Low Visibility Operations/Surface Movement Guidance and Control System (LVO/SMGCS) Chart Symbology

Andrea L. Sparko, MA[1]

Stephanie G. Chase, PhD[1]

Michelle Yeh, PhD[2]

Bruce McGray, MSNRM, MPA, ATP[2]

[1] U.S. Department of Transportation
Office of the Secretary of Transportation
John A. Volpe National Transportation Systems Center
Cambridge, MA

[2] U.S. Department of Transportation
Federal Aviation Administration
Washington, D.C.

Final Report — February 2016

DOT-VNTSC-FAA-16-05
DOT/FAA/TC-16/25

Prepared for:

Federal Aviation Administration
NextGen Advanced Concepts and Technology Development Directorate
Human Factors Division, ANG-C1
Washington, D.C. 20591

U.S. Department of Transportation
John A. Volpe National Transportation Systems Center

Notice

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for the contents or use thereof.

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the objective of this report.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	February 2016	Final Report

4. TITLE AND SUBTITLE
Low Visibility Operations/Surface Movement Guidance and Control System (LVO/SMGCS) Chart Symbology

5a. FUNDING NUMBERS
FAN2C4; FAN2C5

6. AUTHOR(S)
Andrea L. Sparko, MA; Stephanie G. Chase, PhD; Michelle Yeh, PhD; and Bruce McGray, MSNRM, MPA, ATP

5b. CONTRACT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Department of Transportation
Office of the Secretary of Transportation
John A. Volpe National Transportation Systems Center
Cambridge, MA 02142-1093

8. PERFORMING ORGANIZATION REPORT NUMBER
DOT-VNTSC-FAA-16-05

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Department of Transportation
Federal Aviation Administration
NextGen Advanced Concepts and Technology Development Directorate
Human Factors Division, ANG-C1
800 Independence Avenue, SW
Washington, D.C. 20591

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
DOT/FAA/TC-16/25

11. SUPPLEMENTARY NOTES
Program Managers: Dr. Katrina Avers, Regina Bolinger, and Dr. Thomas McCloy

12a. DISTRIBUTION/AVAILABILITY STATEMENT

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)
This study examined which symbol shapes are considered to be representative of information shown on Low Visibility Operations/Surface Movement Guidance and Control System (LVO/SMGCS) charts, and how useful pilots perceive that information to be. The information in this report is intended to provide data to the Federal Aviation Administration (FAA) to identify best practices for LVO/SMGCS charts. One-hundred forty-four air transport pilots with category-III qualification and/or LVO/SMGCS training were shown symbol shapes that included symbols currently in use on LVO/SMGCS charts, symbols recommended for LVO/SMGCS charts by the International Civil Aviation Organization, and "foil" (fake) symbol shapes that are not in use. For each symbol shape, pilots responded "Yes" or "No" to whether they considered the symbol shape to be representative of a particular information type. Symbol shapes were presented alone as well as at increasing levels of context to examine whether additional airport-layout chart information helped pilots identify representative symbol shapes. Once pilots identified representative shapes, they rated the usefulness of various types of information depicted on LVO/SMGCS charts. Pilots identified real symbols as representative for geographic position markings (GPM), instrument landing system (ILS) hold lines, and the combination of runway guard lights (RGL) *and* stop bar lights. The majority of pilots rated the following information types to be *very useful*: GPM, clearance bar, ILS hold line, approach hold line position marking, stop bar lights, RGL, and the combination of RGL *and* stop bar lights. It is important to note that these ratings were made without operational context. Regardless of pilot ratings, all the information types in the study play a unique role in supporting LVO/SMGCS operations.

14. SUBJECT TERMS
Low Visibility Operations/Surface Movement Guidance and Control System; LVO/SMGCS; Charts; Symbology

15. NUMBER OF PAGES
56

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
oz	ounces	28.35	grams	g
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
mL	milliliters	0.034	fluid ounces	fl oz
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
g	grams	0.035	ounces	oz
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	Kilopascals	0.145	poundforce per square inch	lbf/in^2

***SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)**

Contents

List of Figures

List of Tables

List of Abbreviations

Abbreviation	Term
AC	Advisory Circular
AIM	Aeronautical Information Manual
ALPA	Air Line Pilots Association
ATP	Air Transport Pilot
CAT	Category
CFR	Code of Federal Regulations
DOD	Department of Defense
EASA	European Aviation Safety Agency
FAA	Federal Aviation Administration
GPM	Geographic Position Marking
ICAO	International Civil Aviation Organization
IFALPA	International Federation of Air Line Pilots' Associations
ILS	Instrument Landing System
IRB	Institutional Review Board
LVO/SMGCS	Low Visibility Operations/Surface Movement Guidance and Control System
LVP	Low Visibility Procedures (ICAO/EASA low visibility program similar to LVO/SMGCS)
NACO	National Aeronautical Charting Office
RGL	Runway Guard Lights
RVR	Runway Visual Range
SME	Subject Matter Expert

Preface

This technical report was prepared by the Aviation Human Factors Division at the John A. Volpe National Transportation Systems Center. This research was completed with funding from the Federal Aviation Administration (FAA) Human Factors Division (ANG-C1) in support of the Flight Operations Branch (AFS-410).

We would like to thank our FAA program managers Dr. Katrina Avers, Regina Bolinger, and Dr. Thomas McCloy, as well as our technical sponsors, Bruce McGray and Terry King. We would also like to thank Andrew Burns, Randy DeAngelis, Sean Flack, and Philip Saenger for their help and advice with this project. Thank you to Katarina Morowsky and Andrew Kendra of the Volpe Center Aviation Human Factors Division for their assistance with study design and administration. Also thank you to the International Civil Aviation Organization (ICAO) Operations Panel, Air Line Pilots Association (ALPA), International Federation of Air Line Pilots' Associations (IFALPA), and FedEx who helped to publicize this study and recruit participants. We also appreciate those participants who told their colleagues about the study and helped us recruit additional pilots.

The views expressed herein are those of the authors and do not necessarily reflect the views of the Volpe National Transportation Systems Center or the United States Department of Transportation.

Executive Summary

This study examined which symbol shapes are considered by properly-qualified air-carrier line pilots to be representative of information shown on Low Visibility Operations/Surface Movement Guidance and Control System (LVO/SMGCS) charts, and how useful those pilots perceive that information to be. Results are intended to provide input to the Federal Aviation Administration (FAA) regarding best practices for LVO/SMGCS charts, as well as International Civil Aviation Organization (ICAO)/European Aviation Safety Agency (EASA) versions of those charts under Low Visibility Procedures (LVP) programs.

In this study, 144 air transport pilots with category-III qualification and/or LVO/SMGCS training completed a questionnaire consisting of two parts:

1. *Symbol Shape Representativeness task.* Pilots were shown 60 symbol shapes, including symbols currently in use on LVO/SMGCS charts, symbols recommended for use by ICAO, and fake "foil" symbol shapes that are not currently in use to represent the information type in question. The symbol shapes represented seven information types depicted on LVO/SMGCS charts: geographic position markings (GPMs), clearance bars, instrument landing system (ILS) hold lines, runway guard lights (RGL), stop bar lights, the combination of RGL *and* stop bar lights, and non-movement area boundary markings. Pilots were asked whether they considered each symbol shape to be representative of a given information type. Pilots saw each symbol shape first with no context (i.e., on a white background) and then at increasing levels of airport-layout chart context.
2. *Information Type Usefulness task.* Pilots rated the usefulness of nine information types, including the seven examined in the first task, plus approach hold line position markings and apron holding line up points.

Pilots identified real symbol shapes as representative for only three of the seven information types, as shown in the table below. These symbol shapes were considered representative of the information type regardless of context.

Representative Real Symbol Shapes by Information Type

Information Type	Symbol Shapes
GPM	
ILS hold line	
Combination of RGL *and* stop bar lights	

In addition to the real symbol shapes, some foil symbol shapes were considered representative for RGL, stop bar lights, and GPMs, particularly when context was provided. The use of foil symbol shapes in this study should not be interpreted as an endorsement for using these shapes on LVO/SMGCS or LVP charts. Rather, we use these data to capture key attributes about an information type that may contribute to a perception of representativeness.

The majority of pilots rated the following seven information types to be *very useful*: GPMs, clearance bars, ILS hold lines, RGL, stop bar lights, the combination of RGL *and* stop bar lights, and approach hold line position markings. Most pilots rated non-movement area boundary markings as *somewhat useful*. Pilots rated apron holding line up points to be *very useful* and *somewhat useful* equally. It is important to note that these ratings were made without operational context; that is, each of these information types plays a specific and unique role in supporting LVO/SMGCS operations.

1. Introduction

The U.S. Department of Transportation's Volpe Center is supporting the Federal Aviation Administration (FAA) in gathering data to identify best practices for the design of Low Visibility Operations/Surface Movement Guidance and Control System (LVO/SMGCS) charts, as well as for International Civil Aviation Organization (ICAO)/European Aviation Safety Agency (EASA) versions of such charts under international Low Visibility Procedures (LVP) programs. LVO/SMGCS, and systems under ICAO/EASA LVP, are systems of enhanced procedures and visual aids intended to improve the safety of airport surface operations during low visibility conditions at less than runway visual range (RVR) 1,200 ft/350 m for LVO/SMGCS, and under 1,800 ft/550 m for LVP operations within ICAO states. All airports that operate under LVO/SMGCS or LVP must have LVO/SMGCS or LVP charts to illustrate these procedures and the pertinent visual aids (FAA, 2012a). Symbol shapes used on LVO/SMGCS charts vary across different chart providers and airports. Moreover, many pilots rarely operate in LVO/SMGCS conditions, so symbol shapes must be as easy to recognize and understand as possible, because for many aircrews they are viewed infrequently.

The FAA requested that the Volpe Center conduct a study to gain a better understanding of the representativeness of symbol shapes that may be used to depict information on LVO/SMGCS and LVP charts. This project is part of a coordinated effort between the FAA and ICAO to develop recommendations for LVO/SMGCS and LVP symbology. The study had two objectives. The first was to identify which symbol shapes pilots considered to be representative of information types shown on LVO/SMGCS charts. The second objective was to obtain pilots' opinions on the usefulness of information types commonly depicted on LVO/SMGCS charts.

Section 2 of this report describes the methods used. Section 3 presents the results, starting with the Symbol Shape Representativeness Task and followed by the Information Type Usefulness task. Section 4 provides a summary of the results and conclusions.

2. Methods

2.1 Participants

Participants were recruited using fliers distributed in coordination with the FAA, the Air Line Pilots Association (ALPA), and individual airlines. Requests for international participants were presented to the ICAO Operations Panel and the International Federation of Air Line Pilots' Associations (IFALPA) by the AFS-400 sponsors. Participants were required to be air transport pilots (ATP) with category (CAT)-III qualified experience (preferably for at least five years) or military pilots with LVO/SMGCS training. To compensate participants for their time, 50 of the volunteers who participated in the study were chosen via a random drawing to receive a $50 gift certificate to Amazon.com.

One-hundred eighty-two pilots agreed to participate in the study by signing an online informed consent form; then, via a separate e-mail, those pilots received a link to the online survey. Of the 182 pilots who signed the informed consent form, 144 pilots (137 males, 7 females) completed the questionnaire, and only the data from these 144 pilots were included in this report. Pilots' experience is summarized in Tables 1-3.

Table 1 shows pilots' experience in terms of flight time. Pilots had a median of 11,000 total flight hours, with a median of 50 hours flown in the past month. Pilots had a median of 13 years of CAT-III experience; 128 pilots had at least 5 years of experience. The 16 pilots who had fewer than 5 years (including 5 pilots with 0 years CAT-III) had at least some hours of LVO/SMGCS or LVP experience in an airplane and/or simulator. Across all 144 pilots, there was a median of 15 hours of LVO/SMGCS or LVP experience in an airplane and 30 hours in a flight simulator. In terms of low visibility surface operations, pilots had a median of 9 hours between RVR 1,200 ft/350 m and 600 ft/175 m and 2 hours below RVR 600 ft/175 m.

Table 1. Summary of Pilots' Flight Time

Type of Flight Time Experience	Average	Median	Range
Total flight hours	11,691	11,000	1,000-28,000*
Total flight hours in the last month	61	50	0-400
Years of CAT-III qualification	14	13	0-30**
LVO/SMGCS or LVP flight hours (excluding simulator)	102	15	0-5,000
LVO/SMGCS or LVP simulator hours	103	30	0-2,000
Hours of surface operations between RVR 1,200-600 ft/350-175 m	70	9	0-3,800
Hours of surface operations under RVR 600 ft/175 m	43	2	0-4,000

*One pilot indicated (s)he had125,000 total flight hours; this was considered an error and not included here.
**One pilot indicated (s)he had 40 hours of CAT-III qualification; this was considered an error and not included here.

Pilots were also asked to indicate their international flying experience by selecting one or more of the following options:

- U.S. pilot with domestic routes in the U.S.
- U.S. pilot with international routes
- European pilot with domestic routes in Europe
- European pilot with international routes
- "Other" international experience

As shown in Table 2, the majority (129 out of 144) of participants were U.S. pilots, 114 of whom indicated they flew internationally. Eight European pilots flew both domestic (Europe) and international routes. Seven pilots had "other" international experience.

