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Computer Skills Effects of Flight Data Monitoring Technology in an Aircraft Inspection Process

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College of Technology

**Computer Skills Effects of Flight Data
Monitoring Technology in an Aircraft
Inspection Process**

In partial fulfillment of the requirements for the
Degree of Master of Science in Technology

A Directed Project

By

Thomas P. Speca

March 31, 2011

Committee Member

Approval Signature

Date

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Title of Directed Project: Computer Skills Effects of Flight Data Monitoring Technology in an Aircraft Inspection Process

For the degree of Aviation and Aerospace Management

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EXECUTIVE SUMMARY

Specca, T., Purdue University, April, 2011 Computer Skills Effects of Flight Data Monitoring Technology in an Aircraft Inspection Process. Committee Chair: Dr. Mary E. Johnson

Purdue University has recently purchased and deployed a new fleet of aircraft that include a cutting edge avionics suite with flight data monitoring technology. This technology gathers data during flight on airframe, powerplant, and flight parameters of the airplane. This study evaluated how the new technologies influenced the inspection process of the airplanes, as well as highlight new skills required by the inspectors to utilize the technologies. This issue was addressed because inspectors may not be able to take full advantage of what the new data from the airplane if they don't possess the proper skills to access and assess the information. The project was conducted through process mapping the inspection process as it is currently without the new technology, and after the implementation of the new technology. The maps were used to identify how the process and where the process has changed. From these changes it highlighted the skills were required to use the new technology. The result of the project was four process maps, as well as identification of different skills needed to complete the inspection utilizing the new technology. The process maps with the skills highlighted, may be used to develop training needs or as a tool to benchmark required skills and abilities during the hiring process.

SECTION 1. INTRODUCTION

The process of inspection is one of the most important steps ensuring airworthiness of an aircraft in flight. Inspection is usually a manpower intensive process, frequently carried out visually, and used to identify where and what parts of the airplane are in need of maintenance, repair, or overhaul. Traditionally, inspection takes place with the use of job cards to instruct an aircraft inspector where or what to inspect, and what process to go through. With the introduction of computer based flight data monitoring (FDM) systems, the job of the inspector is requiring increasing amounts of computer interaction. The onboard airplane computers are able to instruct the inspector on places that require more attention than usual, rather than the more general tasks previously required by the paper driven, manual system. This project's goal was to identify the changes in the inspection process brought on by these new technologies, and understand the impact new technologies bring to aircraft safety and maintenance.

1.1. Research Questions

- In what ways will the Purdue Aviation Technology new fleet of Cirrus airplanes and the associated General Aviation Flight Data Monitoring (GA-FDM) system provide change opportunities for the process to inspect aircraft during scheduled and unscheduled inspections?
- What computer skills are needed during the inspection process to access, evaluate, and interpret the information provided by these new technologies?

1.2. Scope

The goal of this research was to gather information on the impact of the new GA-FDM technology and how it affects the inspection processes conducted

during an unscheduled or scheduled phase 1, 2, 3, 4 or 5 inspection of a Cirrus SR20 compared to the traditional system used without the GA-FDM technology. Information was gathered through interviews with the employees of Purdue Aviation Technology and reviewing literature on the functionality of the GA-FDM system.

1.3. Significance

The information gathered from this research was used to highlight baseline skills needed to interpret data from the GA-FDM system into usable aircraft knowledge when performing an inspection. This highlighted skill set could then be used by others in evaluating the current skills of individuals using the system, in establishing training sessions to increase proficiency with the system, and as a set of skills to look for when considering hiring of new employees. The process maps created during the research documented the inspection process which can be used by other to understand the process as it currently is and the process after the incorporation of GA-FDM technology. Those maps can then be used as a baseline for future improvement projects.

1.4. Definitions

Alakai Technologies – “a Hopkinton, Massachusetts-based company that develops, manufactures, and integrates products to enhance aircraft safety. Alakai (pronounced “al-uh-ki”) is the Hawaiian word for “leader” or “guide” (Alakai Technologies & CAPACG, Inc., 2008, p. 2)

CAP Aviation Consulting Group - CAPACG – “a consulting firm and systems integrator focused on helping hardware and software companies develop products specifically for the General Aviation FDM market. CAPACG is an

expert in helping operators develop, implement and operate their FDM programs” (Alakai Technologies & CAPACG, Inc., 2008, p. 2)

Cirrus SR20 – A four seat, piston engine, propeller driven, general aviation airplane model produced by Cirrus Aircraft (Federal Aviation Administration, 2010).

Flight Data Monitoring – FDM – the technology and methodology for collecting and analyzing data recorded in flight (Lau, 2007).

Flight Operations Quality Assurance – FOQA – a voluntary safety program that is designed to make commercial aviation safer by allowing commercial airlines and pilots to share de-identified aggregate information with the Federal Aviation Administration (FAA) so that the FAA can monitor national trends in aircraft operations and target its resources to address operational risk issues (pg.1) (Federal Aviation Administration, 2004).

General Aviation Flight Data Monitoring – GA-FDM – FOQA/MOQA system made by Alakai Technologies and CAPACG, LLC. for use on Cirrus SR20 and SR-22 aircraft (Alakai Technologies, 2010).

Hangar of the Future – (HOTF) – Research project in the Aviation Technology Department of Purdue University that aims to incorporate modern computer and networking tools into the aircraft maintenance hangar of tomorrow.

Maintenance Operations Quality Assurance – MOQA – A program for obtaining and analyzing data recorded in flight to improve maintenance aspects of aircraft operations and safety (Wellington, 2004).

1.5. Assumptions

The research was conducted according to the following assumptions:

- The Alakai flight data monitoring hardware is installed on the Cirrus SR20 airplanes.
- The GA-FDM system will be used for the Cirrus SR20 airplanes.

1.6. Limitations

The research was conducted within the following limitations:

- This research only covered the Purdue Aviation Technology Hangar 6 maintenance facility.
- Only the phase 1, 2, 3, 4 or 5 scheduled and unscheduled inspection processes for the SR20 aircraft were reviewed and mapped.
- Only the GA-FDM system produced by Alakai Technologies and CAPACG was researched.

1.7. Delimitations

The research conducted was completed according to the following delimitations:

- This study did not cover other facilities than the Purdue Aviation Technology Hangar 6 maintenance facility.
- This study did not create or implement software or hardware.
- This study did not assess the technicians for skills and abilities.
- This study did not create training sessions.
- This study did not research opinions on the GA-FDM system.
- This study did not assess the success of the GA-FDM system.
- This study did not assess opinions on the Cirrus airplanes, parts for the airplanes, or maintenance of the airplanes.
- This study did not review or analyze how the flight operations, policies, and procedures were affected by GA-FDM technology.

- This study did not review or analyze the additional cost or safety changes due to GA-FDM technology.

1.8. Summary

This study compared the aircraft inspection process changes at the Purdue Aviation Technology Hangar 6 maintenance facility between the new Cirrus fleet with and without FDM technologies, and highlighted the skills and abilities needed by the maintenance inspectors to use the new technology and realize the benefits.

SECTION 2. LITERATURE REVIEW

A literature review was conducted on the process of aircraft inspection, flight data monitoring technology, and process mapping to seek an understanding of the environment and technology involved in this study.

2.1. Introduction

This project was accomplished as a part of a larger Hangar of the Future (HOTF) ongoing project evaluating aircraft maintenance processes. HOF is currently researched in the Aviation Technology Department of Purdue University. HOTF research is working toward incorporating computer based technologies into maintenance hangar operations to increase efficiency as well as safety of aircraft inspection and maintenance. HOTF research covers topic areas such as the job task card monitoring systems and the use of networked auto-find technologies like radio frequency identification (RFID) and two dimensional bar-code tagging. The project carried out for this report ties into the HOTF through tracking and understanding how the incorporation of new computer technologies influence hangar operations, and how the required skills and abilities change due to the new processes.

2.2. Flight Data Monitoring

Advancements in sensors, computers and statistics are creating new capabilities of next generation aircraft from large commercial airplanes to general aviation aircraft (Pool, 1998). New aircraft such as the Boeing 787 Dreamliner will

have built in health and flight monitoring systems able to analyze data collected from various sensors located around the aircraft, predict maintenance issues, and relay information automatically via wireless communication to awaiting maintenance technicians (“787 Programme update”, 2009). One metric for failure prediction as mentioned by Nordwall (2002) is, “the probability of failure within a specified number of flight hours. For example, the goal is to be able to predict when a certain hydraulic pump has a 90% chance of failing with the next 10 flight hours” (pg. 59). With a new ability to predict failure and automatically report the need for maintenance from on-board aircraft technologies, the inspection and maintenance systems need the ability in their computer systems to handle the information and present it in an understandable format. Computers on-board aircraft used to gather maintenance as well as flight data are called flight data monitoring (FDM) systems.

The FDM data flow from the aircraft to the users starts with sensors built into individual airplane parts (Federal Aviation Administration, 2004). The sensors from the parts on the aircraft send their information to the Airborne Data Recording System (ADRS) where the data is stored. At this point, the data can be retrieved by a computer in flight for displaying to the flight crew, or will be retrieved after flight by maintenance crews. Many FDM systems have the capability to hold information from more than one flight, so aircraft operators can download the information at a frequency and schedule that is convenient. In some cases, data is uploaded through cellular networks or wireless internet based technologies. After retrieving the data, it is uploaded to a Ground Data Replay and Analysis System (GDRAS) which then transforms and analyzes the data into usable information. The information is compared to expected results, and a report is developed highlighting areas of concern. Two forms of expected results are an exceedance analysis and a statistical analysis. An exceedance analysis is when certain maximum and minimum limits, which are set up by each operator are exceeded, resulting in issues such as overloading of the airframe, and require attention, such as an inspection. Statistical analysis is when flight

and aircraft performance is looked at across many flights and used to develop trend data. This trend data can identify when aircraft parts are deteriorating, or it may be used to initiate training sessions with flight crews (Federal Aviation Administration, 2004).

In the late 1990s, new technologies began allowing commercial aircraft operators to easily fill the need for a way to gather and aggregate flight information across companies, in order to strive for increased flight safety. By aggregating flight and maintenance information by aircraft type, trends could be tracked and identified for use in identifying problems before they cause accidents. This need for information initiated the drive for what became the Flight Operations Quality Assurance (FOQA) and Maintenance Operations Quality Assurance (MOQA) programs airlines use today. The FOQA/MOQA information is gathered by the each airline, the Federal Aviation Administration, and equipment manufacturers and can be used in areas such as:

- Operational Safety
- Aircraft Performance
- Aircraft System Performance
- Crew Performance
- Company Procedures
- Training Programs
- Training Effectiveness
- Aircraft Design
- Air Traffic Control System Operation
- Airport Operational Issues
- Meteorological Issues (p. 9) (Federal Aviation Administration, 2004).

Noticing the increased safety brought upon by FOQA/MOQA systems to the large commercial airliners, FOQA/MOQA systems have begun to trickle down into integration for regional aircraft, corporate jets, and general aviation airplanes. With the aid of FOQA/MOQA systems, small single, piston engine aircraft are

becoming capable of providing information to help with flight training, improve maintenance scheduling, and even develop the ability to perform more accurate accident reconstruction (Mitchell, Sholy, & Stolzer, 2007).

2.3. The Changing Role of Aircraft Inspection and Maintenance

Traditional aircraft maintenance and inspection is done through the use of knowledge gains from past aircraft designs. Parts on aircraft are traditionally limited to established maximums whether the maximums are time in service or flight cycles before the airplane must be inspected, repaired, or removed. Inspection of aircraft has been accomplished through the use of paper based systems instructing the inspector to visually look at or in some way perform a non-destructive testing procedure to evaluate the condition of the specific part of the airplane. These traditional methods have proven a level of reliability through the years and lead to a high level of flight safety, but they have grown to a point of limitation.

2.3.1. Airplane Inspectors

Officially, the certification of an inspector is called Inspector Authorization (IA) and is granted by the Federal Aviation Administration (Certification: Airmen other than Flight Crewmembers, 2010) according to The Code of Federal Regulations (CFR), Title 14 – Aeronautics and Space, Part 65 – Certification: Airmen other than Flight Crewmembers. To be eligible for an IA, a person must (Certification: Airmen other than Flight Crewmembers, 2010):

1. Hold a currently effective mechanic certificate with both an airframe rating and a powerplant rating, each of which is currently effective and has been in effect for a total of at least 3 years;
2. Have been actively engaged, for at least the 2-year period before the date he applies, in maintaining aircraft certificated and maintained in accordance with this chapter;

3. Have a fixed base of operations at which he may be located in person or by telephone during a normal working week but it need not be the place where he will exercise his inspection authority;
4. Have available to him the equipment, facilities, and inspection data necessary to properly inspect airframes, powerplants, propellers, or any related part or appliance; and
5. Pass a written test on his ability to inspect according to safety standards for returning aircraft to service after major repairs and major alterations and annual and progressive inspections performed under part 43 of this chapter (Certification: Airmen other than Flight Crewmembers, 2010).

