Dependent Surveillance – Rebroadcast**

To take advantage of all ADS-B In applications, flightcrews must have situational awareness that includes aircraft not equipped with ADS-B and aircraft equipped with ADS-B but transmitting on a different data link. ADS-R is planned as a component of the ADS-B ground infrastructure, which provides interoperability between UAT and 1090 ES.

ADS-R collects traffic information broadcast on the UAT data link and rebroadcasts the information to 1090 ES users. ADS-R also collects traffic information provided on the 1090 ES datalink and rebroadcasts the information to UAT users. With a dual link system, ADS-R allows any ADS-B In-equipped aircraft to receive messages about aircraft transmitting on either 1090 ES and UAT.

## Traffic Information Service – Broadcast

ADS-B is a cooperative surveillance environment that requires all users to participate to maximize operational benefits. During the transition period, when only some users have equipped with ADS-B, other systems will be necessary to provide the best available information to those seeking the total surveillance picture onboard an aircraft. The traffic information service–broadcast (TIS-B) service uses secondary surveillance radars and multilateration systems coupled with other sources to provide proximate traffic situational awareness, including position reports from aircraft not equipped with ADS-B. However, additional ground processing is necessary to create accurate information, and source data may not be equivalent to ADS-B information provided by a participating aircraft. Therefore, the TIS-B signal is planned to be used only as an essential advisory service, not to separate or maneuver aircraft. Figure 4 shows an existing multifunctional aircraft cockpit display that shows both aircraft position reports derived directly from other ADS-B-equipped aircraft and from the TIS-B service (for those aircraft not equipped with ADS-B Out).

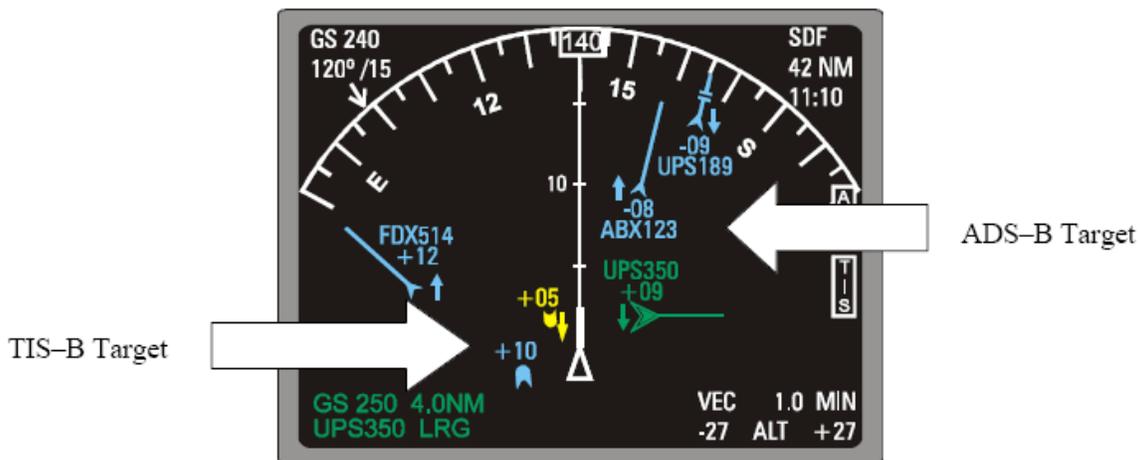


Figure 4—Currently Available Traffic Display

## Flight Information Service – Broadcast

The FIS-B service is carried on the UAT data link and provides additional supplementary flight information. FIS-B is intended to provide enhanced weather services, textual and graphic weather and terrain information, Notices to Airmen (NOTAM), Temporary Flight Restrictions (TFR), and other flight information for processing and display. For the GA user, this provides a single platform that will enhance safety through a broader suite of situational awareness services. Figure 5 shows a prototype FIS-B aircraft cockpit display.