Table 2. Summary of Pilots' International Experience

Domestic/International Experience	Number of Pilots
U.S. pilots	*Total: 129*
Domestic (U.S.) route(s) only	15
International route(s) only	37
Domestic & international routes	74
Domestic routes with international military experience	3
European pilots	*Total: 8*
Domestic (Europe) route(s) only	1
Domestic (Europe) & international routes	7
Pilots with "other" international experience	*Total: 7*
Military international experience only (1 in Europe, 1 unspecified)	2
Asian pilot	2
Japanese pilot	1
Canadian pilot	1
Oceanic (Australia)	1

Pilots were asked to indicate which charts they use most often. The question addressed general chart use, not chart use specific to LVO/SMGCS or LVP operations. As shown in Table 3, the majority of pilots (134 out of 144) used Jeppesen charts most often, and they had an average of 13.9 years of experience with Jeppesen charts. Eighteen of these Jeppesen users also regularly used charts from other chart providers: 11 used Lido charts in addition to Jeppesen, 6 used National Aeronautical Charting Office (NACO) charts (1 of these pilots used both Lido and NACO charts regularly), and 2 pilots used U.S. Department of Defense (DOD) charts regularly. The remaining 10 of the 144 pilots included 7 who used Lido charts most often (1 who also used Jeppesen charts regularly), with an average of 4.7 years of experience using Lido charts; 2 pilots who exclusively used NavTech/Aerad charts, with 2 and 18 years of experience, respectively; and 1 pilot who exclusively used NACO charts with 31 years of experience. Pilots were also asked to indicate whether they used paper and/or electronic charts. Fifty-one pilots selected paper charts, 64 selected electronic charts, and 26 selected both paper and electronic charts (3 pilots left the question blank).

Table 3. Summary of Pilots' Experience with Charts from Several Chart Providers

Chart Provider Used Most	Other Chart Providers Used Regularly	Number of Pilots
Jeppesen		*Total: 134*
	None	116
	Lido	10
	NACO	5
	Lido & NACO	1
	DOD	2
Lido		*Total: 7*
	None	6
	Jeppesen	1
NavTech/Aerad		*Total: 2*
	None	2
NACO		*Total: 1*
	None	1

2.2 Tasks

The study was conducted using a two-part questionnaire: *(1) Symbol Shape Representativeness task* and (2) *Information Type Usefulness task*. Both tasks gathered pilot opinions, so there were no right or wrong answers. The tasks are described in the following sections.

2.2.1 Symbol Shape Representativeness Task

The goal of the Symbol Shape Representativeness task was to identify which symbol shapes are representative of particular information types that are commonly depicted on LVO/SMGCS charts. Symbol shape representativeness was examined with and without context to determine whether the symbol shape was representative on its own or whether additional airport-layout chart information was needed. If a symbol shape was considered representative only with context, this would suggest that the symbol shape was not representative on its own, and that other charting cues (e.g., symbol shape location) are needed to give meaning to the symbol shape.

The Symbol Shape Representative task addressed seven information types, defined in Table 4. The information types were chosen by FAA LVO/SMGCS subject-matter experts (SMEs) to be an important starting point for addressing LVO/SMGCS chart symbology. The definitions for each information type are provided below for reference only; these definitions were not provided to pilots during the Symbol Shape Representativeness task. The definitions were developed using information from Advisory Circular (AC) 120-57A (FAA, 1996) and the FAA's Aeronautical Information Manual (AIM; FAA, 2012b) as well as input from FAA LVO/SMGCS SMEs.

Table 4. Information Types Examined in the Symbol Shape Representativeness Task

Information Type	Definition
Geographic position marking (GPM)	Pavement marking used to verify aircraft position, also used as a specific taxi clearance geographic location
Clearance bar	Lights at the holding position of a taxiway/taxiway intersection
Instrument landing system (ILS) hold line	Pavement marking indicating a holding position at the boundary of an ILS critical area
Runway guard lights (RGL)	Yellow lights at the runway hold short point position of a taxiway/runway intersection, indicating the presence of an active runway
Stop bar lights	Red lights at the holding position of a taxiway or runway intersection, used to indicate clearance to enter a runway when turned off. Also used at non-usable taxiway/runway intersections as a non-crossable blocking stop bar
Combination of RGL *and* stop bar lights	Collocated RGL and stop bar lights
Non-movement area boundary marking	Pavement marking outlining the boundary of an area not under air traffic control

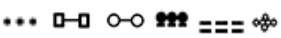
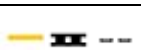
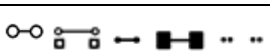
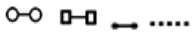
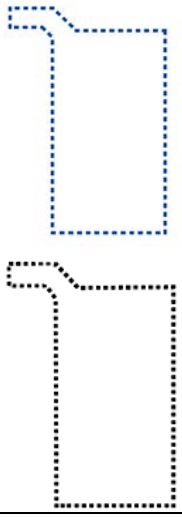
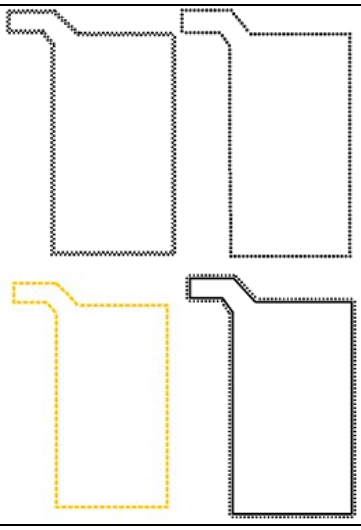
For each information type, pilots were shown symbol shapes and asked to respond "Yes" or "No" to whether they considered each symbol shape to be representative of the information type. The symbol shapes presented for each information type are shown in Table 5. Note that the non-movement area boundary marking was included in this task, although it is a linear pattern rather than a symbol; that is,

the shape of the non-movement area boundary marking varies depending on the shape of the designated area on the airport surface.

A symbol shape could be a real symbol or a "foil." Real symbols were defined as those depicted on LVO/SMGCS charts, FAA prototype LVO/SMGCS charts, or contained in ICAO recommendations for LVO/SMGCS charts (ICAO, 2009). Foil symbol shapes were defined as those shapes that are not currently used on LVO/SMGCS charts to represent the information type in question. The foil symbol shapes were intended to be similar in appearance to real symbols. In some cases, a foil could be a symbol shape that is used to represent other information types. The use of foil symbol shapes was intended to determine whether pilots were discriminating among symbol shapes. Additionally, pilot opinions of foil symbol shapes could show whether pilots accepted variations in symbol shape features (e.g., line thickness or shading) to represent the same information type as long as the shape was consistent (e.g., all squares).

There were 60 symbol shapes in total. Twenty-seven of the 60 symbol shapes were real symbols; the others were foils. Because some real symbols were drawn in color, black-and-white versions of these symbols were added to the symbol set to understand whether the color of the symbol shapes contributed to their representativeness. The black-and-white versions were considered real symbols.

Table 5. Symbols Shapes Presented for Each Information Type

Information Type	Real Symbols	Foil Symbol Shapes
Geographic position marking (GPM)		
Clearance bar		
Instrument landing system (ILS) hold line		
Runway guard lights (RGL)		
Stop bar lights		
Combination RGL *and* stop bar lights		
Non-movement area boundary marking[1]		

[1] Note that the shape of a non-movement area boundary marking symbol will vary depending on the shape of the designated area on the airport surface. In this case, the real non-movement area symbols depict linear patterns that are currently in use by manufacturers and chart providers.

Each symbol shape was shown with increasing levels of context. Most of the information types were shown at four context levels as shown in Figure 1, with each level building on the previous level:

Level 1: Symbol shape shown on a white background

Level 2: Symbol shape shown with a single taxiway

Level 3: Symbol shape shown with adjacent taxiways and runways

Level 4: Multiples of the same symbol shape, shown with adjacent taxiways and runways

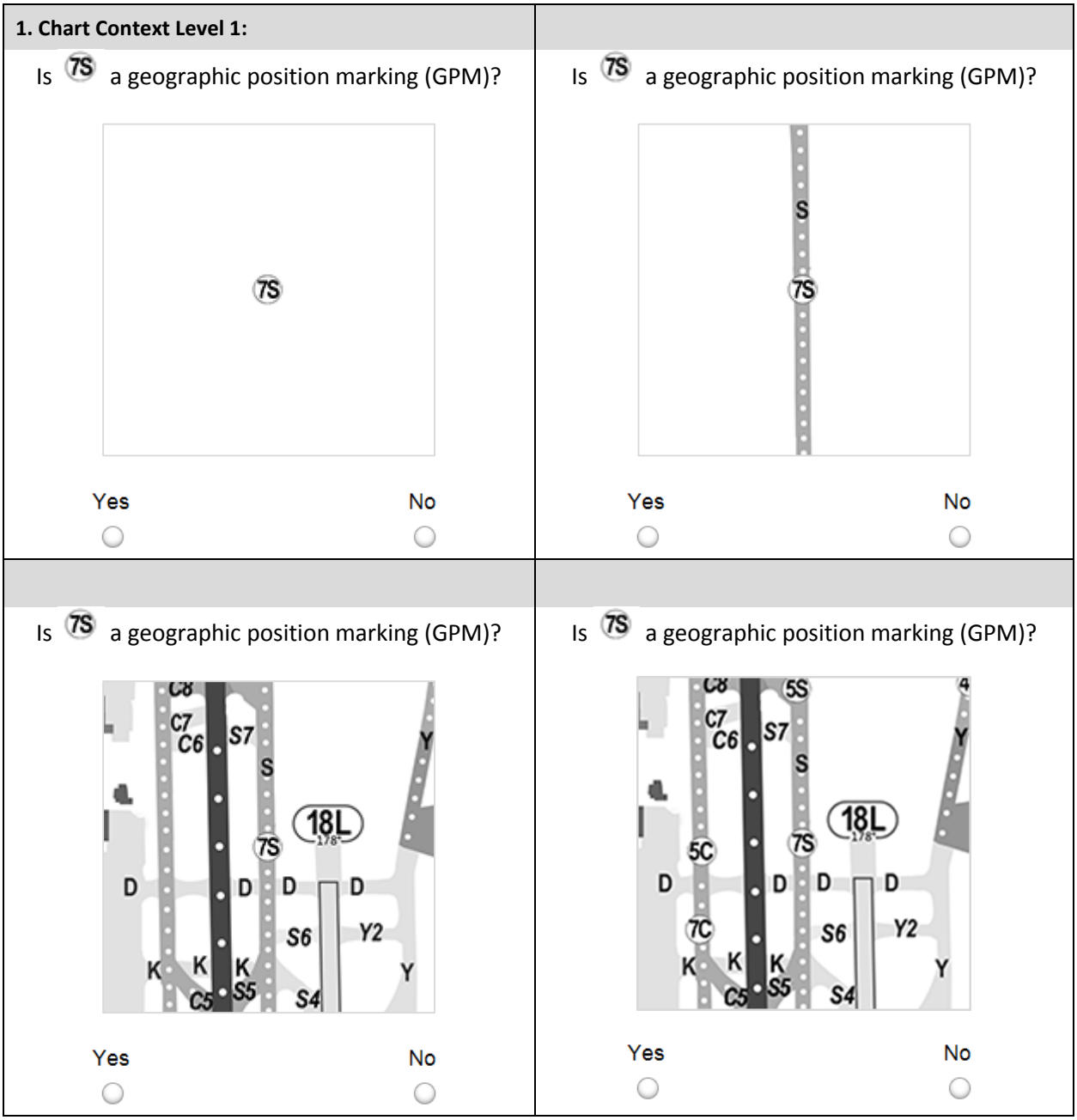


Figure 1. Example of a Symbol Shape Representativeness Task Trial for GPM

There were two exceptions to the use of four context levels described above. One was for clearance bars, for which we added a fifth context level that showed GPM symbol shapes with adjacent taxiways and runways. This fifth context level was included because clearance bar and GPM symbol shapes are usually collocated on charts, and we wanted to understand whether the presence of GPMs helped a symbol shape appear more representative of a clearance bar. The other exception was for non-movement area boundary markings, which were depicted in this study as an area around cargo parking ramps. The non-movement area boundary markings were shown with only three context levels: (1) the non-movement area boundary marking without context, (2) the non-movement area boundary marking depicted around an area labeled as a cargo ramp, and (3) the non-movement area boundary marking around a cargo ramp with adjacent taxiways and runways. Since the non-movement area boundary marking symbol shapes do not overlay single taxiways and runways on charts, some of the context levels used for the other information types did not apply. Note that non-movement area markings depict a boundary, so the shape may not be as important as the line format (e.g., dashed or dotted).

All context levels were shown within the same size frame (2 inches x 2 inches) with a gray border. For level 1, which had no context, the symbol shape was centered inside a 2 inch x 2 inch square of white space surrounded by a gray border. The chart background used to provide context was based on FAA prototype LVO/SMGCS charts. The chart background changed for each information type, but it was the same for all symbol shapes within an information type (e.g., all GPM symbol shapes were shown on the same chart background). Each context level was shown on a separate page.

To minimize time to complete the questionnaire, two symbol sets were used in this study, with each pilot viewing only one set. Each symbol set was comprised of approximately half of the 60 symbol shapes and contained a mix of real symbols and foil symbol shapes. The number of foil symbol shapes shown for each information type was always less than or equal to the number of real symbols for that information type. To minimize order effects, the order of the questionnaire items was counterbalanced across pilots.

