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THE COMPLEX COGNITIVE PROCESS NEEDED TO UNDERSTAND AIRPORT GUIDANCE SIGNS

John Adrian

Abstract

Airport guidance signs are a visual information system. It can be equated to a street sign arrangement for conveying runway and taxiway assistance. Pilots have to learn, comprehend, and interpret each sign's meaning for understanding to occur. The FAA makes this simple by dictating the standardization of signs. Flight crews still have a daunting task of assimilating the message in the brief time that each sign is viewed. When combining simple colors, symbols, letters, and numbers, these elements form an elaborate organization of meaning. The cognitive mental process that takes place is complex. This diversity is complicated even more with the many exceptions to the rule that apply. One must filter through the different scenarios to grasp the sign's message.

Introduction

At the beginning and end of each flight, a pilot needs to use the airport guidance sign system to navigate around an airfield. Each airport is laid out differently so there is no universal set plan. Some airports are simple, while others are complex. A pilot needs to have an increased situational awareness when the aircraft is on the airport's movement area. This is where the greatest congestion is experienced.

To maneuver on an airport, guidance signs help a pilot navigate his/her way around the complex system of runways and taxiways. They assist in aiding the aircraft to reach its final destination whether it is (a) the runway, (b) the hanger, or (c) the gate. The airport sign system is a safety critical system, which is commonly certified with an extremely low probability of failure per hour of use (Boy, 2000). Airport signs come in a number of colors containing lettering, and/or symbols so as to convey a message. They are a fixed information system located throughout the airport to help the pilot make correct decisions related to the movement of their aircraft. Pilots need to have a cognitive

understanding of the meaning of each type of sign to achieve their objective of navigating the airport pavement (Boy, 2000). This conveyance system can become quite complex. By changing the color of a background or the message lettering, the meaning of the sign changes entirely. The intricate mental processing a pilot's brain has to perform to interpret a sign is one that comes from education and experience.

History

At air carrier airports, long before any aircraft ever touched down on a runway, airport management and the Federal Aviation Administration (FAA) decided the layout of the field. Once this had been established, an airfield guidance sign plan needed to be conceived and approved (see Figure 1). The airport determines the (a) requirement, (b) size, and (c) location of each sign. Then, both the airport and the FAA sign off on the plan to become an official document that is part of the Airport Certification Manual (ACM). When the airfield is ready for operation, the pilot becomes the end user of this system.

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Figure 1. An example of a guidance sign plan.

Conventional design methods are based on goal-driven methods, i.e., designers start with an overall goal in mind and attempt to decompose this goal into sub-goals until basic actions can be derived and effectively preformed (Boy, 2000). These plans can become very complex, for each map shows the signage faces and orientation of every unit. As signs are added or deleted, the plan is reviewed by both parties and approved for revision. When a pilot travels down the taxiway and gazes at a guidance sign, it should be known that many people put a lot of time and thought as to why that sign should be there.

Sign Standardization

The FAA in their oversight role mandated that guidance signs be standardized. This implies that for any airport one visits in the United States, the message will have the same connotation. A properly designed and accepted sign arrangement is an essential component of any surface guidance control system, which increases the overall safety of the operation at an airport. A sign plan should (FAA, 2004):

- Provide the ability to easily determine the

designation or name of any taxiway on which the aircraft is located.

- Readily identify routes toward a desired destination.
- Indicate the mandatory hold positions, including hold positions used to maintain aircraft separation during low-visibility weather operations.
- Identify boundaries for approach areas, Instrument Landing System (ILS) critical areas, Precision Obstacle Free Zones (POFZs), and runway safety areas/obstacle free zones (OFZs).

On an airport there are two varieties of guidance signs (a) elevated and (b) surface painted. Both sign types are similar in appearance and have identical meaning. These assortments of differing signs are further broken down into six categories:

- Mandatory signs.
- Location signs.
-

Direction signs.