IAs must renew their authorization during the month of March every odd numbered year (ex: 2011, 2013, ect.), meaning the authorization lasts two years. IAs must also accomplish one out of a set of five activities spelled out in the CFR to keep their authorization current. The CFRs state that it is the role of an IA to (Certification: Airmen other than Flight Crewmembers, 2010):

1. Inspect and approve for return to service any aircraft or related part or appliance (except any aircraft maintained in accordance with a continuous airworthiness program under part 121 of chapter 65) after a major repair or major alteration to it in accordance with part 43 of chapter 65, if the work was done in accordance with technical data approved by the Administrator; and
2. Perform an annual, or perform or supervise a progressive inspection according to §§43.13 and 43.15 of this chapter (Certification: Airmen other than Flight Crewmembers, 2010).

As the laws illustrate, it is the role of the inspector to ensure the condition of the airplane as well as the work accomplished on the airplane is airworthy. This requires the IA to be vigilant in their duties, knowledgeable of aircraft damages and maintenance, and a leader amongst maintenance crews. It is the job of an IA to be on the cutting edge of aircraft technology, as to be able to utilize all the data

that the airplane makes available, to ensure the safety of those onboard when it takes flight.

2.3.2. Computer Incorporation

With the coming of modern computer automation and smarter avionics in aircraft, there is a developing need for strong computer skills amongst aircraft inspectors and maintenance technicians due to the airplane's ability to gather information specific to experienced conditions from each flight. Tegtmeier (2008) states, "MRO maintainers need new engineering skills that include strong IT (information technology) computing proficiency and understanding of hardware and software interfaces to harness e-enabled features on next generation aircraft" (pg. 58). Increased use of computers and electronics on aircraft is narrowing the gap between the computer technicians and aircraft maintenance technicians and engineers (Tegtmeier, 2010). Skills in navigating computers and maintenance management software, as well as a strong ability to communicate electronically, are a few of the skills that Professor Mark Williams at Embry-Riddle Aeronautical University believes that management personnel in aircraft maintenance facilities should have (Baldwin, 2010). Williams also suggested "older personnel" in the business still do not have the skills required to be completely comfortable with today's computer technology (Baldwin, 2010). With the addition of computers that can take on a larger role in flight and maintenance of aircraft, Galloway (2009) argues that the role and definition of the aircraft maintenance technician may have to be updated to cope with the increasing computer technologies.

The changing and advancing world of aircraft maintenance is one that can bring a new level of safety to flight. This new level of safety can slip however, if the technicians lack the ability to access and interpret the new knowledge that the airplane is reporting. In order to completely benefit from the information being provided by the airplanes, all the functionalities of these new systems must be realized and used as to ensure no accessible safety measure is overlooked.

2.4. GA-FDM

The flight data monitoring system incorporated onto Purdue University's Cirrus SR20 aircraft fleet was developed through a joint venture between Alakai Technologies and CAPACG. This system, titled General Aviation Flight Data Monitoring (GA-FDM), was created as a way to bring the benefits of FDM and FOQA systems used on commercial and other large aircraft, to the small aircraft of general aviation and flight training (GA-FDM & Purdue University, 2010). The direct benefits of the GA-FDM system are (Alakai Technologies, 2010):

- Monitor and decrease the cost of flying
- Improve operational safety
- Meet CFR Part 135 requirements
- Conduct Flight Following including real-time FDM
- Predict and avoid maintenance issues
- Monitor and track airframe stress
- Become better, safer pilots
- Implement Safety Management Systems (pg. 2) (Alakai Technologies, 2010).

Supplemental Type Certificate Number SA03407AT, issued by the Federal Aviation Administration, enables owners or operators of Cirrus SR20 and SR-22 airplanes to incorporate the Alakai Technologies' "smart box" and other system hardware on the aircraft (FAA, 2007). The equipment installed on the airplanes consists of (Alakai Technologies, 2010):

- Digital Flight Data System (DFDS), "Smart Box"
- Wireless Unit
- Crash-hardened Robust Memory Unit
- Optional Airborne digital video subsystem
- Optional Iridium-based SATCOM/Flight Following (pg. 2) (Alakai Technologies, 2010).

This hardware tracks and monitors engine and flight parameters whenever the airplane's electrical power is on. The hardware reviews the data in real time,

and sends an e-mail based flight report, AVMail, upon landing and establishing of a wireless connection, either WIFI or cellular data based. The AVMail report includes many MOQA parameters from the flight including (Alakai Technologies, 2010):

- Flight time
- Oil consumption
- Fuel economy
- Service times
- Airframe and Engine Exceedances
- Airframe and Engine Trend Analysis (pg.1) (Alakai Technologies, 2010).

A link for flight track files is also included in AVMail for the pilot to review their flight performance using GoogleEarth or X-Plane (GA-FDM, n.d.).

Recorded flight and engine data is also sent to the CAPACG servers upon landing, where it goes through analysis for trend monitoring and exceedance of various engine parameters (Alakai Technologies & CAPACG, Inc., 2008). CAPACG analysts review the flight information, and send reviews to the owner/operators based on how the data compares to the expected parameters. After completion of the analysis for the airplane, CAPACG sends an e-mail report, FDMail, to the owner/operator for review. FDMail contains information for operations, exceedances, fuel economy, and maintenance (GA-FDM, 2010). Upon receiving the AVMail or FDMail notifications, the owner/operator can take the appropriate action, which may be to conduct an inspection and maintenance on the airplane.

Brian Morrison, President and Chief Technical Officer of Alakai Technologies and Larry McCarrol, Chief Executive Officer of CAP Aviation Consulting Group, LLC., (personal communication, January 26, 2011) explained that AVMail and FDMail are a way to distribute the data and make any exceedances or trends known. The GA-FDM technology does not provide explanation to the root cause of the problem, this interpretation is left up to the

individual who receives the report. The e-mails do provide hotlinks to specific parameters that require attention. Any further information that the ground personnel may need can then be accessed through the GA-FDM servers over the internet (Morrison & McCarrol, personal communication, January 26, 2011).

Pilots can also use the information to improve their flight skills and performance by applying the information to decisions and maneuvers made during their flights. Pilots training on the equipment, as well as students learning to maintain and work with the equipment have an added advantage of experience with FOQA and MOQA systems, leading to quicker understanding and easier transition into larger, commercialized systems.

The ability to understand what happened to the airplane, as well as track the performance of the pilots on every flight provides information which may bring improvements to the safety of flight. With the ability of airplanes to track information on themselves and deliver relevant information to the users, the ability to translate and use the information for valuable feedback is the key to successful implementation of the system.

In the future, GA-FDM plans to expand and push the limits of the system's functionality. Working with cellular networks or ADS-B technologies, GA-FDM hopes to upload data in real-time to servers (Morrison & McCarrol, personal communication, January 26, 2011). Real-time data uploads would mean that in flight problems can be remotely tracked. This gives the ability for ground personnel to begin diagnosing discrepancies that may happen during a flight, and direct the pilots to change flight plans accordingly. In certain cases, ground crews may even be able to diagnose a problem, schedule a technician, and gather any needed tools, parts, and other materials while the airplane is still in the air in order to correct the problem immediately upon landing for quicker turnaround of the airplane (Morrison & McCarrol, personal communication, January 26, 2011).

2.5. Computer Skills and Abilities

Currently there is no one common standard for how to accurately assess an individual's computer abilities. Computer users from software and operating system developers to, schools, and private companies have developed their own set of standards to which they can assess individuals to the needed skills they have defined as necessary. A list of basic computer skills and abilities was developed by adapting and compiling literacy skills from assessment tools used by Microsoft, the St. Paul Community Literacy Consortium (SPCLC), and Indiana University at Kokomo.

These three sources represent three differing aspects towards the needs for computer skills and abilities. Microsoft creates the Excel software and the Windows operating systems, representing the skills assessment from the viewpoint of the designers (Microsoft, 2010). The St. Paul Community Literacy Consortium, based out of St. Paul, Minnesota, is a community based organization that focuses on increasing the literacy of all types within the community which has recently become the new home for refugees from around the world (St. Paul Community Literacy Consortium, 2010). In 2010 the SPCLC created a task force of professionals from the community, school systems, non-profit organizations and state agencies to develop digital computer learning standards (St. Paul Community Literacy Consortium, 2010). Their skill sets represent the basic need from a community viewpoint towards abilities to function computers. Indiana University at Kokomo, a regional campus of Indiana University, uses the computer skills assessment as a basis for the ability for students to succeed in the learning environment established at the university. This skill set represents the computer skills and ability foundation needed by modern incoming university students (Indiana University at Kokomo, 2010).

The basic categories for computer skills and abilities derived from the previous sources include *operating system skills*, *basic software skills*, *basic internet browsing skills*, *basic e-mail skills*, and *Microsoft Excel skills*.

Operating system skills consisted of any skills needed to navigate and manipulate the desktop environment, using Microsoft based operating systems as the basis. Table 1. Basic Operating System Skills is the derived basic skills list for using an operating system (St. Paul Community Literacy Consortium, 2010; Indiana University at Kokomo, 2010).

Table 1. Basic Operating System Skills

Basic Skills List	St. Paul Community Literacy Consortium, 2010	Indiana University at Kokomo, 2010
Turn on and off the computer.	X	X
Log into and out of a profile.	X	X
Identify the desktop and the associated icons	X	
Customize the desktop environment.	X	
Identfy and use basic hardware (mouse, keyboard, monitor)	X	X
Use single click, double click, right click	X	X
Navigate through the menu bar to access software or other computer tools.	X	X
Maximize and Minimize windows	X	X
Navigate and manipulate (open, copy, paste, move, create) files and folders.	X	X

Being able to use an operating system is the basic set of skills needed in navigating the computer environment, and is the foundation to using any other computer tool. The inspectors need to be able to use the operating system to organize and store data, as well as access the computer tools needed to analyze and share the data.

Table 2. Basic Software Skills

Basic Skills List	St. Paul Community Literacy Consortium, 2010	Indiana University at Kokomo, 2010
Turn on and off the computer.	X	X
Log into and out of a profile.	X	X
Identify the desktop and the associated icons	X	
Customize the desktop environment.	X	
Identify and use basic hardware (mouse, keyboard, monitor)	X	X
Use single click, double click, right click	X	X
Navigate through the menu bar to access software or other computer tools.	X	X
Maximize and Minimize windows	X	X
Navigate and manipulate (open, copy, paste, move, create) files and folders.	X	X

Basic software skills are skills that are used by standard software packages created for the general computer user. General software is software that can be installed and used by a novice computer user with little to no training. The skills needed for basic software packages are required to open and manipulate data in order to make it into usable information. The software programs used by the inspectors are EG View, Cirrus Reports, X-Plane, and PDF document viewers. Table 2 is the derived basic skills list for using basic software (St. Paul Community Literacy Consortium, 2010; Indiana University at Kokomo, 2010). Basic software skills are needed by the inspectors to use the software packages which can analyze the data from the airplane. The basic software tools used available to the inspectors to analyze the data are EG View, Cirrus Reports, and X-Plane.

Table 3. Internet Browsing Skills

Basic Skills List	St. Paul Community Literacy Consortium, 2010	Indiana University at Kokomo, 2010
Identify and open a web browser.	X	X
Type in a URL.	X	X
Search terms in a search engine.	X	
Use the forward and back buttons.	X	X
Use the webpage history to revisit webpages.		X
Bookmark to favorites lists.		X
Create and use tabs.	X	X
Fill in text boxes for online forms.	X	
Use hyperlinks.	X	X

Internet browsing skills are increasing in importance in today's society. The need to efficiently browse, navigate, and research on the internet are more often being required due to incorporating common computer utilities to internet based environments. Table 3 is the derived basic skills list for basic internet browsing (St. Paul Community Literacy Consortium, 2010; Indiana University at Kokomo, 2010). The internet has become today's basic tool to information searching and sharing. The inspectors can use the internet to research problems they may be having on an airplane, or even to access internet based software such as Cirrus Reports.

Table 4. Basic E-mail Skills

Basic Skills List	St. Paul Community Literacy Consortium, 2010	Indiana University at Kokomo, 2010
Input e-mail addresses to the "To", "CC", and "BCC" sections appropriately.		X
Create a secure password.	X	
Write a proper subject.	X	X
Use the reply, reply all, and forward features.	X	X
Attach files and open attached files.	X	X
Create folders to save and organize important e-mails.	X	
Use basic e-mail etiquette when writing an e-mail.	X	
Properly identify and handle junk mail.	X	

Basic E-mail skills are used to communicate through the basic peer-to-peer internet information sharing tool. E-mail allows not only allows a personal message to be sent between people, but also allows for easy attachment of files. The sharing of files and information makes e-mail another important tool in today's industrial environment.

Table 4 is the derived basic skills list for basic e-mail skills (St. Paul Community Literacy Consortium, 2010; Indiana University at Kokomo, 2010). The Hangar 6 inspectors can use e-mail to share any data from the airplane between one another, or with Cirrus for further analysis. The inspectors will also receive AVMail reports on the airplanes over e-mail, therefore utilizing e-mails efficiently will be part of their everyday job tasks.