2.2.2 Information Type Usefulness Task

Pilots were asked to rate the usefulness of nine information types. Seven were the ones examined in the Symbol Shape Representativeness task (see Table 4). The other two were:

- Approach hold line position marking: Pavement marking indicating a holding position at the boundary of a protected approach hold containment area for a runway
- Apron holding line up point: Pavement marking indicating a holding position at the boundary of an apron, parking ramp, located close to where aircraft cross into the movement area (for ICAO/EASA the manoeuvering area.)

All nine information types were provided in a table with definitions. An excerpt from the table is provided in Figure 2. The definitions provided to the pilots are in Table 6.

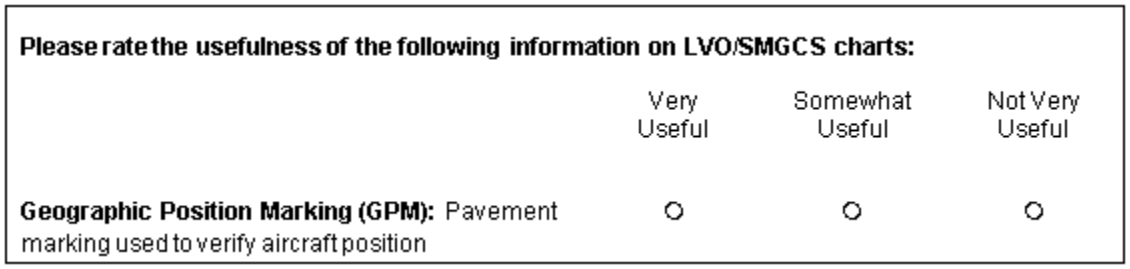


Figure 2. Excerpt from the Information Type Usefulness Task

Table 6. Information Type Definitions Provided in the Information Type Usefulness Task

Information Type	Definition
Geographic position marking (GPM)	Pavement marking used to verify aircraft position
Clearance bar	Lights at the holding position of a taxiway/taxiway intersection
Instrument landing system (ILS) hold line	Pavement marking indicating a holding position at the boundary of an ILS critical area
Runway Guard Lights (RGL)	Lights at the runway hold short point position of a taxiway/runway intersection, indicating the presence of an active runway
Stop bar	Lights at the holding position of a taxiway or runway intersection, used to indicate clearance to enter a runway when turned off
Combination RGL *and* stop bar	Collocated RGL and stop bar
Non-movement area	Pavement marking outlining the boundary of an area not under air traffic control
Approach hold	Pavement marking indicating a holding position at the boundary of a protected approach hold containment area for a runway
Apron holding point	Pavement marking indicating a holding position at the boundary of an apron

2.3 Procedure

There were two versions of the questionnaire: online and in-person. One-hundred five U.S. and international pilots completed the online version. To verify that the online results were reliable (e.g., that pilots were not consulting charts to identify symbols) and to gather response time data for pilots' opinions of representativeness, we also conducted an in-person version of the online study, in which 39 pilots participated.

Before participating in the study, pilots read and signed an informed consent form (see Appendix A) as required by the Institutional Review Board (IRB) for human-subjects research.

For the online version, interested pilots who contacted the Volpe Center were first sent a link to an online informed consent form to read and provide their electronic signature. Once the research team received the signed informed consent form, a researcher sent the pilot a link to the online questionnaire. The online questionnaire was administered via Survey Monkey (www.surveymonkey.com). The entire questionnaire was completed online through a single hyperlink. Pilots completed the online questionnaire at their leisure and on a device of their choosing (e.g., laptop, desktop, tablet computer). The entire online questionnaire took approximately 45 minutes to complete.

For the in-person version, pilots read and signed a paper informed consent form before completing the questionnaire. The questionnaire was administered on a laptop via E-Prime 2.0 Professional. The entire in-person questionnaire took approximately 30 minutes to complete (the question format on the in-person version may have enabled quicker responses; see Appendix D for examples of both questionnaire versions).

Pilots completed the following for both versions of the questionnaire (in order):

- Study introduction (see Appendix B)
- Background questionnaire (see Appendix C)
- Symbol Shape Representativeness task (see Appendix D for example)
- Information Type Usefulness task (see Appendix E)
- General feedback/comments (if they had any) on LVO/SMGCS or on the questionnaire itself (see Appendix F)
- Study summary (see Appendix G)

3. Results

3.1 Symbol Shape Representativeness Results

Initial analyses showed a high correlation between pilot responses on the online version and the in-person version of the questionnaire ($r = .88$, $p < .001$), so the data from both versions (105 online and 39 in-person pilots) were combined in the analyses described below. The exception was the response time data, which were only recorded for the in-person version.

Pilots' identifications of each symbol shape were examined using statistical tests that compared the number of pilots who considered a symbol shape to be representative ("Yes") to the number of pilots who did not ("No") at each context level. The results were considered statistically "significant" if there was a low probability (< 5%) of those results occurring by chance (e.g., if pilots were guessing). The results of the statistical tests allowed us to categorize the symbol shapes into three groups:

- *Representative*: symbol shapes that received significantly more "Yes" responses than "No" responses, indicating that pilots generally felt the symbol shape was representative of the information type it was shown to depict
- *Mixed*: symbol shapes that received a mix of "Yes" and "No" responses; that is, approximately half of the pilots felt that the symbol shape was representative and approximately half felt it was not representative
- *Not representative*: symbol shapes that received significantly more "No" responses than "Yes" responses, indicating that pilots generally felt the symbol shape was not representative of the information type it was shown to depict

We conducted this analysis for each level of context. We expected that as more context was added, pilots would be better able to judge whether symbol shapes were representative or not.

Response times were analyzed to better understand pilots' responses to real symbols versus foil symbol shapes. A faster response to real symbols might indicate that pilots have an implicit understanding of the symbols' meaning.

A detailed description of the statistical tests and the results are provided in Appendix H. In the following sections, we summarize the results of the Symbol Shape Representativeness task for each information type:

3.1.1 Geographic Position Marking (GPM)

3.1.2 Clearance Bar

3.1.3 ILS Hold Line

3.1.4 Combination RGL *and* Stop Bar Lights, RGL, and Stop Bar Lights

3.1.5 Non-movement Area Boundary Marking

Following the results for each information type, we provide a summary of the analysis on the response time data (section 3.1.6 Response Times). Note that in some cases, foil (fake) symbol shapes were considered to be representative of a symbol type. The use of foil symbol shapes in this study should not be interpreted as an endorsement for using these shapes on LVO/SMGCS or LVP charts. Rather, we use these data to capture key attributes about an information type that may contribute to a perception of representativeness.

3.1.1 Geographic Position Marking (GPM)

The symbol shapes presented in the questionnaire for representing GPMs are shown in Table 7 grouped by representativeness at each context level. The symbol shapes in the table were real symbols used on LVO/SMGCS charts unless marked as a foil.

Pilots identified circle shapes as representative of a GPM regardless of shape outline, color, fill, font format (normal or italicized), or context. One foil symbol shape was identified as being representative,  , possibly because it shared that circle characteristic. As context increased, another foil symbol shape,  , moved from the "not representative" category to the "mixed" category (where about ½ of the pilots felt the symbol shape was representative and the other ½ felt it was not representative).

Table 7. Symbol Shape Representativeness for GPMs

Context Level	Representative	Mixed	Not Representative
1	Foil:	Foil:	Foil:
2	Foil:	Foil:	Foil:
3	Foil:	Foils:	
4	Foil:	Foils:	

3.1.2 Clearance Bar

As shown in Table 8, no representative symbol shapes were identified for a clearance bar, regardless of context. As context increased, six symbol shapes moved from the "not representative" category to the "mixed" category: , , , , , and . Five of those six symbol shapes moved to the "mixed" category at context level 5, which showed GPM symbol shapes collocated with clearance bars. Since clearance bars are always collocated with GPMs on the airport surface and on LVO/SMGCS charts, the data suggest that pilots may not have enough context to identify a symbol shape as a clearance bar without the presence of GPMs.

Table 8. Symbol Shape Representativeness for Clearance Bars

Context Level	Representative	Mixed	Not Representative
1			Foils:
2			Foils:
3			Foils:
4			Foils:
5		Foils:	Foils:

3.1.3 ILS Hold Line

Pilots generally identified ladder shapes as representative of an ILS hold line, regardless of color or the number of rungs, as shown in Table 9. Two symbol shapes, and , were considered representative regardless of context. Additionally, context helped pilots to identify one foil symbol shape, , as representative at the highest level of context; again, this finding should not be interpreted as an endorsement for using this shape on LVO/SMGCS or LVP charts. The symbol shapes found to be representative look similar to the ILS pavement markings on taxiways.

Table 9. Symbol Shape Representativeness for ILS Hold Lines

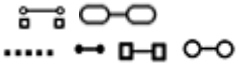
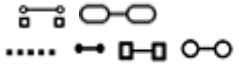
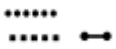
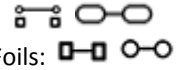
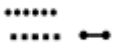
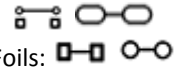
Context Level	Representative	Mixed	Not Representative
1		Foil: 	Foils: 
2		Foil: 	Foils: 
3		Foil: 	Foils: 
4	 Foil: 		Foils: 

3.1.4 Combination RGL *and* Stop Bar Lights, RGL, and Stop Bar Lights

Pilot responses to the Symbol Shape Representativeness task suggested that they may not distinguish between the combination of RGL *and* stop bar lights, RGL only, and stop-bar-lights only information types. Thus, we consider all three information types here.

The results for the combination of RGL *and* stop bar lights are shown in Table 10. One symbol shape,  , was considered to be representative, regardless of context. Although this symbol shape was drawn in color (red) and black-and-white, only the symbol shape presented in color was considered to be representative. Note that the FAA restricts the use of the color red to warnings or hazards that require immediate action (14 CFR sections 23.1322, 25.1322, 27.1322, and 29.1322).

Table 10. Symbol Shape Representativeness for the Combination RGL *and* Stop Bar Lights

Context Level	Representative	Mixed	Not Representative
1			Foils: 
2			Foils: 
3		 Foils:	Foils: 
4		 Foils:	Foils: 

Furthermore, as Table 10 shows, as context increased, two foil symbol shapes,  and  , moved from the "not representative" category to the "mixed" category. These two foil symbol shapes are similar to the foil symbol shapes considered to be representative of stop bar lights only (see Table 11) and RGL only (see Table 12).

For both the stop bar lights only and RGL only information types, no real symbol was found to be representative of the information type. For the stop bar lights only information type, the symbol shape  was considered to be representative, but this is used on LVO/SMGCS charts to depict the combination of RGL *and* stop bar lights (and was found to be representative of the combination of the two information types as shown in Table 10 above).

Table 11. Symbol Shape Representativeness for Stop Bar Lights

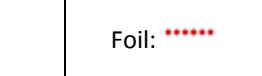
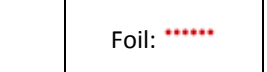
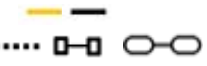
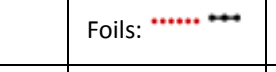
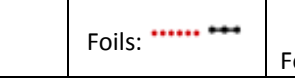
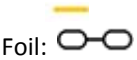
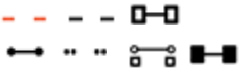
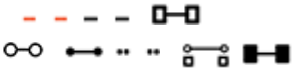
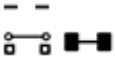
Context Level	Representative	Mixed	Not Representative
1	Foil:	Foils: 	Foils: 
2	Foil:	Foils: 	Foils: 
3	Foils:	Foils: 	Foils: 
4	Foils:	Foils: 	Foil: 

Table 12. Symbol Shape Representativeness for RGL

Context Level	Representative	Mixed	Not Representative
1		Foil: 	Foils: 
2			Foils: 
3		Foils: 	Foils: 
4	Foil: 	Foils:	Foils: 

3.1.5 Non-movement Area Boundary Marking

No representative symbol shapes were identified for non-movement area boundary markings, as shown in Table 13. Non-movement area boundary markings are required to be depicted by regulation. We did not expect the non-movement area boundary marking symbol shapes to be understood without context because it is not the shape of the boundary, but rather, its relationship to the ramp and other movement areas that give it meaning.

Table 13. Symbol Shape Representativeness for Non-movement Area Boundary Markings

Context Level	Representative	Mixed	Not Representative
1		Foils: 	
2		Foils: 	
3		Foils: 	

Note: The table shows only the line pattern used to draw the non-movement area boundary marking, not the shape of the boundary.

3.1.6 Response Times

Statistical analyses compared pilots' average time to respond to real symbols versus foil symbol shapes, without context. We hypothesized that a faster response to real symbols than to foil symbol shapes might provide an indication of "intuitiveness." Results showed no statistically significant difference in pilots' time to respond to real symbols compared to foil symbol shapes, regardless of whether symbol shapes were considered to be representative or not.

3.2 Information Type Usefulness Results

In the Information Type Usefulness task, pilots rated the usefulness of nine information types. Seven of the nine information types were previously examined in the Symbol Shape Representativeness task, but pilots' usefulness ratings did not seem to be affected by their exposure to these information types.

We counted the frequency with which each information type was considered to be *very useful*, *somewhat useful*, or *not very useful*. We then conducted analyses to determine whether there was agreement on the usefulness of an information type. The results are shown in Figure 3.