- Destination signs.
- Runway Distance remaining signs.
- Information signs.

The meaning and location of each brand of sign is specific. The complex processing of sign information comes from the fact that there are (a) three different background colors, (b) three letter colors, and (c) two colors for symbols. The blending of these elements increases the variety of messages that can be conveyed. A pilot must have a clear understanding of these color combinations to correctly understand the sign.

Information Processing

A problem faced by all mobile organisms is how to search their environment for resources (Goldstone & Ashpole, 2004). The concept of a cognitive function helps analyze how people and information-intensive systems may interact (Boy, 2000). The task for a pilot is to achieve an objective. This endeavor is obtained from the controller giving the aircraft a route to travel on the airfield. Guidance signs along the way help the pilot stay on course with their plan. The processing occurring in the pilot's head involves both the left and right brain hemispheres working separately on their selected bits of information. They come together by combining the data to attain a universal understanding. Each half of the brain has its own hemispherical specialization. The left-brain deals with logic and word meaning. The right

brain manages symbols and abstract concepts. This processing is done in nanoseconds so that almost instantaneously, the meaning of a guidance sign is realized. The brain is kept busy absorbing the intricacies of sign elements with the various combinations of letters, numbers, symbols, and color coding.

Education

Guidance sign messages are made to be as simple to read as possible. There is a reason for this. The use of perceptually rich, concrete symbols may hinder learning (Sloutsky, Kaminski, & Heckler, 2005). A pilot only has a few seconds to view a sign before moving on to another task. Therefore, knowledge gleaned from perceptually rich objects could be less portable than knowledge gleaned from more abstract, generic entities (Sloutsky, Kaminski, & Heckler, 2005). The solution is – the simpler the better. Symbols and verbiage kept to the most basic elementary componet, will convey the message in the small time allotted. The faster the information is comprehended, the more time there is for additional data segments to be processed which builds an increased awareness of the airport environment.

A discrimination effect also sets in as to the relevancy and irrelevancy of the information presented. People process pertinent information faster than incompatible data. A sign array is an example of this (see Figure 2).

Figure 2. Taxiway sign array.

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It shows the direction of turns that an aircraft can make to access different taxiways. If a pilot has a set plan, all other nonessential options are disregarded so that the objective can be achieved. Automatic selection comes into play, as a pilot makes a visual search for the sign with the information for which he/she is looking. Once that information is acquired, it is instantaneously acknowledged. This shows there is a mechanism that selects input on the basis of its similarity to the required action (Magen & Cohen, 2002).

Visual Working Memory

Almost all models that account for a visual search of data propose that working memory plays an important role in the enabling of efficient processing of search arrays (Woodman & Luck, 2004). Visual Working Memory (VWM) is made up of a combination of both Visual Short Term Memory (VSTM) and Visual Long Term Memory (VLTm). Once an item is selected by attention, an object file is created (Woodman & Luck, 2004). This object file, the goal being sought, becomes a criterion placed in Long Term Memory, which has a higher capacity for input. Pilots visually search the environment for signs matching their criteria. Each guidance sign searched is placed into a different memory location. This location is called Visual Short Term Memory (VSTM), and is used to retain visual information for up to a few seconds. This is all the time that is needed for the brain to decide if there is a match. If there is an affiliation, the pilot goes to the next objective element on the taxi list. If there is no relationship, the visual clue is disregarded. VSTM is highly limited in its capacity: only four simple objects and six spatial locations can be retained (Olson & Jiang, 2004). This limit remains constant for life in both the young and adults alike. Studies have sought ways to find out how to increase this capacity. VSTM is insensitive to being changed. It has fixed memory slots. Chunking is a way to improve its performance. With object-based chunking, multiple items can be remembered as a single, complex pattern, rather than as several isolated items (Olson & Jiang, 2004). VLTm may help VSTM with this associative process so as to reinforce chunking. By doing so, this increases the functional capacity of VSTM. The FAA made the chunking process easier by mandating all airports code taxiways with an alphabetic or alphanumeric system. This shortened guidance signs legends to one or two letter names. An example of this improvement occurred in the early 1990s. O'Hare Airport still had full word names for many of its taxiways. Taxiway names like (a) "Lake Shore Drive," (b) "North-South," (c) "Hanger Alley," and (d) the "Branch Taxiway," were not unusual. These names were shortened with abbreviations on sign faces, but to a novice they would be hard to interpret. In this instance, the process of Visual Working Memory decreased as the stimuli, or sign, becomes more complex.