Table 5. Basic Microsoft Excel Skills

Basic Skills List	Microsoft, 2010
Understand the structure of the spreadsheet	X
Interpret data from an existing spreadsheet	X
Understand the terminology such as row, column, and cell	X
Enter and upload the data to cells	X
Create appropriate row and column titles	X
Format Cells	X
Input basic calculations	X
Use basic formulas and cell references	X
Sort data	X
Create graphs	X
print spreadsheets	X

Basic Microsoft Excel skills are needed for organizing and displaying data the spreadsheet software. Microsoft Excel is a tool incorporates the basic software skills, and extends needed skills to more advanced skills such as programing. Skills and knowledge in Microsoft Excel are valued by many employers, as it is an efficient way to store, and organize data. The Purdue University Aviation Technology Hangar 6 operations use Microsoft Excel to manipulate data for easy reading as well as graphing.

Table 5 is the derived basic skills list for Microsoft Excel (Microsoft, 2010). These basic skills in Microsoft Excel allow an individual to quickly manipulate data into usable information that can be applied to their particular situation. Inspectors using the data from the airplane may use these skills to pull out the data that are interested, and produce a spreadsheet or graph that allows them to

focus on the information that will lead them to diagnosing a potential problem on the airplane.

The skill sets are an aggregate of the skills listed in the basic requirements lists as published by Microsoft (2010), the St. Paul Community Literacy Consortium (2010), and Indiana University at Kokomo (2010). The skills represent the foundation needed to function in the digital environment.

2.6. Process Mapping

As the use of Lean and Six Sigma techniques in the workplace becomes more widespread, the incorporation of process map as a tool to guide the improvements does as well. Process maps are used in this role for many reasons. According to George, Rowlands, Price, and Maxey (2005) process maps help by providing a readily available visualization of the work flow which shows how each step can affect the process and the overall ability to reach the end goal. Turning the focus from a step specific scope to a process wide scope increases the ability of each process step to work together towards reducing the process flow time as a whole. These maps may be used as a standard to establishing guidelines and setting up expectations for each step in the process from start to finish. Any problems that may arise in the process can be easily reviewed using the map as a reference to how the step fits in the process, providing an opportunity to change the process to a more efficient plan.

Process mapping has been used by many studies in order to achieve the benefits described in the previous paragraph. Eiff and Suckow (2008) explain that the aviation industry has been successful in the incorporation of process mapping to reduce accidents, and increase efficiency and profitability in flight, maintenance and operational environments by controlling the process. They further explain how the “big picture” gained from the easy to understand, graphic nature of the process map by all the stakeholders, was a large part in making all the benefits possible. Eiff and Suckow (2008) recommend using process maps as a way to identify how and where new technology incorporates into the

process, “The process mapping tool can provide a roadmap for strategically determining appropriate points where technology can provide the biggest benefit to the technician and company as well as potential problems associated with technology integration” (p. 50).

Another successful integration of process mapping into an aviation environment is in a study by Aungst, Johnson, Lopp and Williams (2008) to map the process of planning and preparing non-routine job cards for airplane maintenance in a large commercial aircraft maintenance, repair, and overhaul facility. In this research, a graduate student team used the process mapping technique to follow non-routine maintenance through the stay of an aircraft. By simply mapping this process, the graduate team eliminated as many non-value added steps as possible, and streamlined the routine to make it as computerized and quick as possible. The new process developed by the team reduced the original 103 tasks by more than 54, and replaced 27 tasks with computer data sorting, illustration tasks, or computer decision functions (Aungst, Johnson, Lopp & Williams, 2008).

Process mapping can also be used to accomplish more than just Lean and Six Sigma programs in an industrial facility. In his efforts to bring real life professional work to the class room, Ropp (2008) explains how the use of process map in his undergraduate, senior level class at Purdue University accomplishes the tasks of establishing a Safety Management System (SMS). Using the process map and other process hazard assessment tools as a guideline, Ropp was able to develop an industry based laboratory scenario that was focused on safety, as well as completing maintenance tasks as efficiently as possible.

Process maps have a vast amount of uses in the workplace. Not only can a process map be used to establish the way things are being done, but can be used to incorporate new technologies, fix problems, increase safety, and spread knowledge to those people that are a part of the process. Process maps provide

a way to see how each process step affects the others, and can be used to suggest changes that will improve the overall flow and safety of the business.

2.7. Summary

Safety in the aviation industry is the number one priority. Consistently achieving the primary goal of safety can be facilitated through the use of process mapping, new technologies, and new skills. With the arrival of new technologies such as flight data monitoring to today's fleets, spanning from big to small airplanes, the jobs and knowledge of those working with them must also keep up. Using process maps is one proven way to not only control and establish the current process, but to find ways to push the envelope to make the industry a safer and more efficient for those working in it, and for everybody affected by it. Using the process maps, the additional skills required by new technologies can be traced to process steps, and managed through planning and preparing for the incorporation of the new technology.

SECTION 3. METHODOLOGY

This research was a case study to determine the impact of a technology change on the existing aircraft maintenance inspection process between the Cirrus airplane fleet with and without new Flight Data Monitoring technology at the Purdue Aviation Technology Hangar 6 maintenance facility. This section outlines the approach and process that was carried out to develop a map of the processes, and analyze the differences in order to create an inventory of the skills needed to interpret and use the data from the flight data management system

3.1. Population and Data Collection

Interviews were conducted with individuals in the Purdue Aviation Technology Hangar 6 maintenance facility to document the processes used to conduct inspections on the airplanes with and without the new GA-FDM technology. Process maps were developed and validated with the individuals to ensure accuracy and completeness.

3.2. Project Steps

- 1) Apply for and obtain Institutional Review Board approval.
- 2) Gain approval from Assistant Department Head in charge of Flight Operations to conduct the interviews of the Purdue Aviation Technology Hangar 6 maintenance facility maintenance staff.
- 3) Contact the Hangar 6 Inspectors to plan and prepare them for the mapping session.

- 4) Develop four process maps with the Purdue Aviation Technology Hangar 6 maintenance facility maintenance staff for the inspection processes used on the Cirrus fleet without FDM and the Cirrus fleet with GA-FDM technologies during the scheduled and unscheduled inspections.
 - a. Use poster paper and sticky notes to write and lay-out the process flows (George, Rowlands, Price, & Maxey, 2005).
 - b. Review the overall flow after completing the steps.
 - c. Transfer the process maps to digital form (George, Rowlands, Price, & Maxey, 2005).
- 5) Validate the process map with the Purdue Aviation Technology Hangar 6 maintenance facility maintenance staff and make any necessary revisions.
- 6) Develop an understanding of the steps in the process affected by the GA-FDM system used on the Cirrus aircraft.
- 7) Identify the process changes, as well as highlight skills and abilities needed to complete the inspection process using the GA-FDM technology.

3.3. Analysis

A comparison was conducted between the Purdue Aviation Technology Hangar 6 inspection processes used on Cirrus aircraft fleet without GA-FDM and the fleet with the GA-FDM technology. The research established how the new technology has influenced the process, as well as, highlighted skills required to utilize the functionality of the flight data monitoring system incorporated into the aircraft fleet. A step-by-step process map gap analysis was used along with interviews with GA-FDM representatives, a review of literature, and interviews with the inspectors at Hangar 6 to develop a highlighting of the skills required to complete the aircraft inspections.

3.4. Summary

This research was conducted in association with the Purdue Aviation Technology Hangar 6 maintenance technicians, to map their inspection processes, and highlight needed skills.

SECTION 4. DATA AND RESULTS

The data and results in this section were gathered in accordance with the Institutional Review Board at Purdue University and the methodology explained in Section 3. The data found applies only to the Purdue University Aviation Technology Hangar 6 maintenance facility using the Cirrus SR20 aircraft and the associated flight data monitoring (FDM) technologies.

4.1. Data Collection

Data for the research was collected during three meetings over three consecutive weeks in January 2011 with the lead inspectors at the Purdue University Aviation Technology maintenance operation.

The first meeting included development of the rough draft of the inspection process map for the fleet of Cirrus airplanes. Sticky notes were used to place process steps onto a large section of paper in the order described by the lead inspectors for both the scheduled and unscheduled inspection processes. At the end of the initial process development, the process was reviewed for completeness, and some minor changes were made. After the meeting, a digital version of the map was created. The digital version of the process maps not only included the process as described by the inspectors, it categorized every step of the process into skill based categories to be described in Section 4.2.

The second meeting with the lead inspectors further refined the process by removing, reorganizing, or adding appropriate steps to the process. The categorization of skills was introduced, and confirmed with the lead inspectors as well. Print outs of the digital version of the process maps were brought to this meeting. Changes were suggested by the lead inspectors, and then written onto

the printout. These corrections were made to the digital version after the meeting, and any additional steps were then categorized into the previously described format.

The final meeting was used to validate the maps that were created. A digital version was once again brought to this meeting. Final validation of the process was confirmed. After the meeting, a copy of each of the process maps was e-mailed to the lead technicians. The complete versions of the four maps, scheduled inspection without the GA-FDM technology, scheduled inspection with the GA-FDM technology, unscheduled inspection without the GA-FDM technology, and unscheduled inspection with the GA-FDM technology, can be found in the appendix; Appendix B, Appendix C, Appendix D, and Appendix E respectively.

4.2. Map Format Conventions

Process maps for scheduled and unscheduled inspection were created using the basic process map shapes on Microsoft Visio. After completion of the process steps, each step was assigned a number based on a simple numbering convention. The scheduled and unscheduled processes without the GA-FDM technologies were numbered starting on the left and ending on the right, incorporating any vertically placed steps into the numbering system while moving horizontally to the right. The scheduled and unscheduled processes with GA-FDM steps were numbered the same as the scheduled and unscheduled steps without GA-FDM when they read exactly the same. When the process with GA-FDM had steps added that weren't on the processes without GA-FDM, the steps were numbered starting with the step immediately before where they were, and adding a decimal based on location amongst the added steps. Figure 1 is an example of this addition, where the top row of steps is the original process without the GA-FDM technology, and the bottom row is the process with the GA-FDM technology. The modified inspection process adds a step for including any

GA-FDM based discrepancy reports, so the number for that step was made 7.1 due to its incorporation after step 7, but before step 8.

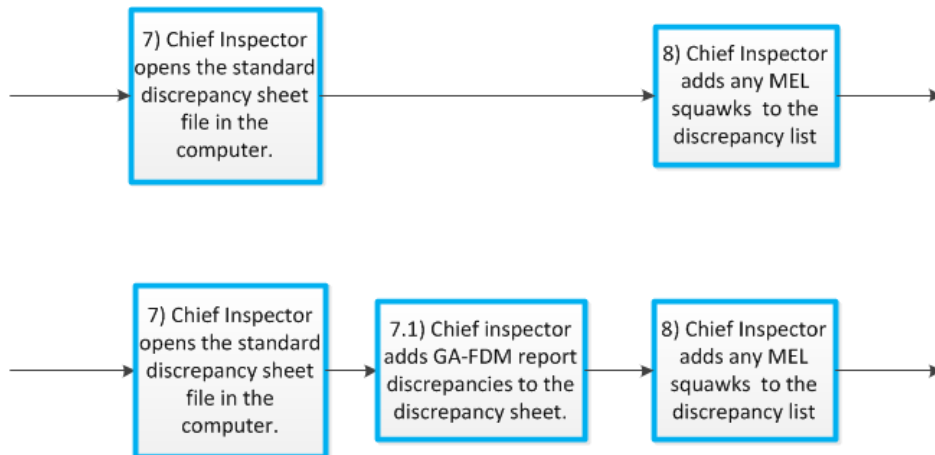


Figure 1. Numbering Convention – Added Steps

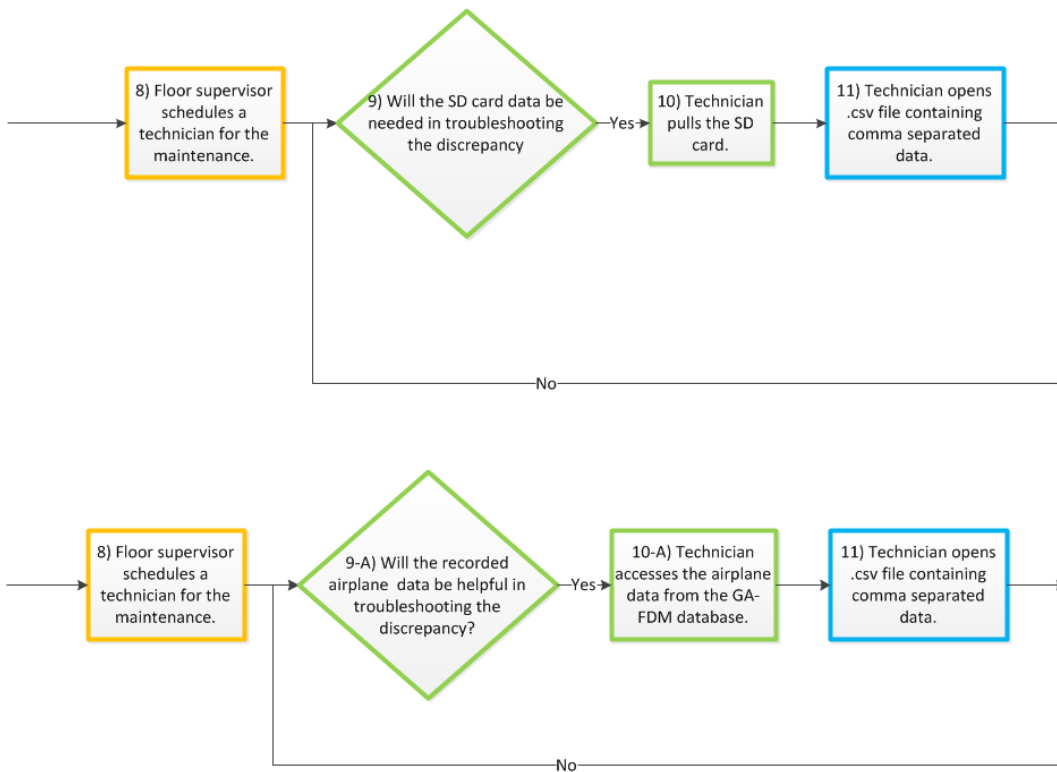


Figure 2. Numbering Convention – Altered Steps

Steps that are similar to the process without the GA-FDM technology, but slightly changed due to the technology incorporation, added a “-A” to the step number. Figure 2 is an example of steps that were changed when the GA-FDM technology was incorporated, but were still similar to the process without the GA-FDM technology. In this example, without the GA-FDM technology the technician had to get the SD card out of the airplane, and with the technology, the technician can access the information over the internet, so the number for this step would change from 10 to 10-A.