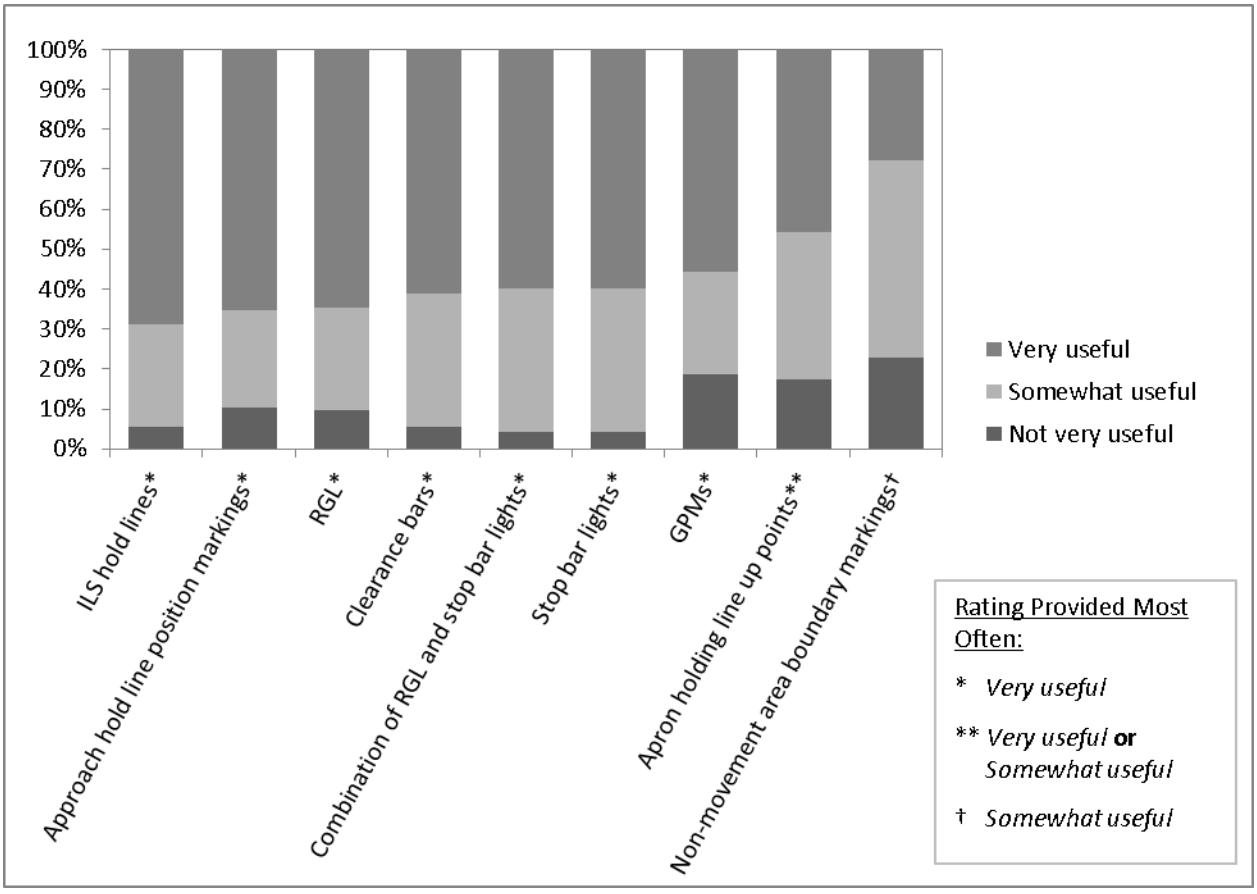


Figure 3. Usefulness Ratings by Information Type

As shown in the figure, pilots rated the following information types to be *very useful*:

- ILS hold lines ($\chi^2 = 90.04$, $p < .0001$)
- Approach hold line position markings ($\chi^2 = 70.29$, $p < .0001$)
- RGL ($\chi^2 = 68.79$, $p < .0001$)
- Clearance bars ($\chi^2 = 66.67$, $p < .0001$)
- Combination of RGL *and* stop bar lights ($\chi^2 = 67.17$, $p < .0001$)
- Stop bar lights ($\chi^2 = 91.54$, $p < .0001$)
- GPMs ($\chi^2 = 33.04$, $p < .0001$)

Apron holding line up points received approximately equal numbers of *very useful* (46%) and *somewhat useful* (37%) ratings ($\chi^2 = 18.29$, $p < .0001$). Pilots most often rated non-movement area boundary markings as *somewhat useful* ($\chi^2 = 17.04$, $p < .0001$).

It is important to note that the pilot ratings for usefulness were considered outside the context of LVO/SMGCS operations. The results do not intend to imply that specific information type(s) do not need to be depicted on LVO/SMGCS charts; rather, all information types included in this study play a specific and important role in LVO/SMGCS operations.

4. Summary and Conclusion

Pilots identified real symbol shapes as representative for only three of the seven information types, as shown in Table 14 below.

Table 14. Representative Real Symbol Shapes by Information Type

Information Type	Symbol Shapes
GPMs	
ILS hold lines	
Combination of RGL *and* stop bar lights	

The results suggest that pilots generally used the symbol *shape* itself, regardless of color, fill, etc., to identify representative symbol shapes for GPMs (circle shapes) and ILS hold lines (ladder shapes). Participants identified a row of six red dots—used on LVO/SMGCS charts to represent the combination of RGL *and* stop bar lights—as both the combination of RGL *and* stop bar lights and as stop bar lights only. This finding suggests that pilots may not distinguish between these two information types on LVO/SMGCS charts, since both require the same response.

Three foil symbol shapes were only considered representative when context was provided, suggesting that for these information types, the shape might matter less than its location with respect to other chart features. Regardless, the use of foil symbol shapes in this study should not be interpreted as an endorsement for using these shapes on LVO/SMGCS or LVP charts.

On the Information Type Usefulness task, the majority of pilots expressed the opinion that the following information types were *very useful* on LVO/SMGCS charts:

- GPMs
- ILS hold lines
- RGL
- Stop bar lights
- Combination of RGL *and* stop bar lights
- Clearance bars
- Approach hold line position markings

Most pilots rated non-movement area boundary markings as *somewhat useful*. Apron holding line up points were rated as *very useful* and *somewhat useful* equally. It is important to note that the usefulness of the information types was considered outside of LVO/SMGCS operations (i.e., not in a simulator); each of these information types provide unique and specific information that allows pilots to taxi safely in LVO/SMGCS conditions.

The results of this study suggest that symbol *shape* may be the most salient cue for judging whether a symbol shape is representative of a particular information type, specifically in cases where the symbol shape is a visual representation of the lights or markings, that is, if it looks similar to the actual lights or markings. Pilots generally accepted modifications to symbol shapes—for example, changes in border or fill—as long as the shape was consistent. The results of this study provide a better understanding of human factors considerations for LVO/SMGCS and LVP chart symbology and support a need to promote symbol consistency across different airports and LVO/SMGCS and LVP chart manufacturers.

5. References

E-Prime 2.0 Professional [Computer Software]. Pittsburgh: Psychology Software Tools.

Federal Aviation Administration. (1996). *Surface Movement Guidance and Control System* (AC 120-57A). Washington, D.C.

Federal Aviation Administration. (2012b). *Aeronautical Information Manual: Official Guide to Basic Flight Information and ATC Procedures.* Washington, D.C.

Federal Aviation Administration. (2012a). *Procedures for Establishing Airport Low-Visibility Operations and Approval of Low-Visibility Operations/Surface Movement Guidance and Control System Operations* (Order 8000.94). Washington, D.C.

International Civil Aviation Organization. (2009). *Aeronautical Charts* (Annex 4 to the Convention on International Civil Aviation). Montreal.

Title 14 of the Code of Federal Regulations (CFR) 23.1322, *Warning, Caution, and Advisory Lights.*

Title 14 of the Code of Federal Regulations (CFR) 25.1322, *Warning, Caution, and Advisory Lights..*

Title 14 of the Code of Federal Regulations (CFR) 27.1322, *Warning, Caution, and Advisory Lights.*

Title 14 of the Code of Federal Regulations (CFR) 29.1322, *Warning, Caution, and Advisory Lights.*

Survey Monkey [Online Survey Software]. Palo Alto: Survey Monkey, Inc.

Appendix A: Informed Consent Form

Informed Consent Form

LVO/SMGCS Symbology Study

US Department of Transportation (DOT) Volpe Center

Purpose of Study. The purpose of this study is to understand what key features are necessary for symbols to be recognized, as well as what information is most useful on charts. This study focuses on symbols found on LVO/SMGCS charts.

Procedure. The survey will start out with a background questionnaire which asks you about your experience as a pilot. Then, you will complete two tasks related to LVO/SMGCS chart symbology:

1. Task 1. You will be shown a series of symbols and asked whether each symbol is representative of a particular type of information shown on LVO/SMGCS charts. You will respond by clicking a “Yes” or “No” button.
2. Task 2. You will be shown a list of information commonly shown on LVO/SMGCS charts and you will be asked to rate the usefulness of each type of information. A rating scale will be provided and you will respond by clicking on your rating.

The study is estimated to take less than 45 minutes to complete.

Discomfort and Risks. There are no foreseeable risks in this study other than what a participant might experience working at a desk. Participants should immediately report any suspected adverse effects of completing the study to Andrea Sparko (see contact information below).

Benefit to you. Fifty participants who complete the survey will receive a $50 gift card to Amazon.com as compensation for your time. Gift card recipients will be chosen via a random drawing the day after the survey closes. All participants who complete the survey will have an equal chance at receiving a gift card. Gift cards will be sent via postal mail. If your name is randomly drawn to receive a gift card, a researcher will contact you via e-mail to obtain a mailing address. If you work for the federal government this study should only be completed while you are on break from your official duties.

Assurances and Rights of the Participant. Your participation in this study is completely voluntary. Your participation is strictly confidential, and no individual names or identities will be

recorded with any data or released in any reports. Arbitrary numbers will be assigned to your data to identify you. You may terminate your participation in the study at any time. If you choose to terminate your participation, we will discard all data that you provide.

Organization Responsible for this Study. This study is being conducted by the John A. Volpe National Transportation Systems Center, United States Department of Transportation (USDOT). For this study, the USDOT Volpe Center is funded by the Federal Aviation Administration, Human Factors Division (ANG-C1). For further information about this study, please feel free to contact:

Andrea Sparko

US DOT Volpe Center, 55 Broadway, Cambridge, MA 02142

Andrea.Sparko@dot.gov, 617-494-3363

Statement of Consent. If you would like to participate, please verify that you have read this form and understand your rights as a participant. Read the statement below and indicate your agreement with the statement by providing your electronic signature in the space provided. Your signature indicates your consent to participate.

> **The information that I provide as a participant is strictly confidential and I shall remain anonymous. I understand that no Personally Identifiable Information [PII] will be disclosed or released, except as may be required by statute. I understand that situations when PII may be disclosed are discussed in detail in FAA Order 1280.18 "Protecting Personally Identifiable Information [PII]"**

Enter Electronic Signature (Full Name): Date (MM/DD/YY):

Please confirm your electronic signature.

- ❍ Confirm
- ❍ Cancel

Click submit to send this form to the researcher. The researcher will then send you a link to the online survey.

Submit

Appendix B: Study Introduction

Low-Visibility Operations/Surface Movement Guidance and Control System (LVO/SMGCS) Survey

Purpose of Study. The purpose of this study is to understand what shapes are recognized on LVO/SMGCS charts. We are also interested in what types of information are most useful on LVO/SMGCS charts.

Description. This study has two parts (in order):

1. *Task 1 is a symbol-identification task.* You will be shown various **symbol shapes** and asked to decide whether or not the shapes represent particular **information types**. In this study, an information type is defined as a category of information that is depicted on a chart (e.g., a taxiway is an information type).

2. *Task 2 is a rating task.* You will be given a list of **information types** and asked to rate their usefulness.

Detailed instructions will be provided before each task. Before you begin the tasks, we will ask you to fill out a background questionnaire.

If you have any questions, please feel free to contact us:

Andrea Sparko
US DOT Volpe Center
55 Broadway, RVT-82
Cambridge, MA 02142
Andrea.Sparko@dot.gov
(617)494-3363

Stephanie Chase, Ph.D.
US DOT Volpe Center
55 Broadway, RVT-80
Cambridge, MA 02142
Stephanie.Chase@dot.gov
(617)494-6348

Appendix C: Background Questionnaire

Background Questions

1. Age: ☐

	Male	Female
2. Gender:	○	○

3. What ratings do you hold (you may choose more than one option)?

- ☐ Airline Transport Pilot (ATP)
- ☐ Certified Flight Instructor (CFI)
- ☐ Certified Flight Instructor - Instrument (CFII)
- ☐ Commercial
- ☐ Instrument Rating
- ☐ Multi-Engine
- ☐ Private Pilot
- ☐ Other

If other, please specify:

☐

	Yes	No
4. Are you a military pilot?	○	○

If yes, please describe your military experience:

☐

5. Please describe your international flying experience (you may choose more than one option):

- ☐ U.S. pilot, domestic route(s)
- ☐ U.S. pilot, international route(s)
- ☐ European pilot, domestic route(s)
- ☐ European pilot, international route(s)
- ☐ Other

If other, please specify:

☐

	Captain	First Officer	Other
6. Current flight crew position:	○	○	○

If other, please specify:

7. Years of CAT III operational experience:

8. Please estimate your hours in the following conditions:

Total flight hours:

Total flight hours in the past month:

SMGCS (<1200 ft RVR) flight hours (excluding simulator):

SMGCS (<1200 ft RVR) simulator hours:

Surface operation hours between 1200 ft and 600 ft RVR:

Surface operation hours below 600 ft RVR:

	Paper	Electronic
9. What type of charts do you use?	☐	☐

	Paper	Electronic
Which type of chart do you use most?	○	○

	FAA	Jeppesen	Lido	Other
10. Which manufacturer provides the charts that you use most?	○	○	○	○

If other, please specify:

How long have you used the provider's charts?