Years of experience also aids a pilot in guidance sign scrutiny. Having a constant exposure to the runway and

taxiway environment help flight crews to more swiftly identify a guidance sign's meaning. This is because an elaborate file has been constructed in a pilot's Long Term Memory for quick association, making sign recognition spontaneous.

Sign Interpretation

As stated earlier, pilots have a task at the beginning and end of each flight to taxi the aircraft on the airport's movement area to its destination. Planning, monitoring, negotiating, supervising, communicating, and coordinating are all part of this process. One only has a few seconds to view a guidance sign, process the information, and understand the meaning. The mental models that the brain sifts through in comparing one sign to another is an ongoing selection process until a match occurs and the message is realized.

Stroop effect

The Stroop color-word task examines speed performance, usually naming, of an ink color embedded with a printed word. This typically spells out a color word or distracter dimension (Schmidt & Cheesman, 2005). Response times are slower if the color of the ink does not match the word color spelled out. It is like a mental hurdle the brain has to overcome to process the task. This is an example on a two-dimensional scale.

Figure 3 shows a set of runway and taxiway signs each having the same written message. The colors of the differing backgrounds and lettering give the sign different meanings. This is a multi-dimensional scale. It can tell the user a number of things: (a) what direction to Runway 5, (b) when you are about to go on to Runway 5, (c) when you are on Runway 5, and (d) the distance remaining on a runway which may or may not have any association to Runway 5. A pilot must go through a complex filtering process to arrive at to validate the sign's message. Sometimes, unusual signs show up that are used only in certain situations.

One such sign is displayed in Figure 3f, the mandatory hold short sign for Taxiway-S. This sign may cause some pilots to become confused. It is a sign used in conjunction with Land and Hold Short Operations (LAHSO) for a runway. LAHSO is an air traffic control procedure which permits the issuance of landing clearances to aircraft to land and hold short of an intersecting runway, taxiway, or other designated point on the runway. In this case, the landing pilot would hold short and not cross Taxiway-S, which intersects the runway if LAHSO operations were in effect.

Figure 3. Two sets of signs with the same display.

Colors

Colors are important in making a statement about the guidance sign. Sign panel background colors include (a) red, (b) yellow, and (c) black. Each color denotes a different message. Red signs denote mandatory compliance is necessary before entering a runway environment or not entering a unidirectional taxiway. Yellow signs are informative, giving directions, destinations, locations, or make a statement to the pilot. Black signs inform pilots of

location or the distance remaining. Color is very useful in separating signs. In a long sign array, a color change in a sign panel or a message divider denotes a different sign message, even though it is still part of one unit (see Figure 2). This makes multiple messages readable in one location instead of having an individual sign for each message. Color can enhance a sign's message. It can make the message stand out (see Figure 4).

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Figure 4. An example of sign enhancement.

Color can also cause confusion. As already stated, color can be used to separate attached sign panels with different messages with the use of a message divider. In some cases this color change has to be ignored. Figure 5 is an example of this. The perceived black separator is actually the end of two small signs module units abutting each other

to cause an illusion that there are two messages. This is probably due to the fact that the wrong module boxes were ordered for that location, and the airport made due with what they had on hand. When one comes near the sign, it is easy to ignore the black outer casing so that the message can be understood.