**Figure 5—Currently Available FIS-B Display**

The air transport community also has expressed interest in using the FIS-B service to increase the real-time availability of weather data in the cockpit on 1090 ES-equipped aircraft — this would require the aircraft to be equipped with a UAT In capability

## **ADS-B, TIS-B and FIS-B Information from Aeronautical Information Manual**

**Note: As ADS-B evolves this information may change. Please consult the latest issue of the Aeronautical Information Manual for the most current information.**

### **4-4-18. Automatic Dependent Surveillance-Broadcast (ADS-B)**

- a.** ADS-B (aircraft-to-aircraft) provides proximity warning only to assist the pilot in the visual acquisition of other aircraft. No recommended avoidance maneuvers are provided nor authorized as a direct result of an ADS-B display or an ADS-B alert.
- b.** ADS-B does not alter or diminish the pilot's basic authority and responsibility to ensure safe flight. ADS-B only displays aircraft that are ADS-B equipped; therefore, aircraft that are not ADS-B equipped or aircraft that are experiencing an ADS-B failure will not be displayed. ADS-B alone does not ensure safe separation.
- c.** Presently, no air traffic services or handling is predicated on the availability of an ADS-B cockpit display. A "traffic-in-sight" reply to ATC must be based on seeing an aircraft out-the-window, NOT on the cockpit display.

### **4-4-19. Traffic Information Service-Broadcast (TIS-B)**

- a.** TIS-B provides traffic information to assist the pilot in the visual acquisition of other aircraft. No recommended avoidance maneuvers are provided nor authorized as the direct result of a TIS-B display or TIS-B alert.
- b.** TIS-B does not alter or diminish the pilot's basic authority and responsibility to ensure safe flight. TIS-B only displays aircraft with a functioning transponder; therefore, aircraft that are not transponder equipped, or aircraft that are experiencing a transponder failure, or aircraft out of radar coverage will not be displayed. TIS-B alone does not ensure safe separation.
- c.** Presently, no air traffic services or handling is predicated on the availability of TIS-B equipment in aircraft. A "traffic-in-sight" reply to ATC must be based on seeing an aircraft out-the-window, NOT on the cockpit display.

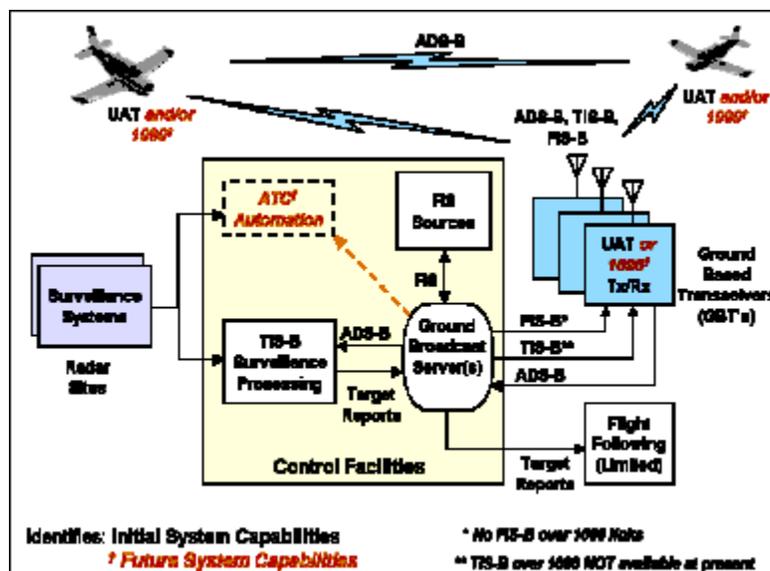
## 4-5-7. Automatic Dependent Surveillance-Broadcast (ADS-B) Services

### a. Introduction

1. Automatic Dependent Surveillance-Broadcast (ADS-B) is a surveillance technology being deployed in selected areas of the NAS (see FIG 4-5-7). ADS-B broadcasts a radio transmission approximately once per second containing the aircraft's position, velocity, identification, and other information. ADS-B can also receive reports from other suitably equipped aircraft within reception range. Additionally, these broadcasts can be received by Ground Based Transceivers (GBTs) and used to provide surveillance services, along with fleet operator monitoring of aircraft. No ground infrastructure is necessary for ADS-B equipped aircraft to detect each other.