	Yes	No
11. Do you use charts from other providers regularly?	○	○

Which ones? For how long?

Appendix D: Symbol Shape Representativeness Task Instructions and Example

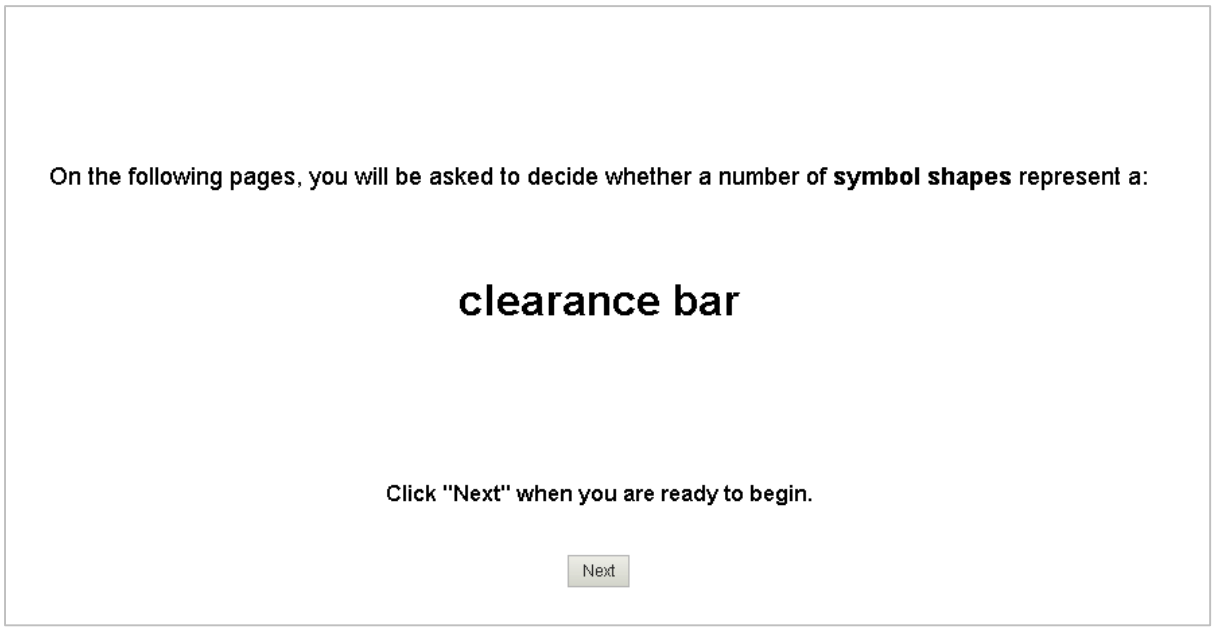
There were two versions of the questionnaire, online and in-person, with the main difference being the way that pilots completed the Symbol Shape Representativeness Task. In the online version, pilots completed the task using the computer mouse. In the in-person version, pilots responded via the keyboard. On the following pages we first provide the instructions for the online version, followed by the instructions for the in-person version, and finally an example of the question and context levels for each information type (same for both versions).

Instructions for online version

Task 1 Instructions (p. 1/3)

Instructions. On the following pages you will be shown a series of **symbol shapes** and asked whether each **symbol shape** is representative of a particular **information type**. An **information type** is simply a category of information that is depicted on charts (e.g., taxiways are an information type). More information about this is provided on the next page of the instructions.

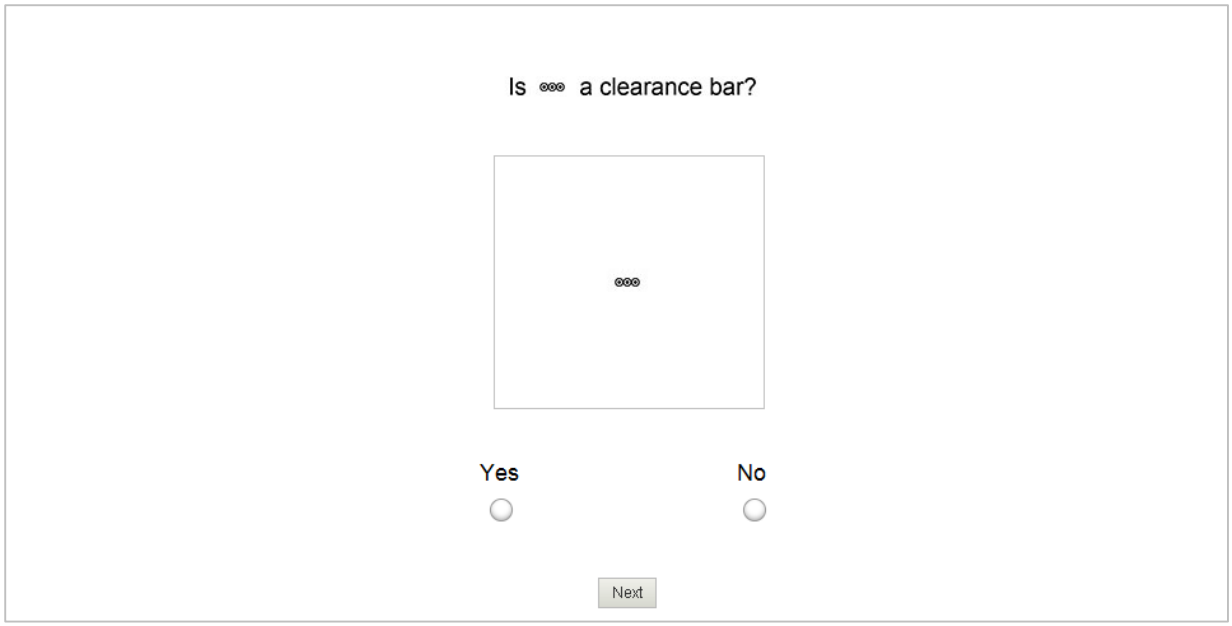
You will be told which **information type** you are about to see. Here is an example of what you would see prior to seeing **symbol shapes** for clearance bars:



Clicking the "Next" button would bring you to a new page with the first question.

Task 1 Instructions (p. 2/3)

Here is an example question:



In the above example:

1. The **information type** is listed in the center at the top.
2. The **symbol shape** is shown in the center of the screen.
3. You will answer the question by clicking “Yes” or “No.”
4. You will click the “Next” button to move on to the next question. The next question will open in a new page.

Next

Task 1 Instructions (p. 3/3)

You will see each symbol shape a few times; each time with a bit more information from the chart which may help you make your decision. In some cases you may feel like you need additional information to make your decision; please give us your **best guess**.

Some of the shapes are real symbols and some are not. **We are not looking for right answers.** Rather, we are looking for your **first impression** of what each symbol shape represents given the information provided. For this reason, **you will not be able to go backwards** to change your answers or to see a previous shape. Clicking the "back" button on your web browser will not allow you to change your answers; only your first response will be recorded.

Click "Next" to begin Task 1.

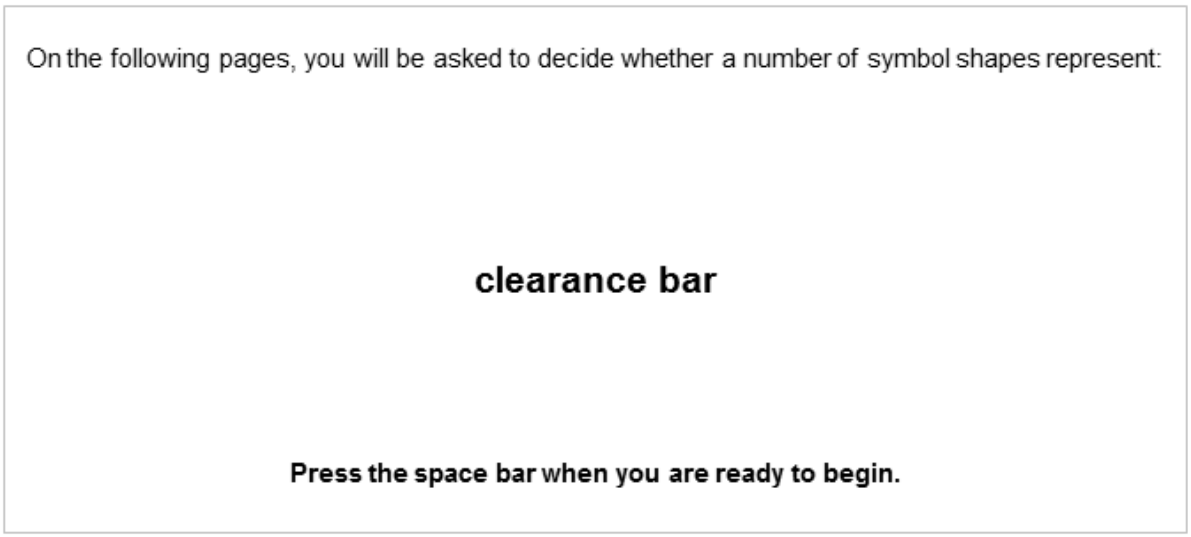
Next

Instructions for the in-person version

Task 1 Instructions (p. 1/4)

Instructions. On the following pages you will be shown a series of **symbol shapes** and asked whether each **symbol shape** is representative of a particular **information type**. An **information type** is simply a category of information that is depicted on charts (e.g., taxiways are an information type). More information about this is provided on the next page of the instructions.

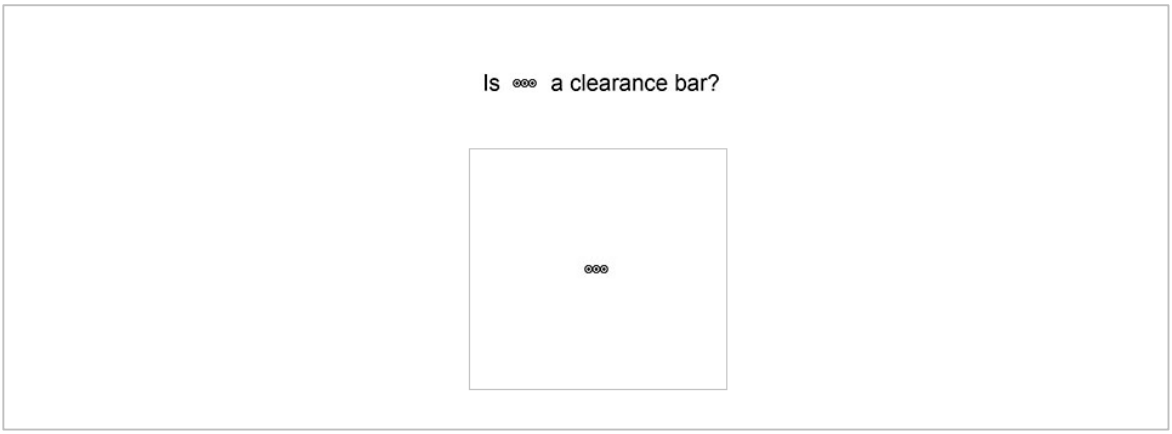
You will be told which **information type** you are about to see. Here is an example of what you would see prior to seeing **symbol shapes** for clearance bars:



Press the → key to continue with the instructions.

Task 1 Instructions (p. 2/4)

Here is an example question:



In the above example:

1. The **information type** is listed in the center at the top.
2. The **symbol shape** is shown in the center of the screen.
3. You will answer the question using the keyboard:
    - Press **"F"** for **"Yes"**
    - Press **"J"** for **"No"**
4. The next question will appear immediately after you press the response key.

Press the → key to continue with the instructions.

Task 1 Instructions (p. 3/4)

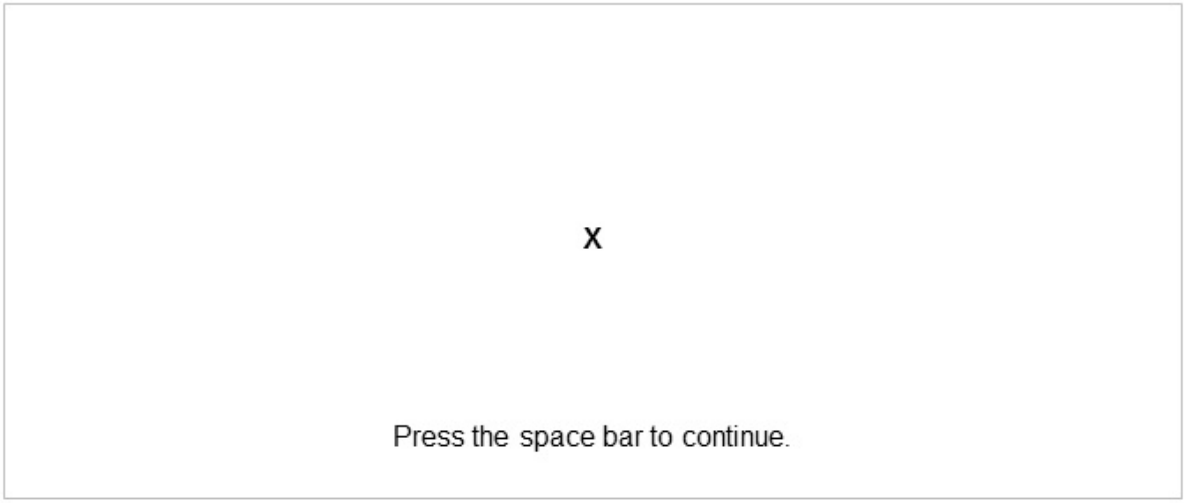
You will see each symbol shape a few times; each time with a bit more information from the chart which may help you make your decision. In some cases you may feel like you need additional information to make your decision; please give us your **best guess**.