A decision step, common in all the four of the process maps, was mapped with an intentional deviation from the norms of process mapping. The decisions step deviates from the norms in order to make for a more aesthetic, easy to read process map that reads similarly to the way one thinks, rather than the way a computer reads. Figure 3 and Figure 4 are the steps from the Hangar 6 inspection process maps showing the standard method to map the decision process, and the alternate way the decisions were mapped respectively. In these steps, a decision needs to be made about using one of four software packages in order to present the information from the flight. The inspector has the option to use any of the packages, and therefore must decide which package would work best.

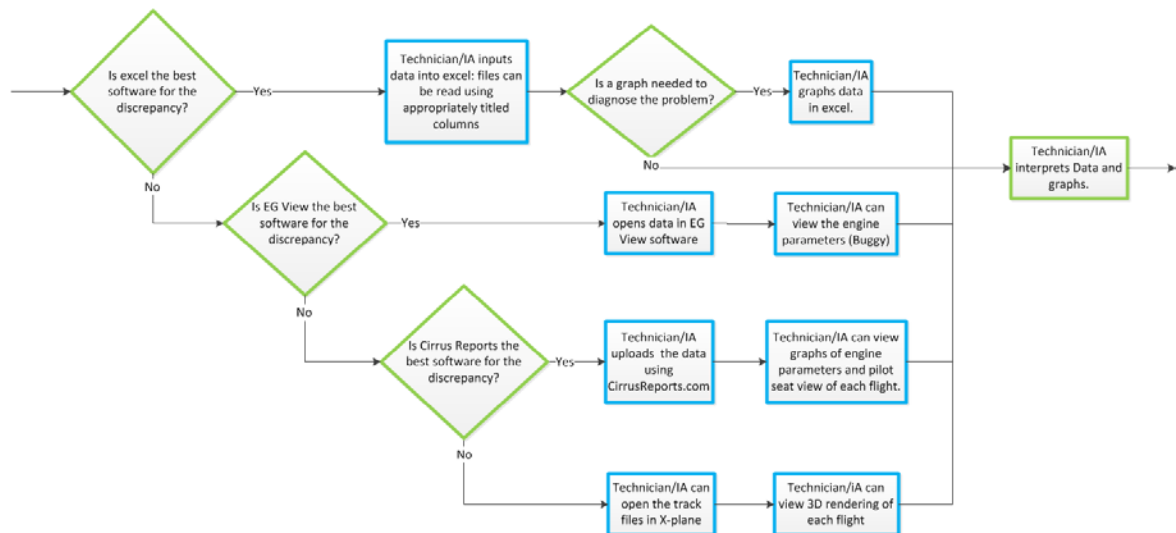


Figure 3. Four Way Decision – Standard

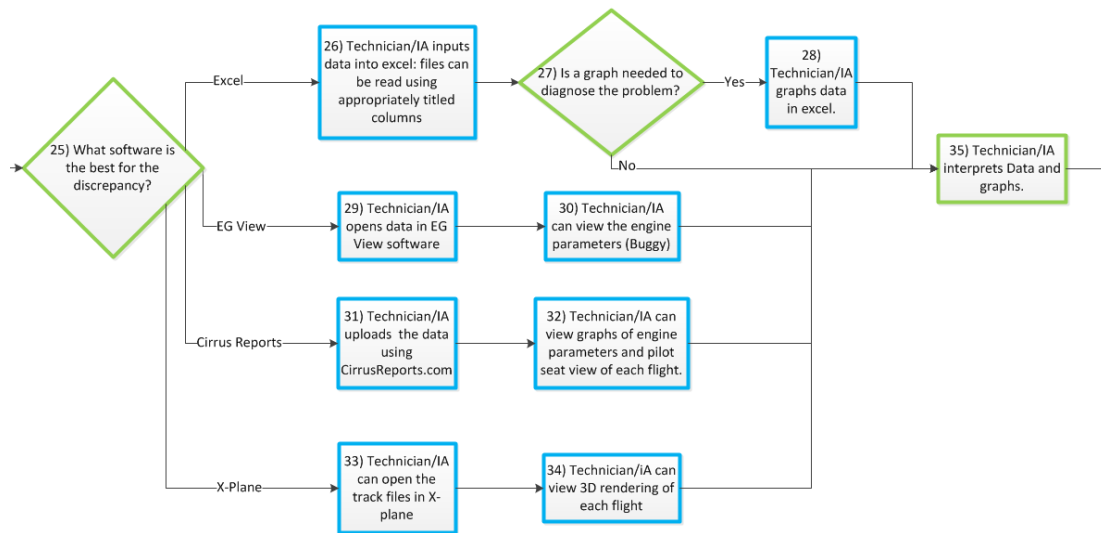


Figure 4. Four Way Decision – Alternative

The alternative four way decision process method reduced multiple decision steps into one step, similar to the way they would mentally consider which package to choose. The alternative way is easy to understand, and does not clutter the map with extra decision steps.

Another convention that was used in the process maps was color coding. The color coding calls attention to the specific types of skills required by each step. The skills categories that were considered in this study along with the color codes used for each of them were:

- *Computer Interaction* – Blue
- *Non-Hangar 6 Operations* – Red
- *Computer Automation* – Purple
- *Airframe and Powerplant (A&P) Skills* – Green
- *Office Skills* – Orange.

A *computer interaction* step is a step that requires the personnel in Hangar 6 to use a computer to complete the step. A *non-hangar 6 operations* step is any step in the process that is completed by personnel not a part of the maintenance

operations completed in Hangar 6. A *computer automation* step is any step that is completely done by a computer and requires no human interaction. An *A&P skills* step is any step that requires that the person has knowledge and skills relating to the airframe and powerplant certification issued by the Federal Aviation Administration. Finally, an *office skills* step is any skill set that would be used in an office setting other than skills used with computers. Some office skills examples are reading, writing, job assignment, and completing, filing and organizing paperwork.

4.3. Computer Interaction Analysis

Steps that require computer interaction by the inspectors were further divided as to what types of skills were required to access the data from the airplane, as well as the skills required to apply the data to a software package. A review of the requirements and criteria in computer usage, as covered in Section 2.5, was used to categorize the computer skills needed by the inspectors on the scheduled and unscheduled inspections with and without the GA-FDM technology. A comparison of the required skill sets before and after the incorporation of the GA-FDM technology was then used to highlight new skills required after the GA-FDM technology is functioning. The general computer skills categories are operating system skills, general software skills, internet browsing, e-mail, and Microsoft Excel.

Each of the steps on the process maps that required computer interaction was analyzed for the specific skill sets required. A Microsoft Excel spreadsheet was created to organize the skills required by each based on an overview of the software packages, as well as the experience of the researcher. Figure 5 is an example of the spreadsheet developed for the computer interaction analysis.

Scheduled Phase Check Inspection Process Analysis

Process Step Number	Process Step Title	Skill Category	Specialized Computer Skills (previous box is "Computer Interaction")
1	Flight dispatch update airplane flight times in Flight Scheduler Pro.	Not H6 Operations	
1.1	Chief Inspector checks GA-FDM reports for discrepancies.	Computer Interaction	E-Mail, Internet Browsing, Basic Operating System Skills
1.2	Is there a discrepancy?	Office Skills	
1.3	No action required	Not H6 Operations	

Figure 5. Computer Interaction Analysis (Partial worksheet)

The spreadsheet includes the process step number, the process step title, the skill category, and specialized computer skills if the step required computer interaction. The complete spreadsheets for the scheduled inspection can be found in Appendix F and the unscheduled processes can be found in Appendix G.

4.4. Scheduled Inspection Process Analysis

The scheduled inspection process contained 47 steps before the incorporation of the GA-FDM technology, and 54 steps with the GA-FDM technology. The analysis of steps in the process can be found in Table 6.

Table 6. Scheduled Inspection Process Analysis

	Without GA-FDM	With GA-FDM	Added Steps	Altered Steps
Not H6 Operations	3	4	1	0
Computer Interaction	16	20	3	1 (from A&P Skills)
Office Skills	7	8	1	0
Automated	0	0	0	0
A&P Skills	21	22	2	-1 (to Computer Interaction)
Total	47	54	7	

When the GA-FDM technology is added to the process, there will be seven extra steps in total required to complete the inspection. After the incorporation of GA-FDM, one altered step changed the required skill to complete the step from A&P skills to computer interaction skills. This step previously required the inspectors to retrieve a memory card from the airplane without the GA-FDM technology. With the GA-FDM technology, the inspectors will be able to access the data downloaded to a database from the aircraft using a wireless connection. The database is accessible from any internet connected computer.

Table 7 is the analysis of the skill sets required by the scheduled maintenance process with and without the GA-FDM technology.

Table 7. Scheduled Inspection Computer Skills Analysis

	Scheduled w/o GA-FDM	Scheduled with GA-FDM
Basic Operating System Skills	X	X
Software	X	X
Internet Browsing	X	X
Email		X
MS Excel	X	X

The additional skills required by the process after the GA-FDM technology is incorporated are the skills needed to use e-mail.

4.5. Unscheduled Inspection Process Analysis

The unscheduled inspection process contained 35 steps before the incorporation of the GA-FDM technology, and 40 steps with the GA-FDM technology. The analysis of steps in the process can be found in Table 6.

Table 8. Unscheduled Inspection Process Analysis

	Without GA-FDM	With GA-FDM	Added Steps	Altered Steps
Not H6 Operations	1	1	0	0
Computer Interaction	10	11	0	1 (from A&P Skills)
Office Skills	2	2	0	0
Automated	0	5	5	0
A&P Skills	22	21	0	-1 (to Computer Interaction)
Total	35	40	5	

When the GA-FDM technology is added to the process, there will be five extra steps in total required to complete the inspection. After the incorporation of GA-FDM, one altered step changed the required skill to complete the step from A&P skills to computer interaction skills. The change in this process is the same change as in the scheduled inspection process, where the inspectors no longer would have to retrieve the memory card and can access the information from a database stored on the internet.

Table 9 is the analysis of the skill sets required by the unscheduled inspection process with and without the GA-FDM technology. There are no differing computer skills required by the process after the GA-FDM technology is incorporated.

Table 9. Unscheduled Inspection Computer Skills Analysis

	Unscheduled Without GA- FDM	Unscheduled With GA-FDM
Basic Operating System Skills	X	X
Software	X	X
Internet Browsing	X	X
Email		
MS Excel	X	X

4.6. Further Analysis

Although Table 6 and Table 8 show the process increased in steps, and Table 7 and Table 9 show a minimal change in computer skills, the new technology does offer increased content to the process. This content enriches the process with data that was unavailable to the Hangar 6 inspectors before the current Cirrus fleet. This data may provide an opportunity to build knowledge about the airplanes as they age. The ability for the inspectors and technicians to turn the data into knowledge however, is a skill and ability that may require further analysis.

4.7. Summary

Data gathered during the research was sorted into tables for analysis and comparison of the processes with and without GA-FDM technology. In the scheduled inspection process seven steps were added, one altered step changed required skill sets, and e-mail is required when GA-FDM is incorporated into the process. In the unscheduled inspection process five steps were added, one altered step changed required skill sets, one altered step remained the same required skill set and no new computer skills were required when GA-FDM is

incorporated into the process Further conclusions as well as recommendations based on this analysis are further discussed in Section 5.