Figure 5. Scenic pad sign.

Another example of this confusion is in the black panel squares used to fill up an extra-unused sign space. They are also used to cover the back of a two-sided sign when there is no message to be displayed. When one sees a blacked out panel, that sign section is to be ignored (see Figure 6).

Most sign messages associated with a runway have white lettering. This would go hand and hand with the metrics of pavement markings. White paint means you are on a runway. Yellow paint indicates you are on a taxiway. A runway location sign, which has a yellow message on a black background, gives the illusion of being on a taxiway,

but in actuality one is on a runway (see Figure 3c). This sign is the exception. If it had a white message, it may be confused with a runway distance remaining marker because the two are very similar (see Figure 3d).

The message

Guidance sign messages are made to be as simple to understand as possible. The sign is read from left to right. Messages beginning with a number usually denote a reference to a runway. Letters denote a taxiway. Symbols show a location, connection, or what not to do, such as the "No Entry Sign." The message can be confusing for a number of reasons.

Figure 6. Black panels.

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First the message has to be read as a whole. Sign panels can only hold so many characters before a connecting rib is inserted and another panel is attached to continue the message. One message may be stated over a number of panels. Also, Figure 5 demonstrated a different problem that has already been discussed. The pilot needs to view the message as one whole statement and not read to where connections or separations exist (see Figure 7).

Second, because the message may be labeled over a number of panels the kerning may be distracting. The span between the joints may cause the lettering to be spaced

improperly for the message to be understood. The pilot may have to fixate on the sign for a while, before it can be interpreted correctly.

Third, airports may run out of single taxiway designators if they have a complex layout. They may have to use double or even triple lettering to name the taxiways. These identification schemes should not be confused with alphabetic signs used in the abbreviations for such things as (a) ILS, (b) MIL, (c) PAX, and (d) FBO, for these acronyms have very specific meanings associated to them.

Figure 7. Bad kerning on a sign.

Fourth, as stated earlier, numbers usually make reference to a runway but can mean the distance remaining on a runway when the color of the number is altered (see Figure 3d). Changing the color of the number totally modifies the meaning of the sign. One has to be very careful in discerning the subtle differences in numeric signs.

Symbols

A symbol is a graphical representation that is associated with the identification of an object, idea, or a form of connection. They are processed in the brain at a faster rate than words. This picture association causes the brain to link a meaning to the abstract item which then creates a form of understanding to occur. As a stand alone item, a symbol can make a functional statement or it can be used as a bridge to bring two sign elements together. For the experienced pilot, the interpretations of symbols that are used in signs are done effortlessly. Compared with someone

new to aviation, they may bring mental models that have been established from the outside world which may interfere with the true meaning. Figure 8 displays six graphics that are approved for use in the airport environment. The “ILS Critical Area Boundary” sign (see Figure 8a), looks like a train track symbol, or the “No Entry” sign (see Figure 8b), looks like the symbol for a standard slotted screwdriver tip at the local hardware store. Those mind frames have to be broken for the pilot to correctly perceive the aviation environment. This is why training is so important in aviation. The learning process corrects those misperceptions so that the true meaning can be perceived. Once understanding has been established, the speed at which the message that the symbol conveys increases dramatically. It comes to a point where a glance is all that is needed.

Symbol usage has the same importance as color differences. The shape of the symbol correlates to different

concepts. A dash (-), dot (●) or an arrow (→) used in a guidance sign have separate meanings, but all are related to one another in their readability. ILS Critical Area Boundary sign (see Figure 8a), No Entry sign (see Figure 8b), Runway Boundary sign (see Figure 8c), and Taxiway End marker (see Figure 8d) are all statement signs. They tell the pilot a number of things, such as (a) what area they are leaving, (b)

what area not to enter, or (c) the taxiway is ending. Symbols break the language barrier, just as numbers do, for they both have a similar commonality. Once the meaning of a symbol is known, it does not have to rely on letters or spelling to convey the message. It is an international communication tool that is universally accepted and understood.