Some of the shapes are real symbols and some are not. **We are not looking for right answers.** Rather, we are looking for your **first impression** of what each symbol shape represents given the information provided. For this reason, please respond as soon as you think you have the right answer.

Press the → key to continue with the instructions.

Task 1 Instructions (p. 4/4)

You will have a break between symbol shapes. During the break you will see the slide below:

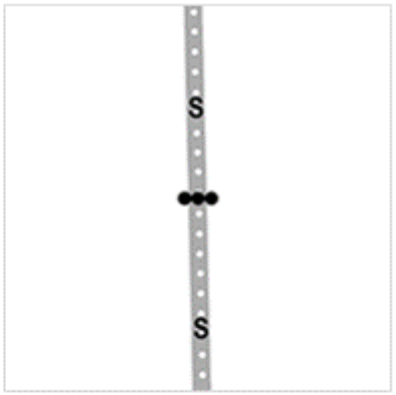


You will have a chance to practice before you begin. Press the → key to continue.

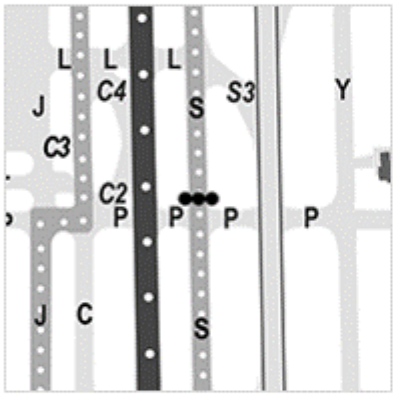
Example questions for each information type (same for both online and in-person versions)

Is ●●● a clearance bar?

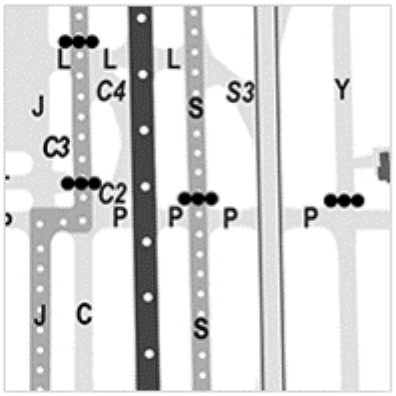
Level 1



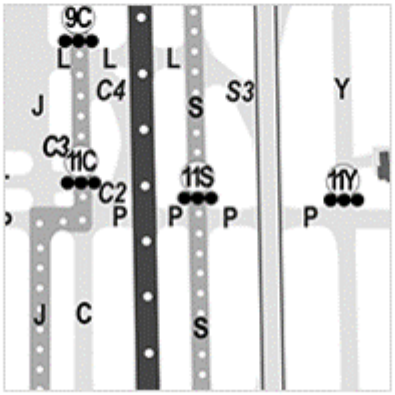
Level 2



Level 3

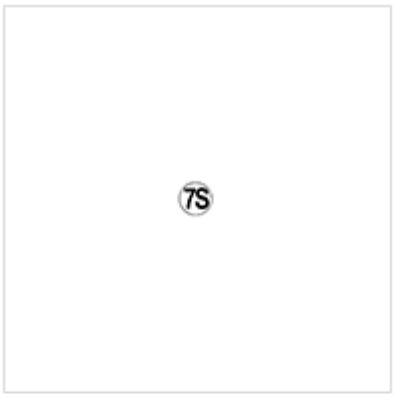


Level 4

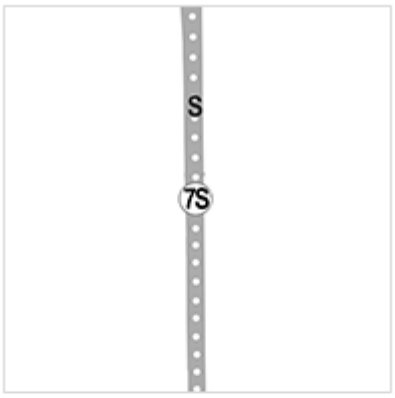


Level 5

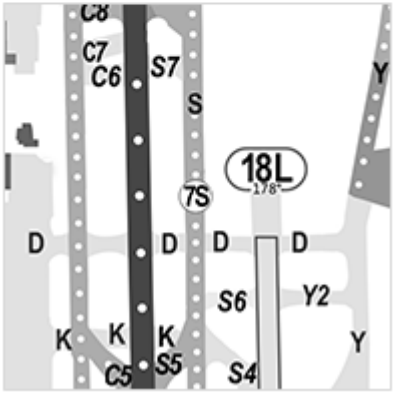
Is 7S a geographic position marking (GPM)?



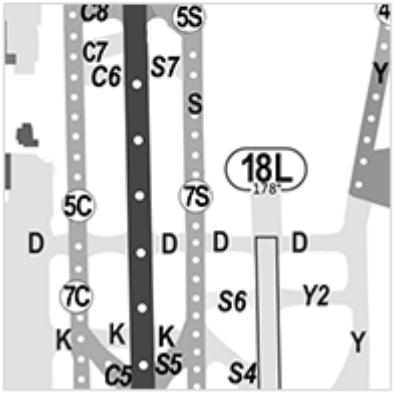
Level 1



Level 2



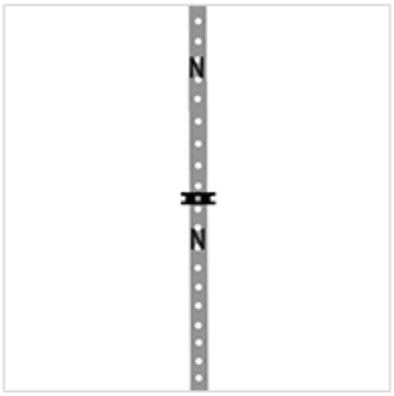
Level 3



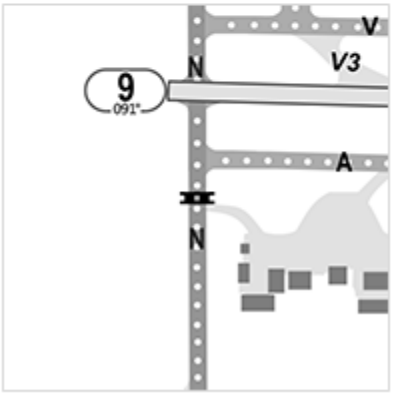
Level 4

Is an ILS hold?

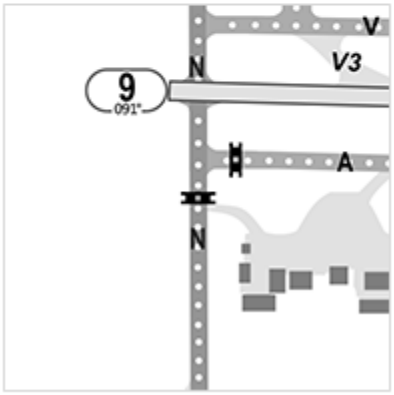
Level 1



Level 2



Level 3

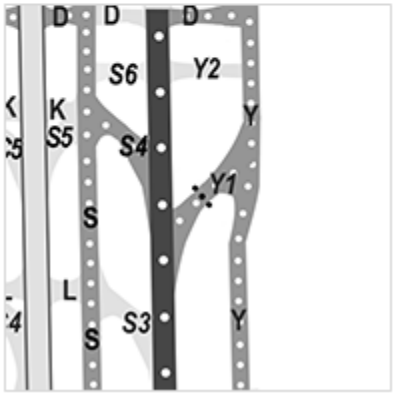


Level 4

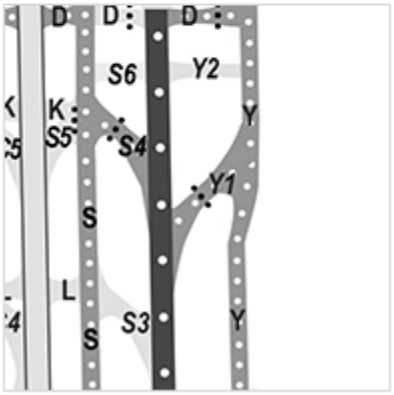
Is ••• a stop bar?

Level 1

Level 2

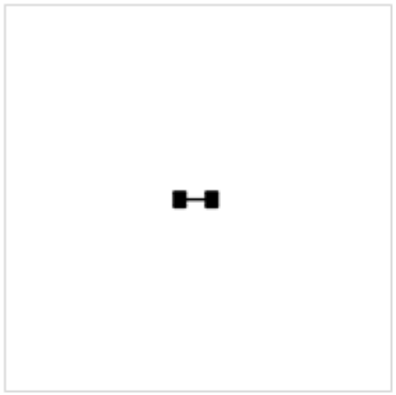


Level 3

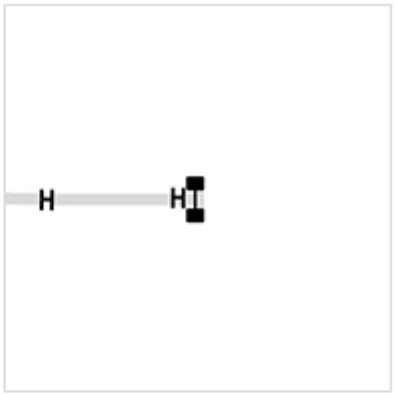


Level 4

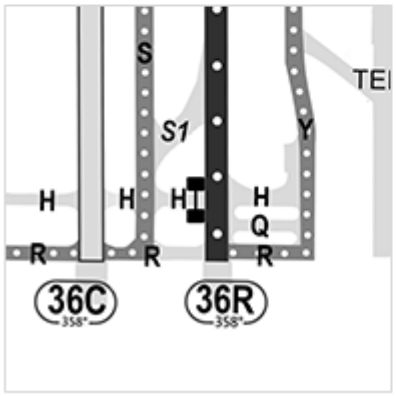
Is ▪▬▪ a runway guard light (RGL)?



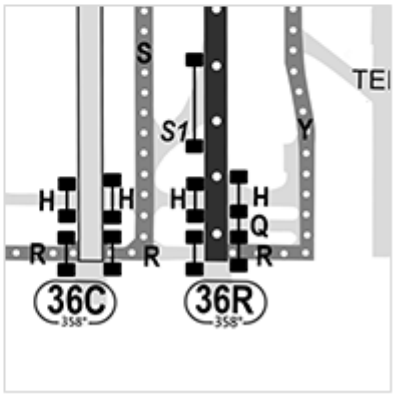
Level 1



Level 2

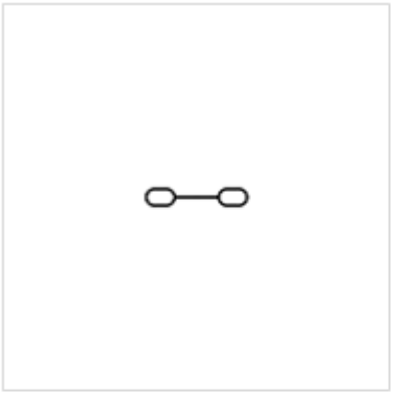


Level 3

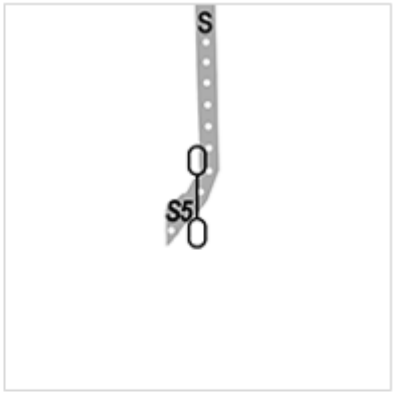


Level 4

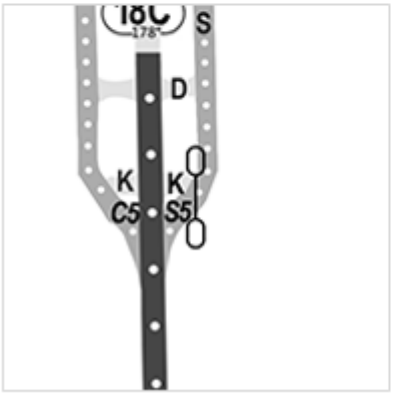
Is  a combination runway guard light (RGL) and stop bar?