2. In the U.S., two different data links have been adopted for use with ADS-B: 1090 MHz Extended Squitter (1090 ES) and the Universal Access Transceiver (UAT). The 1090 ES link is intended for aircraft that primarily operate at FL 180 and above, whereas the UAT link is intended for use by aircraft that primarily operate at 18,000 feet and below. From a pilot's standpoint, the two links operate similarly and support ADS-B and Traffic Information Service-Broadcast (TIS-B), see paragraph 4-5-8. The UAT link additionally supports Flight Information Services-Broadcast (FIS-B), subparagraph 7-1-11d.

**FIG 4-5-7**  
**ADS-B, TIS-B, and FIS-B:**  
**Broadcast Services Architecture**



## **b. ADS-B Certification and Performance Requirements**

ADS-B equipment may be certified as an air-to-air system for enhancing situational awareness and as a surveillance source for air traffic services. Refer to the aircraft's flight manual supplement for the specific aircraft installation.

## **c. ADS-B Capabilities**

1. ADS-B enables improved surveillance services, both air-to-air and air-to-ground, especially in areas where radar is ineffective due to terrain or where it is impractical or cost prohibitive. Initial NAS applications of air-to-air ADS-B are for "advisory," use only, enhancing a pilot's visual acquisition of other nearby equipped aircraft either when airborne or on the airport surface. Additionally, ADS-B will enable ATC and fleet operators to monitor aircraft throughout the available ground station coverage area. Other applications of ADS-B may include enhanced search and rescue operations and advanced air-to-air applications such as spacing, sequencing, and merging.

2. ADS-B avionics typically allow pilots to enter the aircraft's call sign and Air Traffic Control (ATC)-assigned transponder code, which will be transmitted to other aircraft and ground receivers. Pilots are cautioned to use care when selecting and entering the aircraft's identification and transponder code. Some ADS-B avionics panels are not interconnected to the transponder. Therefore, it is **extremely important to ensure that the transponder code is identical in the ADS-B and transponder panel**. Additionally, UAT systems provide a VFR "privacy" mode switch position that may be used by pilots when not wanting to receive air traffic services. This feature will broadcast a "VFR" ID to other aircraft and ground receivers, similar to the "1200" transponder code.

3. ADS-B is intended to be used in-flight and on the airport surface. ADS-B systems should be turned "on" — and remain "on" — whenever operating in the air and on the airport surface, thus reducing the likelihood of runway incursions. Civil and military Mode A/C transponders and ADS-B systems should be adjusted to the "on" or normal operating position as soon as practical, unless the change to "standby" has been accomplished previously at the request of ATC. Mode S transponders should be left on whenever power is applied to the aircraft.

## **d. ATC Surveillance Services using ADS-B - Procedures and Recommended Phraseology - For Use In Alaska Only**

Radar procedures, with the exceptions found in this paragraph, are identical to those procedures prescribed for radar in AIM Chapter 4 and Chapter 5.

**1. Preflight:**

If a request for ATC services is predicated on ADS-B and such services are anticipated when either a VFR or IFR flight plan is filed, the aircraft's "N" number or call-sign as filed in "Block 2" of the Flight Plan shall be entered in the ADS-B avionics as the aircraft's flight ID.

**2. Inflight:**

When requesting ADS-B services while airborne, pilots should ensure that their ADS-B equipment is transmitting their aircraft's "N" number or call sign prior to contacting ATC. To accomplish this, the pilot must select the ADS-B "broadcast flight ID" function.

**NOTE-**

*The broadcast "VFR" or "Standby" mode built into some ADS-B systems will not provide ATC with the appropriate aircraft identification information. This function should first be disabled before contacting ATC.*

**3. Aircraft with an Inoperative/Malfunctioning ADS-B Transmitter or in the Event of an Inoperative Ground Broadcast Transceiver (GBT).**

**(a)** ATC will inform the flight crew when the aircraft's ADS-B transmitter appears to be inoperative or malfunctioning:

**PHRASEOLOGY-**

*YOUR ADS-B TRANSMITTER APPEARS TO BE INOPERATIVE/MALFUNCTIONING. STOP ADS-B TRANSMISSIONS.*

**(b)** ATC will inform the flight crew when the GBT transceiver becomes inoperative or malfunctioning, as follows:

**PHRASEOLOGY-**

*(Name of facility) GROUND BASED TRANSCEIVER INOPERATIVE/MALFUNCTIONING.  
(And if appropriate) RADAR CONTACT LOST.*

**NOTE-**

*An inoperative or malfunctioning GBT may also cause a loss of ATC surveillance services.*

(c) ATC will inform the flight crew if it becomes necessary to turn off the aircraft's ADS-B transmitter.