SECTION 5. CONCLUSIONS AND RECOMMENDATIONS

This section draws conclusions from the data that was recorded and analyzed in Section 4. Following the conclusions, recommendations for further advancement of Hangar 6 technologies, GA-FDM abilities, and research are discussed.

5.1. Scheduled Inspection Process Conclusions

When comparing the scheduled inspection process for the Cirrus SR20s with and without GA-FDM, the scheduled inspection process only incurs slight alteration and additions. The process increased by a total of seven steps. Two steps were decisions, one step was not done by Hangar 6 operations, one step led to the unscheduled inspection process, and the last three steps required computer interaction.

The longest additional time requirement for any of these added steps is estimated to be the step that requires reading the FDMail messages sent by GA-FDM, as seen in Figure 6.

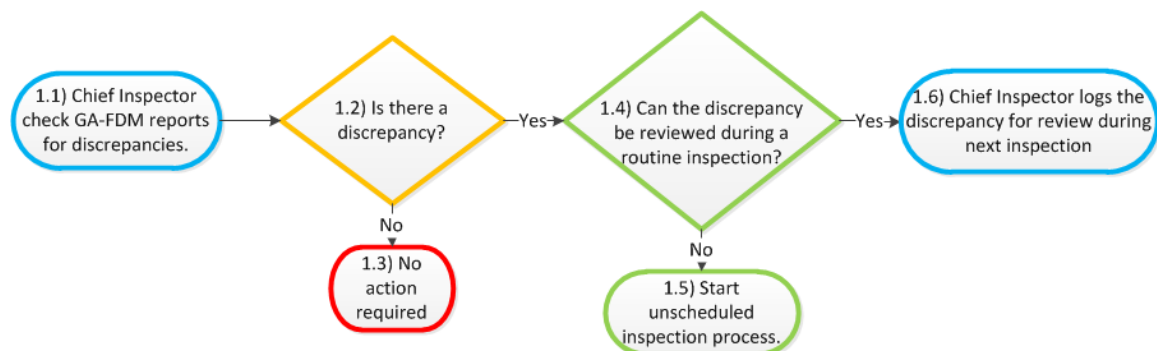


Figure 6. Inspector FDMail Review Process

In this step the inspector may take several minutes to review each airplane's monthly report. Although reading the aircraft reports does require time from the inspectors, the additional safety benefit from outside opinions and trend monitoring may help to identify possible trends toward an unsafe scenario, and then alert the inspectors so they may mitigate the problem. To accomplish this same task from manual records or without the GA-FDM FDmail would require far more time from inspectors.

One step that was altered from the addition of the GA-FDM was the need to access the airplane to retrieve the secure digital (SD) memory card for the airplane data when troubleshooting a discrepancy. The GA-FDM technology allows retrieval of the data over the internet from a database containing all the flight and engine information from the fleet. The ability to access the data from any internet source reduces the need to locate and access the plane for removing and acquiring the SD card. Therefore, the airplane can be stored in a remote hangar while parts are ordered. Remote storage limits the addition of the airplanes in the maintenance hangar, reducing possible damage to aircraft while stored in the maintenance hangar. Remote storage of the data also allows any previously uploaded data to be accessed in case of an accident.

The only new computer skill required by the process is the addition of e-mail based skills. Although the previous process does not include the need for e-mail, the inspectors are currently using e-mail as a key source of communication. Therefore the addition can be considered inconsequential.

The main benefits to be possibly gained by the inspection process are the potential for increased safety due to a third party analysis of the information, and saved time in accessing the information from any airplane, at any time, from any internet connected computer location. Since these benefits were not investigated in this study, these benefits may be assessed in future studies.

5.2. Unscheduled Inspection Process Conclusions

The unscheduled inspection, unlike the scheduled inspection, incurs a significant change in the process after the GA-FDM is incorporated into the process. When using GA-FDM technology, the airplanes will be able to automatically e-mail FDMail reports via wireless links. Discrepancies that happened to the airplane while the power is on are recorded to the SD card and then e-mailed when the airplane is on the ground and a wireless connection is established. Figure 7 shows the automatic update process carried out by the flight computers and GA-FDM technology.

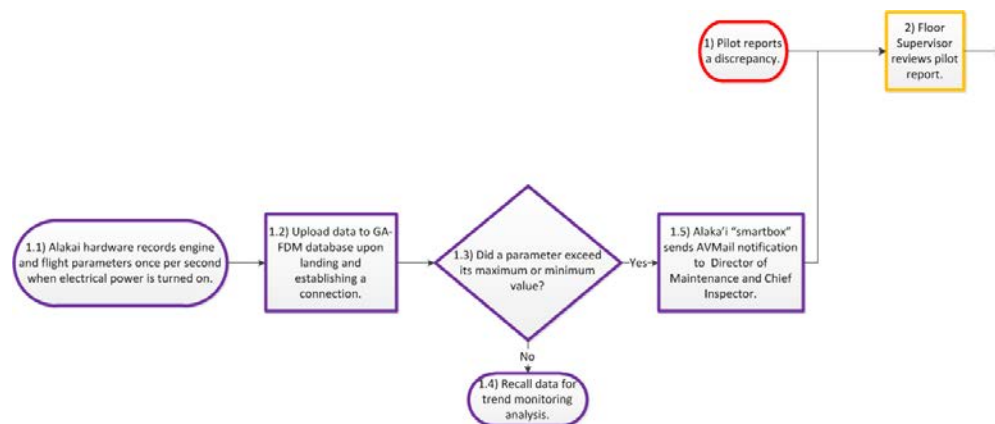


Figure 7. GA-FDM Automatic Flight Report Process

This automation of discrepancy reporting means if a discrepancy occurs and a pilot didn't notice it, or for one reason or another doesn't report it, the inspectors will be e-mailed a notice automatically, and can then look into what the cause was, as well as if there is a need for immediate attention. This e-mail of flight discrepancies will be sent at the end of every flight, so there is a possibility for numerous discrepancies to be passed along to the inspectors considering the size and flight schedule of Purdue University's Cirrus fleet. When the flight department begins to use the GA-FDM, the impact of this system, and the number of discrepancies brought to the attention of the inspectors may need to be reviewed. Small discrepancies which happened during any flight could quickly build up with the busy flight training schedule, possibly stalling the airplane from

departing on its next flight till the discrepancy can be cleared by an inspector or technician.

Besides the contact about flight discrepancies, the only changes to the process occur from no longer needing to access the SD card for the flight data, and instead using the internet to retrieve the information. These changes are exactly the same as the changes made in the scheduled inspection.

5.3. Recommendations

GA-FDM technology as well as the on-board computer flight data recording hardware create a large amount of data, providing opportunities for research and advancement. Cellular wireless technologies, as well as in-house data analysis, are possible near future abilities that may be of research interest.

During an interview with Alakai Technologies' President and Chief Technical Officer Brian Morrison and CAP Aviation Consulting Group, LLC.'s Chief Executive Officer Larry McCarrol (personal communication, January 26, 2011), they suggested the next improvement for the GA-FDM technology would be the ability to transmit flight data in real-time. Real-time information from the airplanes would provide the ability for any discrepancy to be reviewed and mitigated as it happens. Instant alerts would allow ground personnel to instantly contact the pilots in case of trouble, and support them in proper decision-making. This information could also be valuable when assessing a plane accident. All the flight information would have been uploaded to a remote database, protecting it from any possible damage caused by the forced incurred during the wreck. Investigations would be able to analyze all flight data, and make an accurate report on what the cause was, in order to correct any airplane flaws or make procedure updates.

Currently, the Purdue University Cirrus SR20s have all the necessary equipment for data sensing, storage, analysis, and transmitting on board. The fleet is currently capable of linking into the GA-FDM system, but is not currently activated. The benefit of GA-FDM technology is having a third party to review the

data and provide reports based on what they see. The Aviation Technology Department has the knowledge to review the data and make appropriate suggestions. However, there is a need for internal network and database skills. If some advanced computer skills and abilities in the area of networking and databases can be gained and established, the department could bring this service in-house, analyzing the data and developing the reports internally. The department may be able to develop these reviews into a proactive maintenance routine, which may lead into predicting failures before they happen, and replacing parts before the on-board parts fail. This would provide students with opportunities to learn new skills applicable in the commercial flight market. Developing these reports may lead into the development of new research projects, and encourage advances in airplane safety and maintenance monitoring.

Additional studies may look into how this technology affects the quality of the inspection process. The process maps created in this study can be used to guide an analysis into the quality of the aircraft inspection process on the Cirrus fleet, and find out what, if any, improvements in the ability to identify discrepancies are gained with the data available from the airplane and GA-FDM technologies.

5.4. Summary

The incorporation of the GA-FDM flight data monitoring technologies and analysis technologies to the Cirrus SR20 airplanes in the Purdue University Aviation Department fleet will provide the inspectors new insight into the condition of the airplanes. Monthly reports may help make inspectors aware of trending conditions that may exist, and daily flight reports may alert the inspectors to any parameter exceedances that occurred on a specific airplane during a given flight. Leaders in technology improvements are working toward real-time information flow from the airplanes that allows the inspectors to be constantly aware of the condition of each airplane and the fleet in total.

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Appendix A. Industrial Review Board Application

sRevised 11/08

RESEARCH EXEMPTION REQUEST

Ref. # _____

(Category 2 or 3)**Purdue University****Institutional Review Board**

Exemptions under Title 45 CFR §46.101

- (b)(2) exempts research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless:
- (i) Information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and
 - (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.
- (b)(3) exempts research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if:
- (i) The human subjects are elected or appointed public officials or candidates for public office; or
 - (ii) federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

PLEASE BE AWARE that you cannot begin the project until you have received notification that the exemption has been granted.

1. Project Title:

Understanding the Effects of Flight Data Management Technology In an Aircraft Inspection
--

2. Anticipated Funding Source:

N/A

3. Principal Investigator [See Policy on Eligibility to serve as a Principal Investigator for Research Involving Human Subjects]:

Dr. Mary E. Johnson: Associate Professor/ Assistant Department Head Research, Aviation Technology Niswonger, 765.494.1064 mejohnson@purdue.edu
--

Name, Title, Department, Building, Phone, Fax, E-mail address

4. Co-Investigators and key personnel [See Education Policy for Conducting Human Subjects Research]:

- Thomas Speca Graduate Student, AT NISW 815-822-7348 tspeca@purdue.edu - Tim Ropp, Assistant Professor, AT, NISW 765-494-9957 tropp@purdue.edu - Denver Lopp, Professor, AT, NISW, 765-494-6387 denver@purdue.edu - Mike Suckow, Assistant Department Head, Flight Operations/Clinical Associate Professor, AT, NISW, 765-496-6375, 765-496-1149, msuckow@purdue.edu
--

Name, Title, Department, Building, Phone, Fax, E-mail address

5. Consultants [See Education Policy for Conducting Human Subjects Research]:

None

Name, Title, Department, Building, Phone, Fax, E-mail address

6. Anticipated Duration of Study: Please indicate when this project will end. Estimate how long it will take to transcribe audio and/or video tapes if used, and when they will be destroyed.

Project END Date: 11/30/2011

Participant Population

7. Expected Age Range

Check all that apply:

- <18 (for public observation only when researchers do not interact with subjects)
 18-64
 65 and older

8. Describe location of subjects during research data collection

Check all that apply:

- Purdue University, specify campus: West Lafayette, IN
 Elementary/Secondary Schools, specify:
 Community Center, specify:
 Other University Campus, specify:
 Subject's Home, specify:
 International Location, specify:
 Other location, specify:

Summary of Activities

(use lay language, do not cut and paste from or refer to grant or abstract)

9. Briefly state your research question.

In what ways will the Purdue Aviation Technology information systems on the new fleet of Cirrus airplanes change the process to inspect aircraft during routine maintenance checks?

What skills are needed to access, evaluate, and interpret the information provided by these new systems?

10. Describe the tasks subjects will be asked to perform (e.g., frequency and duration of procedures, psychological tests, educational tests, and experiments; including screening, intervention, follow-up etc. Reminder: No sensitive information can be sought under exempt guidelines.) Attach all surveys, instruments, interview questions, focus group questions, etc.

Subjects will be asked to describe the processes used to conduct an inspection on the fleet of airplanes. Two process maps of the inspection process will be created: the inspection process of the airplanes without flight information systems and the inspection process with the new flight information system. Several meetings are planned with the inspectors.

- 1) 1 pre-meeting to introduce, familiarize and prepare the subjects for the study (1/2 hour)
- 2) 1-2 Meetings to develop the two process maps (1-2 hours each)
- 3) 1-2 Meetings to review, revise, and validate the process maps (1-2 hours)

11. How will the data be recorded?

- Written Notes
 Audio
 Video
 Photographs

Compensation

12. Will you give subjects gifts, payments, compensation, reimbursement, services, or extra credit?

YES

NO

If yes, please explain:

Snacks/beverages will be provided.

Recruitment

13. Check all that apply:

The subjects are elected or appointed public officials or candidates for public office.