Figure 8. Symbols used in guidance signs.

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Sign reading

A mandatory runway hold sign is read with the corresponding number of the runway threshold end to be on the same side as it relates to the sign (see Figure 9). The runway end that is on the right will be shown to be on the sign's right, and the one on the left will be displayed to the left. Confusion may occur when communicating with the FAA tower. A pilot has to mentally shift gears when viewing this sign, for this system of displaying information

must be disregarded for one that only uses a portion of the information presented. The pilot merely uses the runway designator that is being utilized in the direction of landing or departure. The sign gives more information than is needed at any one time, but the flexibility that the system presents does so with a minimum amount of verbiage. It is the pilot who must adapt and select the correct information segment when confronted with this display.

Figure 9. Mandatory runway hold sign.

The mandatory hold sign for a runway approach area does not follow the fore mentioned logic, as related a mandatory runway hold sign (see Figure 10). Even though the two signs are presented in the same manner, they do not have the same meaning or readability. The ideology of "what is left is left" and "what is right is right" does not apply to this sign. The thought of being on the Runway 32L approach threshold, which the sign implies, is also incorrect. The sign's meaning is that one is about to taxi into the approach airspace behind Runway 32L. The airport's pavement geometry plays a major factor in the use of this sign.

Syntax

At the beginning of a pilot's career, one starts with

the A-B-Cs. The phonetic alphabet is learned, memorized, and used. It is a standard that is applied to many things. It is also applies to guidance signs, half of the time. Taxiway signs which include the letters such as "L," "R," and "C" follow the coding in the naming scheme of Lima, Romeo, and Charlie. Runway guidance signs break this rule with the associated names of Left, Right, and Center. The runway naming metrics that apply here is location-location-location. Parallel runways are named for being left, right, or in-between (center) the other runway(s). There are other letters such as "I," "O," and "X" that will never be used in a guidance sign system for naming taxiways. They could be confused for such things as the number one (1), zero (0), and the symbol for closed pavement (X).

Figure 10. Mandatory runway approach area sign.

Miscellaneous

Outside influences can cause ambiguity in a sign due to a number of reasons. One factor is normal wear and tear. Jet aircraft produce an enormous amount of thrust. These forces can have a detrimental affect on a sign (see Figure 11). The panels used in a sign do break or get blown

out. The jet blast may even completely knock down a sign due to its frangibility. These factors have the negative effect and interfere with the overall message. Even the corrective action of putting black panels in, as a substitute for the damaged card, hinders the understanding of the sign until the appropriate replacement can be inserted.

Figure 11. Damaged sign from jet blast.

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Another factor causing message interference comes from nature itself. Weeds, vegetation, and snow in front of and around a sign mask the content and significance of the information. These situations are easily corrected. Regular maintenance is required around a sign to keep the area clear. Constant inspections are necessary to check the sign's readability (see Figure 12).

Summary

The cognitive processing the brain must go through is complex when dealing with airport guidance signs. Simple letters, numbers, and symbols are used, combined, and color-coded to produce a logical visual road map at each airport. The problem with this system is that there are exceptions to all the rules. A pilot's ability for understanding a sign's meaning must go through an intellectual filtering process that sorts the elements until a match is found.

Figure 12. Weeds in front of a sign.

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Experience and training builds up this internal aptitude file, so that in a mere fraction of a second, recognition and comprehension is obtained. As with any established system, rules and regulations need to be learned, exceptions need to be recognized, and unique applications understood. The guidance sign system is an information methodology that conveys where you are, where to go, and what to do. The

FAA has standardized signs to assist with universal awareness. Pilots need to adapt and understand the complex mental models that form from simple object groupings so an instantaneous recognition is achieved. Once a pilot has a clear understanding of the guidance sign dynamics, movement on the airport will be improved.➔

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