**PHRASEOLOGY-**  
*STOP ADS-B TRANSMISSIONS.*

(d) Other malfunctions and considerations:

Loss of automatic altitude reporting capabilities (encoder failure) will result in loss of ATC altitude advisory services.

**e. ADS-B Limitations**

1. The ADS-B cockpit display of traffic is NOT intended to be used as a collision avoidance system and does not relieve the pilot's responsibility to "see and avoid" other aircraft. (See paragraph 5-5-8, See and Avoid). ADS-B shall not be used for avoidance maneuvers during IMC or other times when there is no visual contact with the intruder aircraft. ADS-B is intended only to assist in visual acquisition of other aircraft. No avoidance maneuvers are provided nor authorized, as a direct result of an ADS-B target being displayed in the cockpit.

2. Use of ADS-B radar services is limited to the service volume of the GBT.

**NOTE-**

*The coverage volume of GBTs are limited to line-of-sight.*

**f. Reports of ADS-B Malfunctions**

Users of ADS-B can provide valuable assistance in the correction of malfunctions by reporting instances of undesirable system performance. Reporters should identify the time of observation, location, type and identity of aircraft, and describe the condition observed; the type of avionics system and its software version in use should also be included. Since ADS-B performance is monitored by maintenance personnel rather than ATC, it is suggested that malfunctions be reported in any one of the following ways:

1. By radio or telephone to the nearest Flight Service Station (FSS) facility.

2. By FAA Form 8000-7, Safety Improvement Report, a postage-paid card is designed for this purpose. These cards may be obtained from FAA FSSs, Flight Standards District Offices, and general aviation fixed-based operators.

3. By reporting the failure directly to the FAA Safe Flight 21 program at 1-877-FLYADSB or <http://www.adsb.gov>.

## **4-5-8. Traffic Information Service-Broadcast (TIS-B)**

### **a. Introduction**

Traffic Information Service-Broadcast (TIS-B) is the broadcast of traffic information to ADS-B equipped aircraft from ADS-B ground stations. The source of this traffic information is derived from ground-based air traffic surveillance sensors, typically radar. TIS-B service is becoming available in selected locations where there are both adequate surveillance coverage from ground sensors and adequate broadcast coverage from Ground Based Transceivers (GBTs). The quality level of traffic information provided by TIS-B is dependent upon the number and type of ground sensors available as TIS-B sources and the timeliness of the reported data.

### **b. TIS-B Requirements**

In order to receive TIS-B service, the following conditions must exist:

1. The host aircraft must be equipped with a UAT ADS-B transmitter/receiver or transceiver, and a cockpit display of traffic information (CDTI). As the ground system evolves, the ADS-B data link may be either UAT or 1090 ES, or both.
2. The host aircraft must fly within the coverage volume of a compatible GBT that is configured for TIS-B uplinks. (Not all GBTs provide TIS-B due to a lack of radar coverage or because a radar feed is not available).
3. The target aircraft must be within the coverage of, and detected by, at least one of the ATC radars serving the GBT in use.

### **c. TIS-B Capabilities**

1. TIS-B is the broadcast of traffic information to ADS-B equipped aircraft. The source of this traffic information is derived from ground-based air traffic radars. TIS-B is intended to provide ADS-B equipped aircraft with a more complete traffic picture in situations where not all nearby aircraft are equipped with ADS-B. The advisory-only application will enhance a pilot's visual acquisition of other traffic.
2. Only transponder-equipped targets (i.e., Mode A/C or Mode S transponders) are detected. Current radar siting may result in limited radar surveillance coverage at lower altitudes near some general aviation airports, with subsequently limited TIS-B service volume coverage. If there is no radar coverage in a given area, then there will be no TIS-B coverage in that area.