If the above applies, for what office is your subject population a candidate, or if the subject population currently holds a public office for which they were elected or appointed, provide the title(s) of the office:

Federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter (45 CFR §46.101(b)(3)(ii)).

If the above applies, what federal statute(s) require(s) confidentiality?

None of the above applies

14. Describe the recruitment process to be used:

Permission for use of the time of Inspectors at Purdue Hangar 6 is granted from Assistant Department Head, Flight Operations. Inspectors will be asked to volunteer participation.

Attach a copy of any and all recruitment materials to be used (i.e. advertisements, bulletin board notices, e-mails, letters, phone scripts, or URLs.)

15. Explain who will approach potential subjects to take part in the research study and what will be done, if anything, to protect individuals' privacy in this process:

Aviation Technology Assistant Department Head, Flight Operations will inform them of the project. Only the subject's job titles will be used as part of the inspection process maps.

16. Is contact information for your subject population publicly available?

YES

NO

If no, describe your permissible access to this population (or include written documentation for the cooperation/permission from the holder or custodian of the records):

17. Is contact information for your subject population chosen from records?

YES

NO

If yes, what type of records?

Medical

Educational

Employment

Other, specify:

Who controls the permissible access for the use of the records?

Purdue University publishes employee contact information.

Confidentiality

18. Will the data be collected anonymously (without identifiers)?

- YES. Skip to end of document.
 NO. Describe the identifiers to be collected:

The title of the individuals will be used. There are less than 5 inspectors at Purdue Hangar 6. There will be two in the study.

19. Describe provisions that will be taken, if any, to maintain confidentiality of data (i.e. surveys, audio, video, etc.):

Names of subjects will not be taken or used. The maps will be a consensus of the collective knowledge of the group.

20. Estimate how long it will take to transcribe audio and/or video tapes and when they will be destroyed.

N/A

21. Will the PI be able to identify subjects (i.e. identifiers, code keys, etc.)?

- YES
 NO

22. Will identifiable data be made available to anyone other than the PI?

- YES
 NO

If yes, explain who and why they will have access to the identifiable data:

The study team will have access to the data collected, to help with analysis of the process maps, as well as for completion of a Master's Degree Directed project.

As Principal Investigator of this study, I assure the IRB that the following statements are true: I have read the Human Subjects "[Research Exemption Request Guidelines](#)." The information provided on this form is correct. I will seek and obtain prior written approval from the IRB for any substantive modification in the protocol, including changes in procedures, research team members, funding agencies, etc. I will not begin my research until I have received written notification of final IRB exemption. I will comply with all IRB requests to report on the status of the study. I will maintain records of this research according to IRB guidelines.

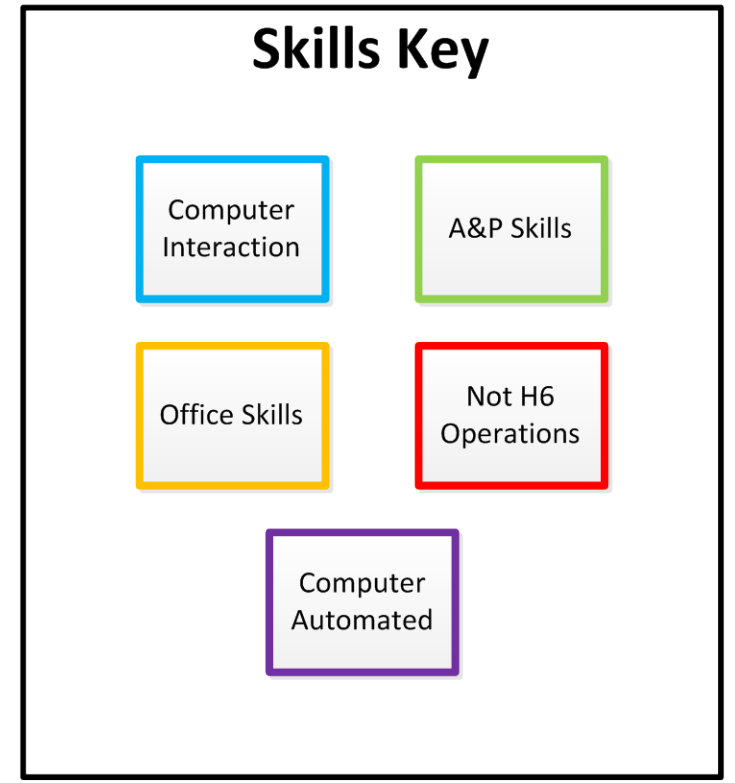
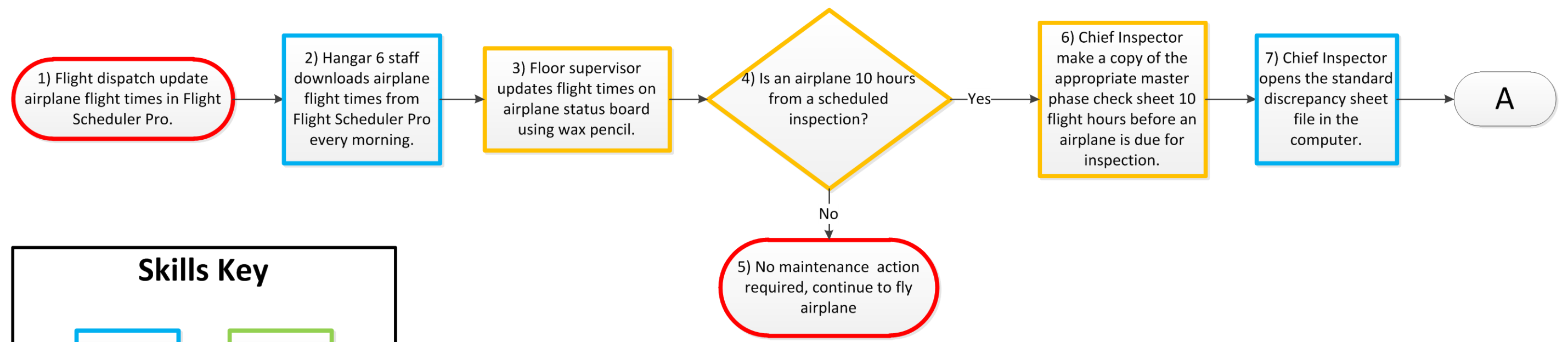
Principal Investigator Signature

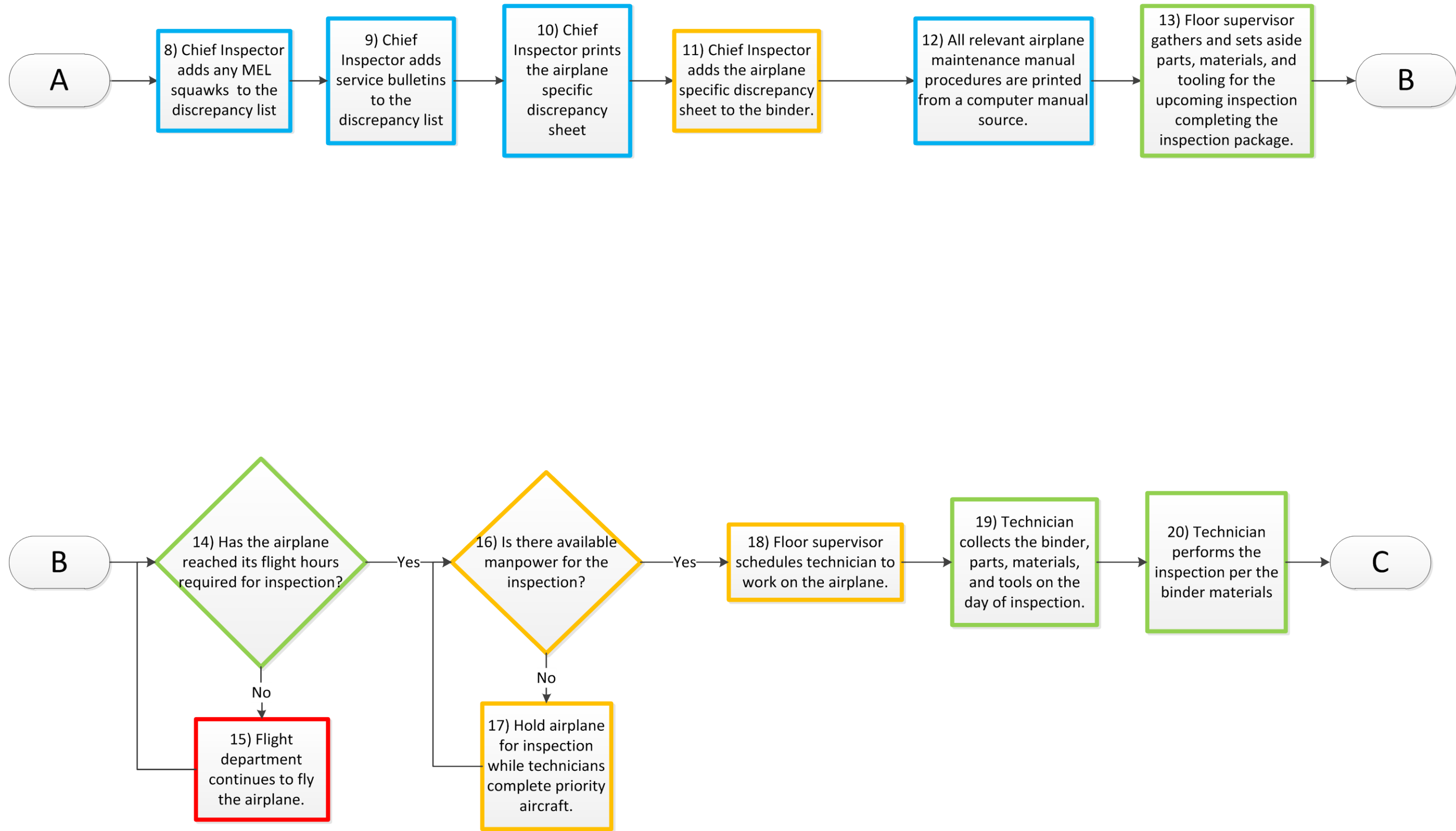
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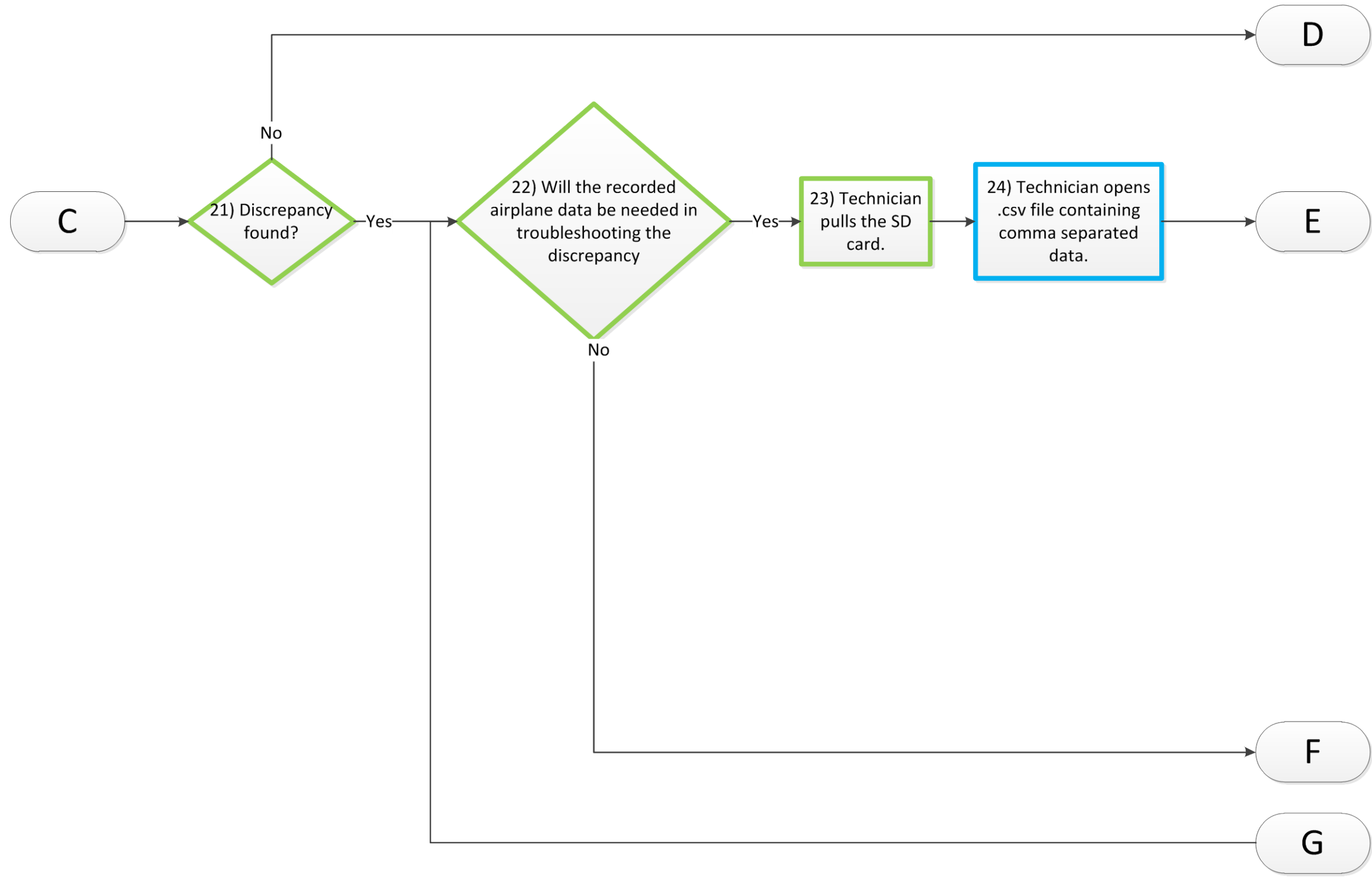
**Submit the original request to: Institutional Review Board (IRB), Ernest C. Young Hall
10th Floor, Room 1032**