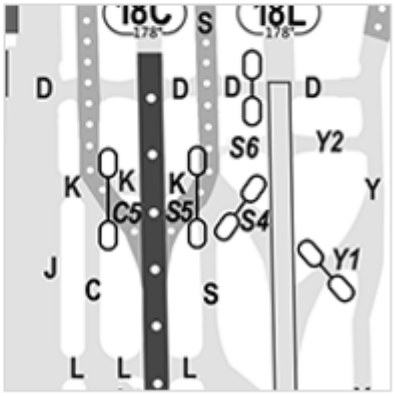
Level 1



Level 2

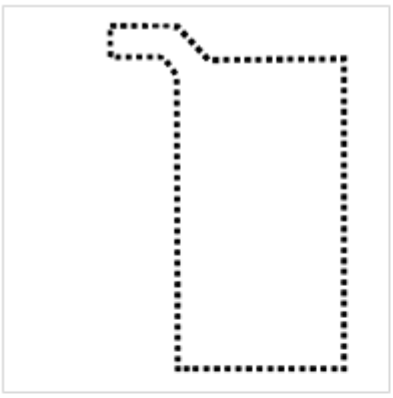


Level 3

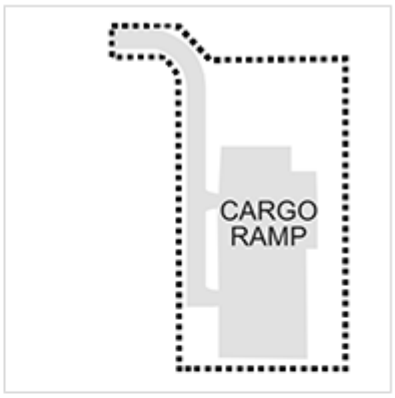


Level 4

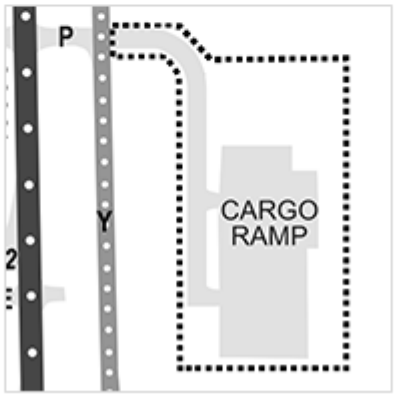
Is ..... a non-movement area?



Level 1



Level 2



Level 3

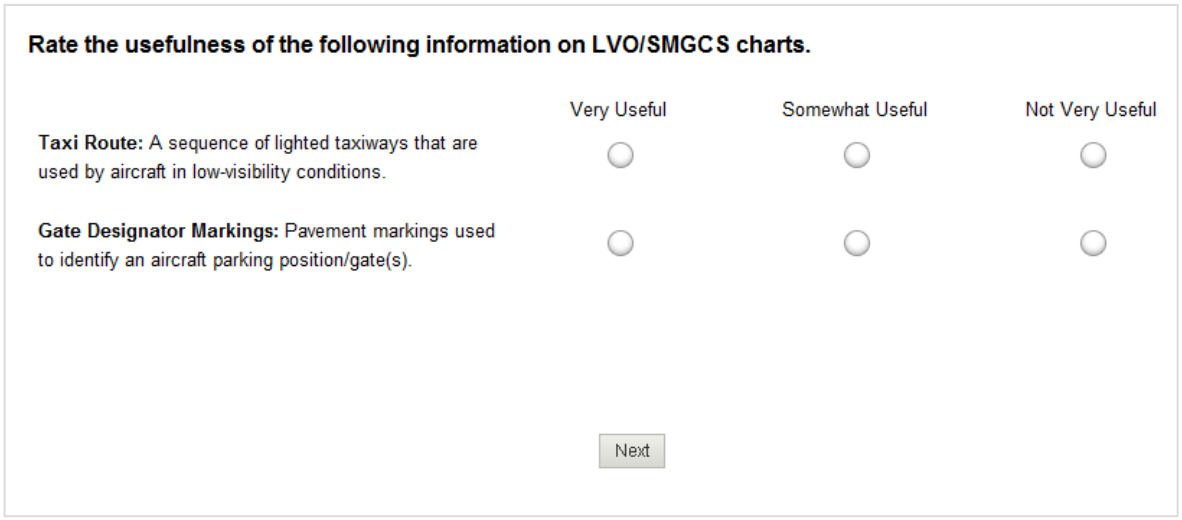
Appendix E: Information Type Usefulness Task Instructions and Example

Task 2 Instructions

Instructions. On the following page you will be given a list of **information types** that are depicted on LVO/SMGCS charts. For each **information type**, you will:

1. Read the definition.
2. Rate how useful that information is on LVO/SMGCS charts. Make your response by clicking on the appropriate rating in the rating scale shown to the right of each information type.

Some example questions are shown below:



Click "Next" to begin Task 2.

Next

Rate the usefulness of the following information on LVO/SMGCS charts.

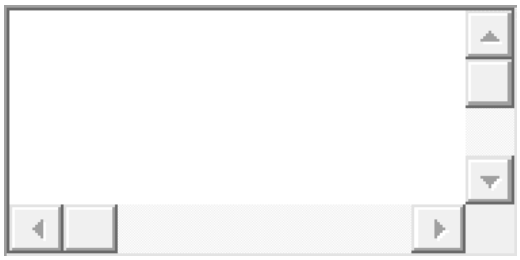
	Very Useful	Somewhat Useful	Not Very Useful
Apron Holding Point: Pavement marking indicating a holding position at the boundary of an apron.	○	○	○
Runway Guard Lights: Lights at the runway hold short point position of a taxiway/runway intersection, indicating the presence of an active runway.	○	○	○
Stop Bar: Lights at the holding position of a taxiway or runway intersection used to indicate clearance to enter the runway when turned off.	○	○	○
Combination Runway Guard Light (RGL) / Stop Bar: Collocated runway guard light (RGL) and stop bar.	○	○	○
Clearance Bar: Lights at the holding position of a taxiway/taxiway intersection.	○	○	○
Approach Hold: Pavement marking indicating a holding position at the boundary of a protected approach containment area for a runway.	○	○	○
Geographic Position Marking (GPM): Pavement marking used to verify aircraft position.	○	○	○
ILS Hold Line: Pavement marking indicating a holding position at the boundary of an ILS critical area.	○	○	○
Non-movement Area: Pavement marking outlining the boundary of an area not under air traffic control.	○	○	○

Next

Appendix F: General Comments

Comments

If you have any comments (on the survey, your LVO/SMGCS experience, LVO/SMGCS in general, etc.) please provide them in the box below?



Did you notice any time delays during the survey?

(•) Yes ( ) No

Next

Survey Time Delay

1. Can you please describe the time delay?

2. Did you feel that the time delay affected your response?

Yes	No
○	○

If so, in what way?

Next

Appendix G: Study Summary

LVO/SMGCS Symbology Study Summary

Thank you for participating in the Low-Visibility Operations/Surface Movement Guidance and Control System (LVO/SMGCS) chart symbology study. Your responses will help the FAA to develop best practices and recommendations for LVO/SMGCS chart symbology. As a thank you for your participation in this study, your name will be entered into a random drawing to receive a $50 Amazon.com gift card. We will contact you by e-mail if your name is selected.

This study is being conducted by the John A. Volpe National Transportation Systems Center, United States Department of Transportation (USDOT). We hope to have final analyses completed by October 2013. If you would like to receive a summary of results when they become available or have additional questions about this study, please contact one of the principal investigators listed below.

Andrea Sparko
US DOT Volpe Center
55 Broadway, RVT-82
Cambridge, MA 02142
Andrea.Sparko@dot.gov
(617)494-3363

Stephanie Chase, Ph.D.
US DOT Volpe Center
55 Broadway, RVT-80
Cambridge, MA 02142
Stephanie.Chase@dot.gov
(617)494-6348

Please contact us if you are interested in participating in future studies.

Appendix H: Statistical Results

Symbol Shape Representativeness

To examine pilots' identification of each symbol shape, we first counted the number pilots who felt that a symbol shape was representative ("Yes") or not ("No") at each chart context level. Then we used chi-square tests (χ^2) to see if the number of "Yes" responses was significantly greater or less than the number of "No" responses. The difference was considered "significant" if the probability that the difference occurred by chance (e.g., if the pilots were guessing) was less than 5% (p-value <. 05). The results of the chi-square tests are provided in the following tables by context level.

Geographic Position Marking (GPM)

Symbol Shape	Statistics	Level 1	Level 2	Level 3	Level 4
	Yes (count) No (count) *X^2 statistic* *p-value*	89 55 8.03 0.00	95 49 14.69 0.00	101 43 23.36 0.00	101 42 24.34 0.00
	Yes (count) No (count) *X^2 statistic* *p-value*	113 30 48.17 0.00	114 29 50.52 0.00	118 24 62.23 0.00	120 23 65.80 0.00
	Yes (count) No (count) *X^2 statistic* *p-value*	102 41 26.02 0.00	104 39 29.55 0.00	107 36 35.25 0.00	108 35 37.27 0.00
 Foil	Yes (count) No (count) *X^2 statistic* *p-value*	85 58 5.10 0.02	93 49 13.63 0.00	97 46 18.19 0.00	97 46 18.19 0.00
 Foil	Yes (count) No (count) *X^2 statistic* *p-value*	28 44 3.56 0.06	32 40 0.89 0.35	35 37 0.06 0.81	37 35 0.06 0.81
 Foil	Yes (count) No (count) *X^2 statistic* *p-value*	23 48 8.80 0.00	26 45 5.08 0.02	29 42 2.38 0.12	30 41 1.70 0.19

Clearance Bar

Symbol Shape	Statistics	Level 1	Level 2	Level 3	Level 4	Level 5
	Yes (count)	54	63	69	70	78
	No (count)	90	81	75	74	66
	X^2 *statistic*	9.00	2.25	0.25	0.11	1.00
	p-value	0.00	0.13	0.62	0.74	0.32
	Yes (count)	29	33	35	36	40
	No (count)	43	39	37	36	32
	X^2 *statistic*	2.72	0.50	0.06	0.00	0.89
	p-value	0.10	0.48	0.81	1.00	0.35
	Yes (count)	19	21	24	24	29
	No (count)	53	51	48	48	43
	X^2 *statistic*	16.06	12.50	8.00	8.00	2.72
	p-value	0.00	0.00	0.00	0.00	0.10
	Yes (count)	17	15	17	17	23
	No (count)	55	57	55	55	49
	X^2 *statistic*	20.06	24.50	20.06	20.06	9.39
	p-value	0.00	0.00	0.00	0.00	0.00
	Yes (count)	21	18	20	21	26
	No (count)	50	53	51	50	45
	X^2 *statistic*	11.85	17.25	13.54	11.85	5.08
	p-value	0.00	0.00	0.00	0.00	0.02
	Yes (count)	46	50	54	56	64
	No (count)	97	93	89	86	79
	X^2 *statistic*	18.19	12.93	8.57	6.34	1.57
	p-value	0.00	0.00	0.00	0.01	0.21
	Yes (count)	43	45	50	54	64
	No (count)	101	99	94	90	80
	X^2 *statistic*	23.36	20.25	13.44	9.00	1.78
	p-value	0.00	0.00	0.00	0.00	0.18
Foil	Yes (count)	38	45	47	49	60
	No (count)	105	98	96	94	83
	X^2 *statistic*	31.39	19.64	16.79	14.16	3.70
	p-value	0.00	0.00	0.00	0.00	0.05
 Foil	Yes (count)	22	24	24	25	30
	No (count)	50	48	48	47	42
	X^2 *statistic*	10.89	8.00	8.00	6.72	2.00
	p-value	0.00	0.00	0.00	0.01	0.16
 Foil	Yes (count)	9	7	10	12	14
	No (count)	63	65	62	60	58
	X^2 *statistic*	40.50	46.72	37.56	32.00	26.89
	p-value	0.00	0.00	0.00	0.00	0.00

Symbol Shape	Statistics	Level 1	Level 2	Level 3	Level 4	Level 5
Foil	Yes (count)	4	7	8	9	16
	No (count)	68	65	64	63	56
	X^2 *statistic*	56.89	46.72	43.56	40.50	22.22
	p-value	0.00	0.00	0.00	0.00	0.00
Foil	Yes (count)	25	37	40	40	49
	No (count)	119	107	104	104	95
	X^2 *statistic*	61.36	34.03	28.44	28.44	14.69
	p-value	0.00	0.00	0.00	0.00	0.00
Foil	Yes (count)	8	13	14	16	20
	No (count)	64	59	58	55	52
	X^2 *statistic*	43.56	29.39	26.89	21.42	14.22
	p-value	0.00	0.00	0.00	0.00	0.00

ILS Hold Line

Symbol Shape	Statistics	Level 1	Level 2	Level 3	Level 4
	Yes (count)	97	82	95	98
	No (count)	47	62	49	46
	X^2 *statistic*	17.36	2.78	14.69	18.78
	p-value	0.00	0.10	0.00	0.00
	Yes (count)	111	104	112	115
	No (count)	33	40	32	29
	X^2 *statistic*	42.25	28.44	44.44	51.36
	p-value	0.00	0.00	0.00	0.00
	Yes (count)	88	85	92	94
	No (count)	56	59	52	50
	X^2 *statistic*	7.11	4.69	11.11	13.44
	p-value	0.01	0.03	0.00	0.00
	Yes (count)	43	39	46	50
	No (count)	100	104	97	93
	X^2 *statistic*	22.72	29.55	18.19	12.93
	p-value	0.00	0.00	0.00	0.00
Foil	Yes (count)	1	2	5	8
	No (count)	71	70	67	64
	X^2 *statistic*	68.06	64.22	53.39	43.56
	p-value	0.00	0.00	0.00	0.00
Foil	Yes (count)	77	73	82	85
	No (count)	67	71	62	59
	X^2 *statistic*	0.69	0.03	2.78	4.69
	p-value	0.40	0.87	0.10	0.03
Foil	Yes (count)	3	3	4	4
	No (count)	69	69	68	68
	X^2 *statistic*	60.50	60.50	56.89	56.89
	p-value	0.00	0.00	0.00	0.00