#### d. TIS-B Limitations

1. TIS-B is NOT intended to be used as a collision avoidance system and does not relieve the pilot's responsibility to "see and avoid" other aircraft. (See paragraph 5-5-8, See and Avoid). TIS-B shall not be used for avoidance maneuvers during times when there is no visual contact with the intruder aircraft. TIS-B is intended only to assist in the visual acquisition of other aircraft. No avoidance maneuvers are provided for nor authorized as a direct result of a TIS-B target being displayed in the cockpit.

2. While TIS-B is a useful aid to visual traffic avoidance, its inherent system limitations must be understood to ensure proper use.

(a) A pilot may receive an intermittent TIS-B target of themselves, typically when maneuvering (e.g., climbing turn) due to the radar not tracking the aircraft as quickly as ADS-B.

(b) The ADS-B-to-radar association process within the ground system may at times have difficulty correlating an ADS-B report with corresponding radar returns from the same aircraft. When this happens the pilot will see duplicate traffic symbols (i.e., "TIS-B shadows") on the cockpit display.

(c) Updates of TIS-B traffic reports will occur less often than ADS-B traffic updates. (TIS-B position updates will occur approximately once every 3-13 seconds depending on the radar coverage. In comparison, the update rate for ADS-B is nominally once per second).

(d) The TIS-B system only detects and uplinks data pertaining to transponder equipped aircraft. Aircraft without a transponder will not be displayed as a TIS-B target.

(e) There is no indication provided when any aircraft is operating inside (or outside) the TIS-B service volume, therefore it is difficult to know if one is receiving uplinked TIS-B traffic information. Assume that not all aircraft are displayed as TIS-B targets.

3. Pilots and operators are reminded that the airborne equipment that displays TIS-B targets is for pilot situational awareness **only** and is not approved as a collision avoidance tool. Unless there is an imminent emergency requiring immediate action, any deviation from an air traffic control clearance based on TIS-B displayed cockpit information must be approved beforehand by the controlling ATC facility prior to commencing the maneuver. Uncoordinated deviations may place an aircraft in close proximity to other aircraft under ATC control not seen on the airborne equipment, and may result in a pilot deviation.

## **e. Reports of TIS-B Malfunctions**

Users of TIS-B can provide valuable assistance in the correction of malfunctions by reporting instances of undesirable system performance. Reporters should identify the time of observation, location, type and identity of the aircraft, and describe the condition observed; the type of avionics system and its software version used. Since TIS-B performance is monitored by maintenance personnel rather than ATC, it is suggested that malfunctions be reported in any one of the following ways:

1. By radio or telephone to the nearest Flight Service Station (FSS) facility.
2. By FAA Form 8000-7, Safety Improvement Report, a postage-paid card is designed for this purpose. These cards may be obtained from FAA FSSs, Flight Standards District Offices, and general aviation fixed-based operators.
3. By reporting the failure directly to the FAA Safe Flight 21 program at 1-877-FLYADSB or <http://www.adsb.gov>.

### **From Section 7-1-10**

**FAA's Flight Information Service-Broadcast (FIS-B) Service.** FIS-B is a ground broadcast service provided through the FAA's Universal Access Transceiver (UAT) "ADS-B Broadcast Services" network. The UAT network is an ADS-B data link that operates on 978 MHz. The FAA FIS-B system provides pilots and flight crews of properly equipped aircraft with a cockpit display of certain aviation weather and flight operational information. The FAA's FIS-B service is being introduced in certain regional implementations within the NAS (e.g., in Alaska and in other areas of implementation).

1. FAA's UAT FIS-B provides the initial products listed below with additional products planned for future implementation. FIS-B reception is line of sight and can be expected within 200 NM (nominal range) of each ground transmitting site. The following services are provided free of charge.
  - (a) **Text:** Aviation Routine Weather Reports (METARs).
  - (b) **Text:** Special Aviation Reports (SPECIs).
  - (c) **Text:** Terminal Area Forecasts (TAFs), and their amendments.
  - (d) **Graphic:** NEXRAD precipitation maps.