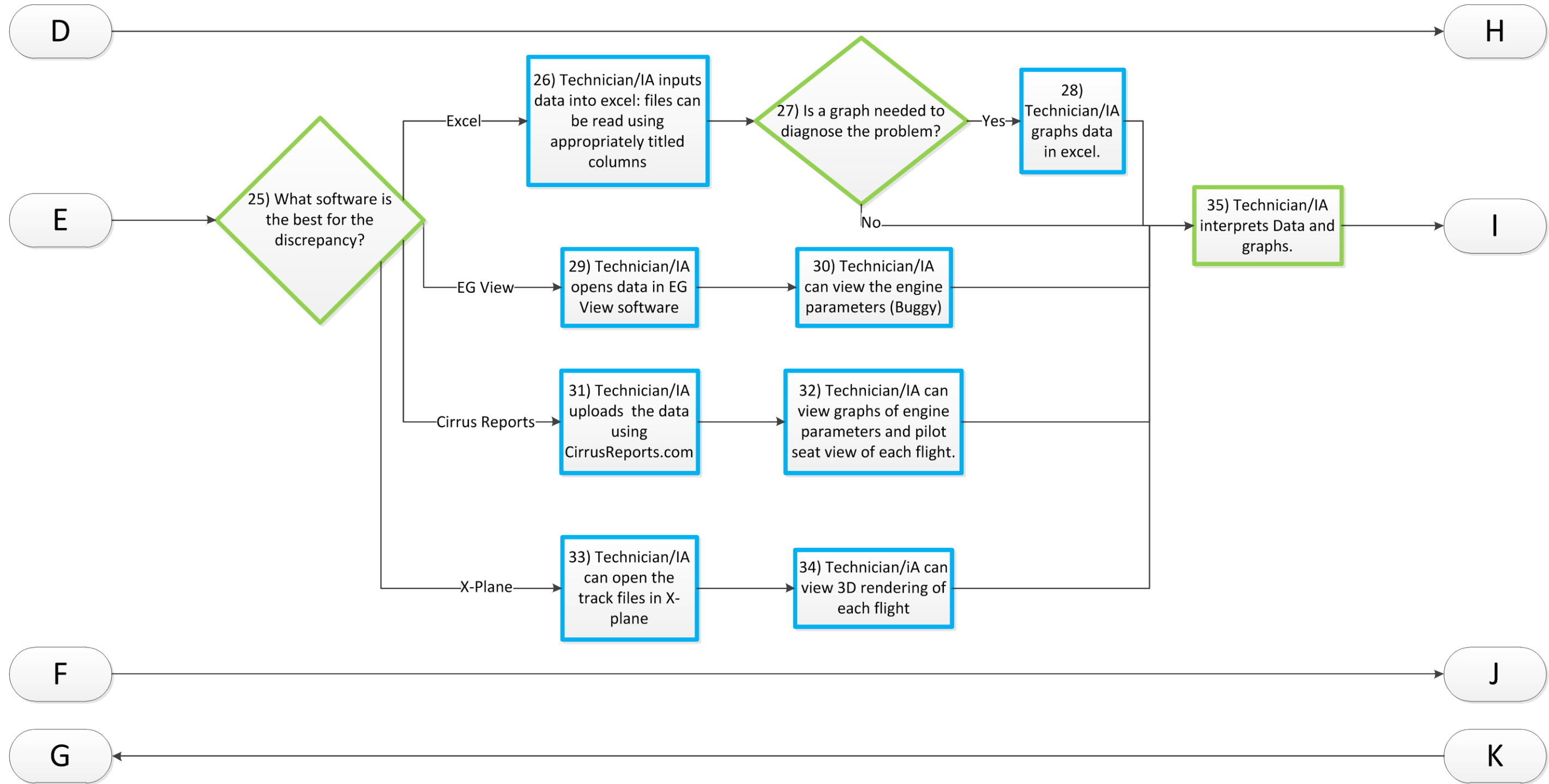
Appendix B. Scheduled Inspection Process without GA-FDM Technology

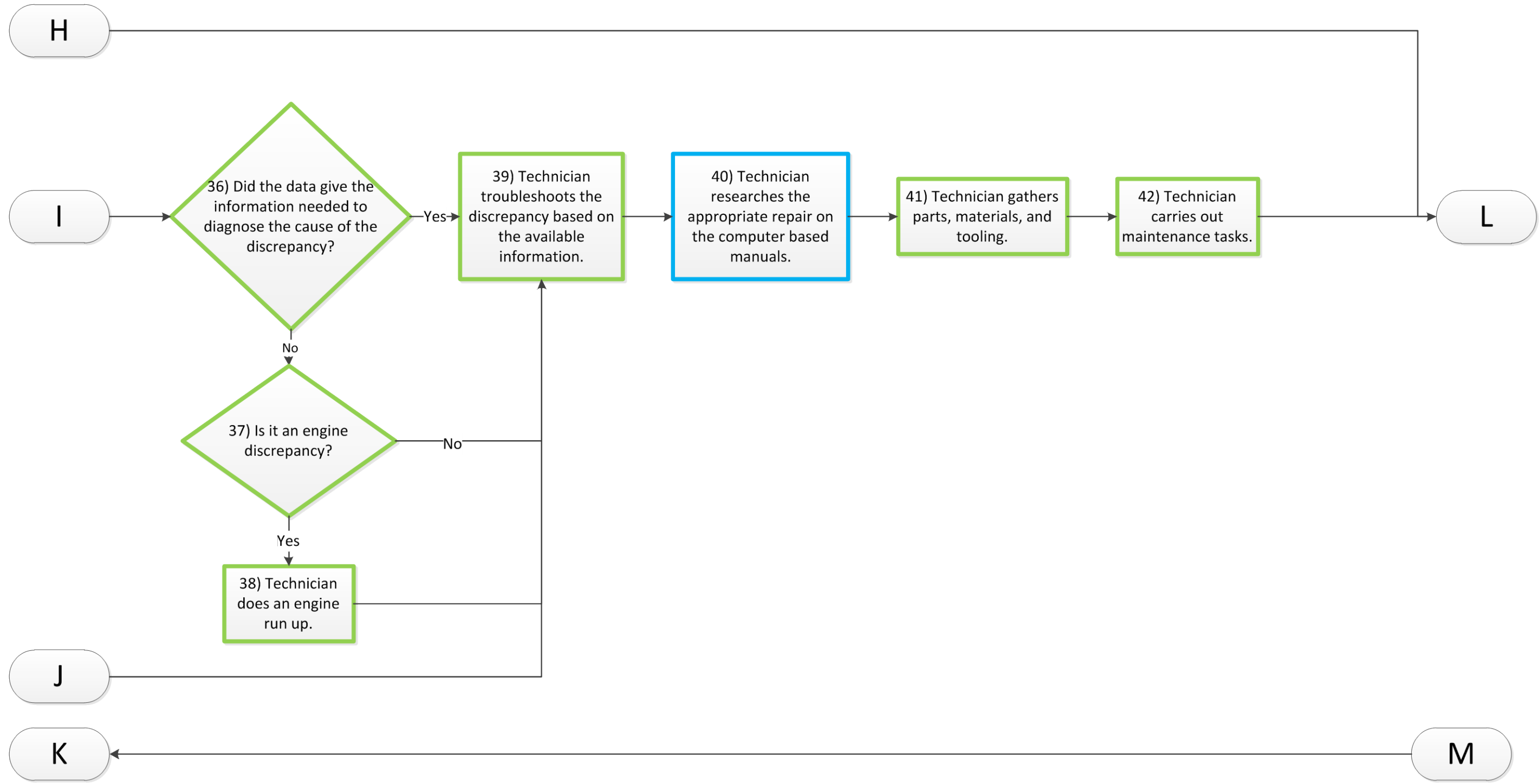
Schedule Phase Check Inspection without GA-FDM Technology