Runway Guard Light (RGL)

Symbol Shape	Statistics	Level 1	Level 2	Level 3	Level 4
	Yes (count)	42	44	60	60
	No (count)	102	100	83	84
	X^2 *statistic*	25.00	21.78	3.70	4.00
	p-value	0.00	0.00	0.05	0.05
	Yes (count)	7	17	26	34
	No (count)	65	55	46	38
	X^2 *statistic*	46.72	20.06	5.56	0.22
	p-value	0.00	0.00	0.02	0.64
	Yes (count)	22	23	32	35
	No (count)	50	49	40	37
	X^2 *statistic*	10.89	9.39	0.89	0.06
	p-value	0.00	0.00	0.35	0.81
 Foil	Yes (count)	13	15	20	24
	No (count)	59	56	52	48
	X^2 *statistic*	29.39	23.68	14.22	8.00
	p-value	0.00	0.00	0.00	0.00
Foil	Yes (count)	19	26	32	35
	No (count)	53	46	40	37
	X^2 *statistic*	16.06	5.56	0.89	0.06
	p-value	0.00	0.02	0.35	0.81
Foil	Yes (count)	31	28	42	47
	No (count)	42	45	31	26
	X^2 *statistic*	1.66	3.96	1.66	6.04
	p-value	0.20	0.05	0.20	0.01
Foil	Yes (count)	20	19	24	26
	No (count)	52	52	48	46
	X^2 *statistic*	14.22	15.34	8.00	5.56
	p-value	0.00	0.00	0.00	0.02
Foil	Yes (count)	20	25	34	39
	No (count)	50	45	36	31
	X^2 *statistic*	12.86	5.71	0.06	0.91
	p-value	0.00	0.02	0.81	0.34

Stop Bar

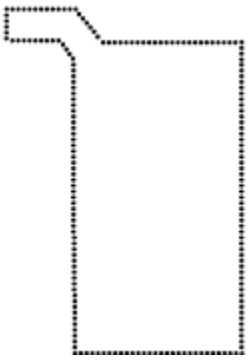
Symbol Shape	Statistic	Level 1	Level 2	Level 3	Level 4
	Yes (count)	53	61	68	69
	No (count)	91	83	76	75
	X^2 *statistic*	10.03	3.36	0.44	0.25
	p-value	0.00	0.07	0.51	0.62
	Yes (count)	28	33	34	34
	No (count)	44	39	38	38
	X^2 *statistic*	3.56	0.50	0.22	0.22
	p-value	0.06	0.48	0.64	0.64
	Yes (count)	18	26	28	28
	No (count)	54	46	44	44
	X^2 *statistic*	18.00	5.56	3.56	3.56
	p-value	0.00	0.02	0.06	0.06
	Yes (count)	17	23	23	24
	No (count)	55	49	49	48
	X^2 *statistic*	20.06	9.39	9.39	8.00
	p-value	0.00	0.00	0.00	0.00
Foil	Yes (count)	37	34	34	37
	No (count)	35	38	38	35
	X^2 *statistic*	0.06	0.22	0.22	0.06
	p-value	0.81	0.64	0.64	0.81
Foil	Yes (count)	30	34	36	36
	No (count)	42	38	36	36
	X^2 *statistic*	2.00	0.22	0.00	0.00
	p-value	0.16	0.64	1.00	1.00
Foil	Yes (count)	29	39	40	41
	No (count)	43	33	32	31
	X^2 *statistic*	2.72	0.50	0.89	1.39
	p-value	0.10	0.48	0.35	0.24
Foil	Yes (count)	48	55	57	58
	No (count)	24	17	15	14
	X^2 *statistic*	8.00	20.06	24.50	26.89
	p-value	0.00	0.00	0.00	0.00
Foil	Yes (count)	18	21	22	25
	No (count)	54	51	50	47
	X^2 *statistic*	18.00	12.50	10.89	6.72
	p-value	0.00	0.00	0.00	0.01
Foil	Yes (count)	18	25	27	29
	No (count)	54	47	44	43
	X^2 *statistic*	18.00	6.72	4.07	2.72
	p-value	0.00	0.01	0.04	0.10

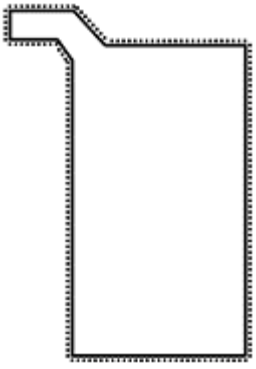
Symbol Shape	Statistic	Level 1	Level 2	Level 3	Level 4
Foil	Yes (count)	31	43	49	49
	No (count)	40	28	22	22
	X^2 *statistic*	1.14	3.17	10.27	10.27
	p-value	0.29	0.08	0.00	0.00
Foil	Yes (count)	25	25	28	29
	No (count)	47	47	44	43
	X^2 *statistic*	6.72	6.72	3.56	2.72
	p-value	0.01	0.01	0.06	0.10

Combination RGL *and* stop bar

Symbol Shape	Statistics	Level 1	Level 2	Level 3	Level 4
	Yes (count)	25	30	36	37
	No (count)	119	114	108	107
	X^2 *statistic*	61.36	49.00	36.00	34.03
	p-value	0.00	0.00	0.00	0.00
	Yes (count)	19	20	21	23
	No (count)	52	51	50	48
	X^2 *statistic*	15.34	13.54	11.85	8.80
	p-value	0.00	0.00	0.00	0.00
	Yes (count)	28	33	36	35
	No (count)	44	37	36	37
	X^2 *statistic*	3.56	0.23	0.00	0.06
	p-value	0.06	0.63	1.00	0.81
	Yes (count)	44	47	53	56
	No (count)	27	23	18	15
	X^2 *statistic*	4.07	8.23	17.25	23.68
	p-value	0.04	0.00	0.00	0.00
Foil	Yes (count)	16	18	20	25
	No (count)	56	54	52	47
	X^2 *statistic*	22.22	18.00	14.22	6.72
	p-value	0.00	0.00	0.00	0.01
Foil	Yes (count)	17	19	19	22
	No (count)	55	53	53	50
	X^2 *statistic*	20.06	16.06	16.06	10.89
	p-value	0.00	0.00	0.00	0.00
Foil	Yes (count)	22	25	29	30
	No (count)	50	46	43	42
	X^2 *statistic*	10.89	6.21	2.72	2.00
	p-value	0.00	0.01	0.10	0.16
Foil	Yes (count)	21	25	29	30
	No (count)	51	46	43	42
	X^2 *statistic*	12.50	6.21	2.72	2.00
	p-value	0.00	0.01	0.10	0.16

Non-movement area

Symbol Shape	Statistics	Level 1	Level 2	Level 3
	Yes (count) No (count) X^2 *statistic* *p-value*	67 76 0.57 0.45	75 68 0.34 0.56	81 63 2.25 0.13
	Yes (count) No (count) X^2 *statistic* *p-value*	53 90 9.57 0.00	64 79 1.57 0.21	66 76 0.70 0.40
 Foil	Yes (count) No (count) X^2 *statistic* *p-value*	34 38 0.22 0.64	37 35 0.06 0.81	37 35 0.06 0.81

Symbol Shape	Statistics	Level 1	Level 2	Level 3
 Foil	Yes (count) No (count) X^2 *statistic* *p-value*	33 39 0.50 0.48	39 33 0.50 0.48	42 30 2.00 0.16
 Foil	Yes (count) No (count) X^2 *statistic* *p-value*	29 43 2.72 0.10	33 39 0.50 0.48	33 39 0.50 0.48
 Foil	Yes (count) No (count) X^2 *statistic* *p-value*	28 44 3.56 0.06	34 37 0.13 0.72	36 35 0.01 0.91

Response Times

Response times greater than 20 seconds were not included in the analysis because response times of this magnitude could be an indication that pilots were distracted away from the task (researcher observations confirmed this in several cases).

An Analysis of Variance (ANOVA) examined potential effects of two variables at context level 1: symbol shape type (real symbols or foils) and response ("Yes" for "representative" or "No" for "not representative"). The ANOVA also examined a potential interaction between the two variables. To meet the assumptions for ANOVA, the data were transformed using log 10. Means and standard deviations (SD) for the raw data (before the transformation) and statistical results are provided in the tables below.

Means (SD) in seconds for Effect of Symbol Type on Response Time

Real Symbols	Foils	Statistical Results
3.42 (2.62)	3.30 (2.54)	$F(1,1527) = 1.37$, $p = .242$

Means (SD) in seconds for Effect of Response (Yes/No) on Response Time

Yes (representative)	No (not representative)	Statistical Results
3.52 (2.60)	3.25 (2.57)	$F(1,1527) = 9.47$, $p = .002$

Means (SD) in seconds for Interaction Effect of Symbol Type x Response on Response Time

Response	Real Symbols	Foils	Statistical Results
Yes (Representative)	3.50 (2.50)	3.54 (2.77)	$F(1,1527) = 0.00$, $p = 1.00$
No (Not representative)	3.34 (2.74)	3.18 (2.41)	

Information Type Usefulness

Information type usefulness was analyzed using chi-square (χ^2) tests that compared the number of pilots who rated each information type as *very useful*, *somewhat useful*, or *not very useful*. If the chi-square was statistically significant at $p < .05$, we conducted post-hoc chi-square tests between pairs of ratings (e.g., the number of *very useful* vs. *somewhat useful* ratings). The Bonferroni correction was applied to post-hoc p-values.

Statistical Results of Information Type Usefulness Analyses

Information Type	Chi-Square Statistics	Significant Post-hoc Differences
ILS hold line	χ^2 (144) = 90.04, $p < .0001$	Very useful > Somewhat useful, χ^2 (136) = 28.26, $p < .001$ Very useful > Not very useful, χ^2 (107) = 77.39, $p < .001$ Somewhat useful > Not very useful, χ^2 (45) = 18.69, $p < .001$
Approach hold	χ^2 (144) = 70.29, $p < .0001$	Very useful > Somewhat useful, χ^2 = 26.98, $p < .001$ Very useful > Not very useful, χ^2 = 57.25, $p < .001$
RGL	χ^2 (144) = 68.79, $p < .0001$	Very useful > Somewhat useful, χ^2 (130) = 24.12, $p < .001$ Very useful > Not very useful, χ^2 (107) = 58.33, $p < .001$ Somewhat useful > Not very useful, χ^2 (51) = 10.37, $p < .01$
Clearance bar	χ^2 (144) = 66.67, $p < .0001$	Very useful > Somewhat useful, χ^2 (136) = 11.76, $p < .001$ Very useful > Not very useful, χ^2 (96) = 66.67, $p < .001$ Somewhat useful > Not very useful, χ^2 (56) = 28.57, $p < .001$
Combination RGL and stop bar	χ^2 = 67.17, $p < .0001$	Very useful > Somewhat useful, χ^2 (138) = 8.38, $p < .01$ Very useful > Not very useful, χ^2 (92) = 69.57, $p < .001$ Somewhat useful > Not very useful, χ^2 (58) = 36.48, $p < .001$
Stop bar	χ^2 (144) = 91.54, $p < .0001$	Very useful > Somewhat useful, χ^2 (135) = 31.3, $p < .001$ Very useful > Not very useful, χ^2 (109) = 75.97, $p < .001$ Somewhat useful > Not very useful, χ^2 (44) = 15.36, $p < .001$
GPM	χ^2 (144) = 33.04, $p < .0001$	Very useful > Somewhat useful, χ^2 (117) = 15.80, $p < .001$ Very useful > Not very useful, χ^2 (107) = 26.55, $p < .001$
Apron holding point	χ^2 (144) = 18.29, $p < .0001$	Very useful > Not very useful, χ^2 (91) = 18.47, $p < .001$ Somewhat useful > Not very useful, χ^2 (78) = 10.05, $p < .01$
Non-movement area	χ^2 (144) = 17.04, $p < .0001$	Very useful < Somewhat useful, χ^2 (111) = 8.66, $p < .05$ Somewhat useful > Not very useful, χ^2 (104) = 13.88, $p < .01$

Information Type Usefulness Ratings Frequencies by Information Type

Information Type	Rating	Number of Pilots	Percent
ILS hold line	Very useful	99	69%
	Somewhat useful	37	26%
	Not very useful	8	6%
Approach hold	Very useful	94	65%
	Somewhat useful	35	24%
	Not very useful	15	10%
RGL	Very useful	93	65%
	Somewhat useful	37	26%
	Not very useful	14	10%
Clearance bar	Very useful	88	61%
	Somewhat useful	48	33%
	Not very useful	8	6%

Information Type	Rating	Number of Pilots	Percent
Combination of RGL and stop bar	Very useful	86	60%
	Somewhat useful	52	36%
	Not very useful	6	4%
Stop bar	Very useful	86	60%
	Somewhat useful	52	36%
	Not very useful	6	4%
GPM	Very useful	80	56%
	Somewhat useful	37	26%
	Not very useful	27	19%
Apron holding point	Very useful	66	46%
	Somewhat useful	53	37%
	Not very useful	25	17%
Non-movement area	Very useful	40	28%
	Somewhat useful	71	49%
	Not very useful	33	23%