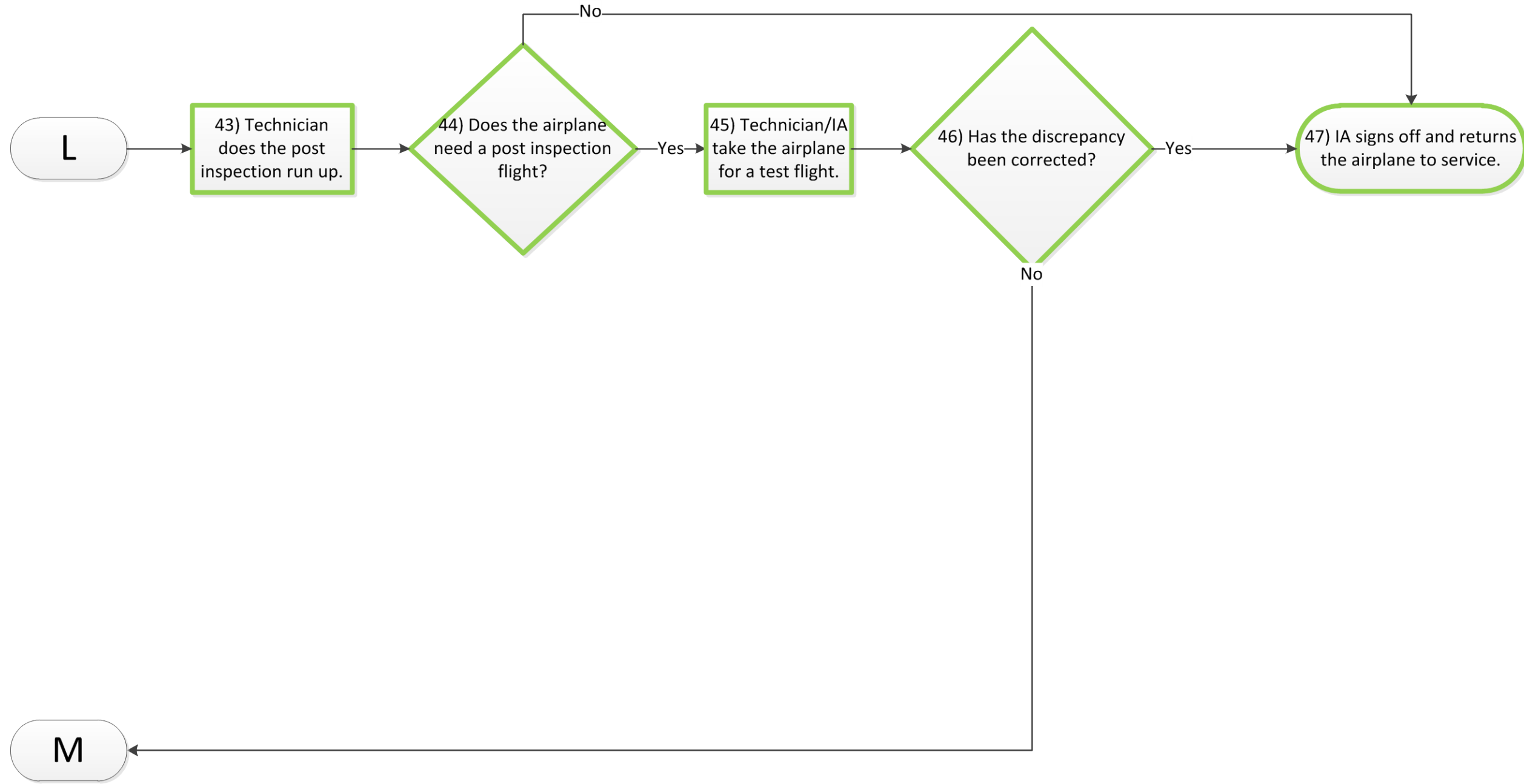






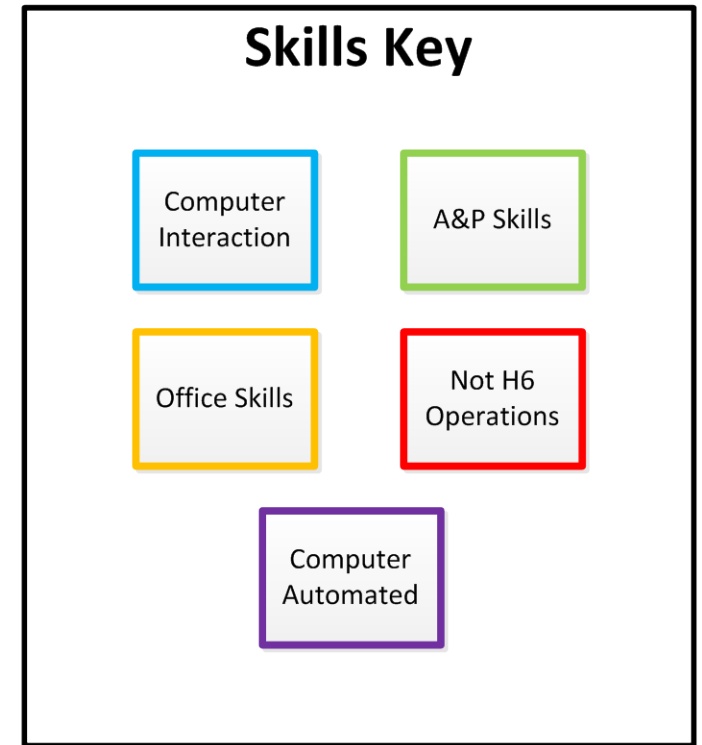
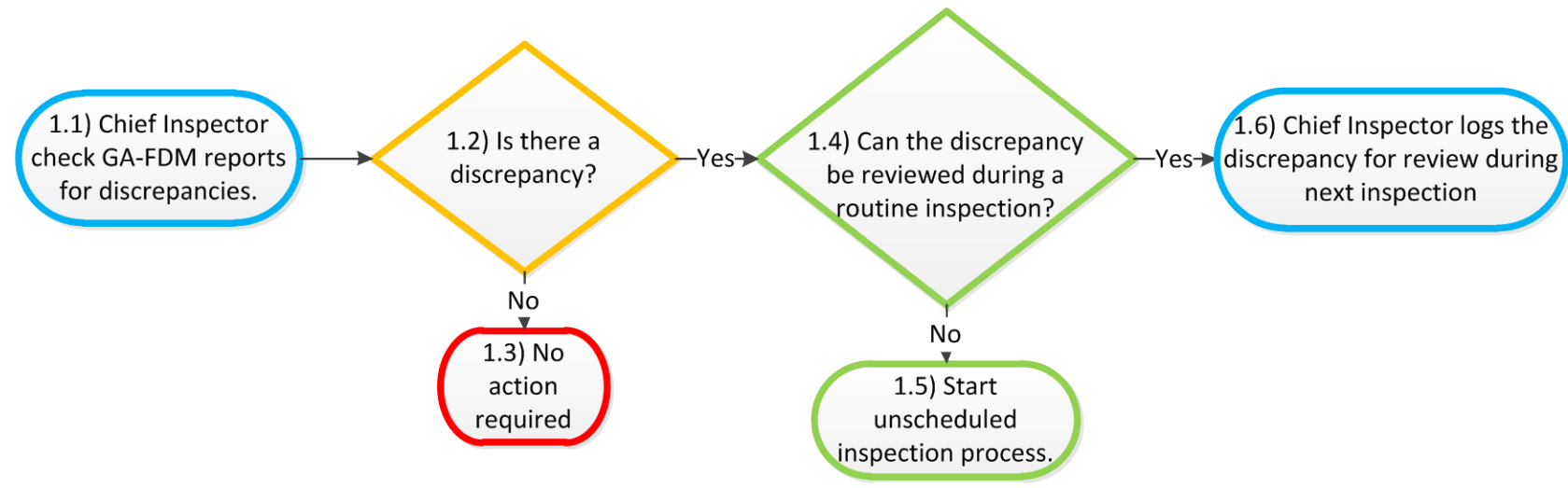
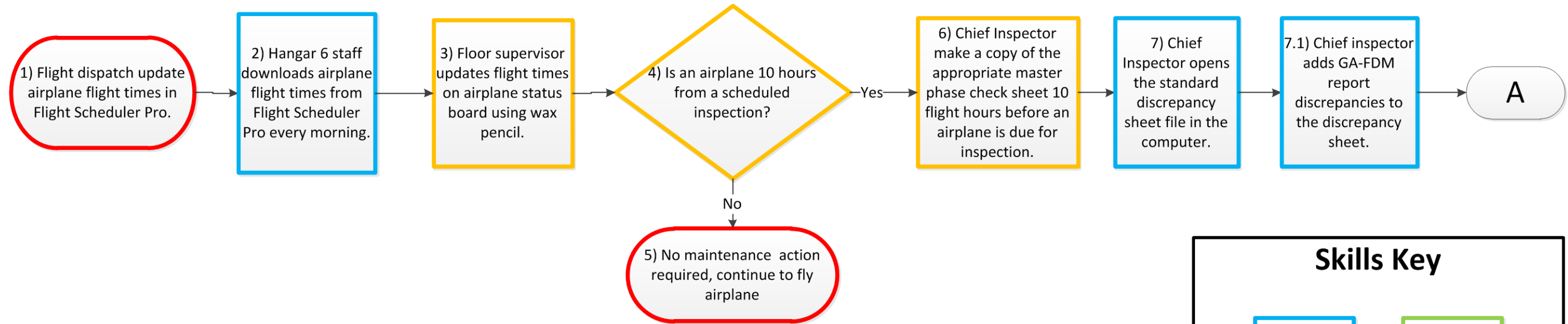


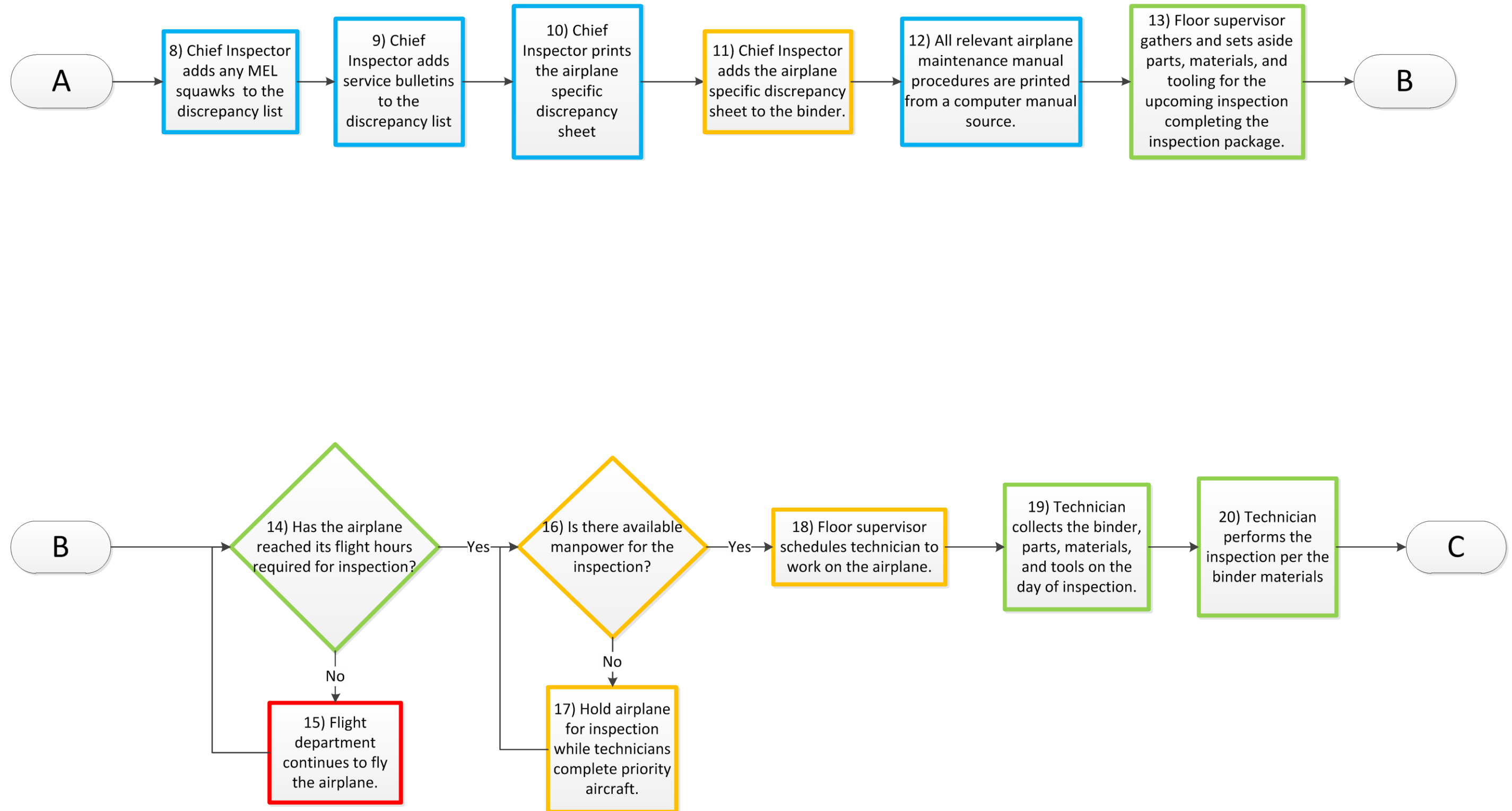


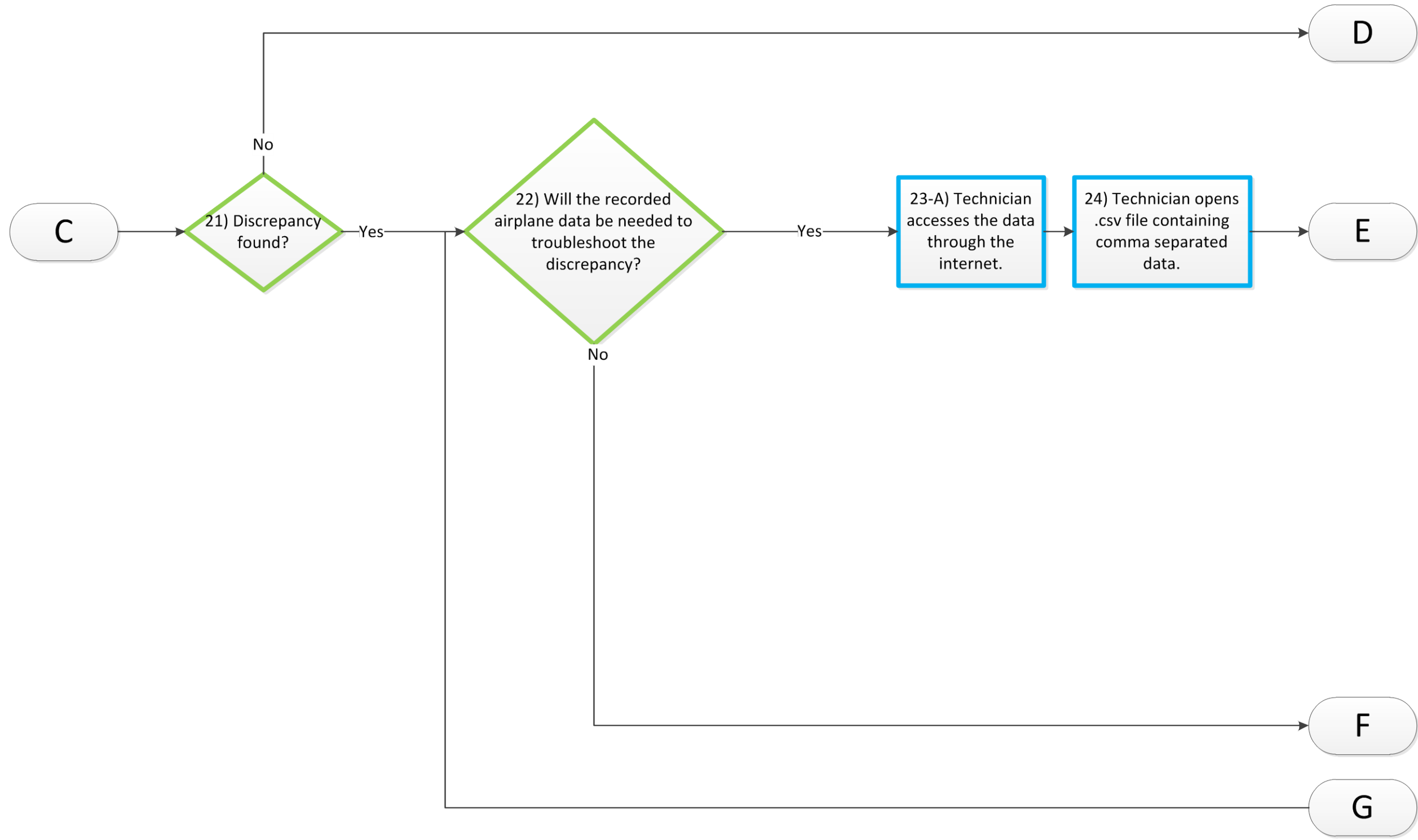


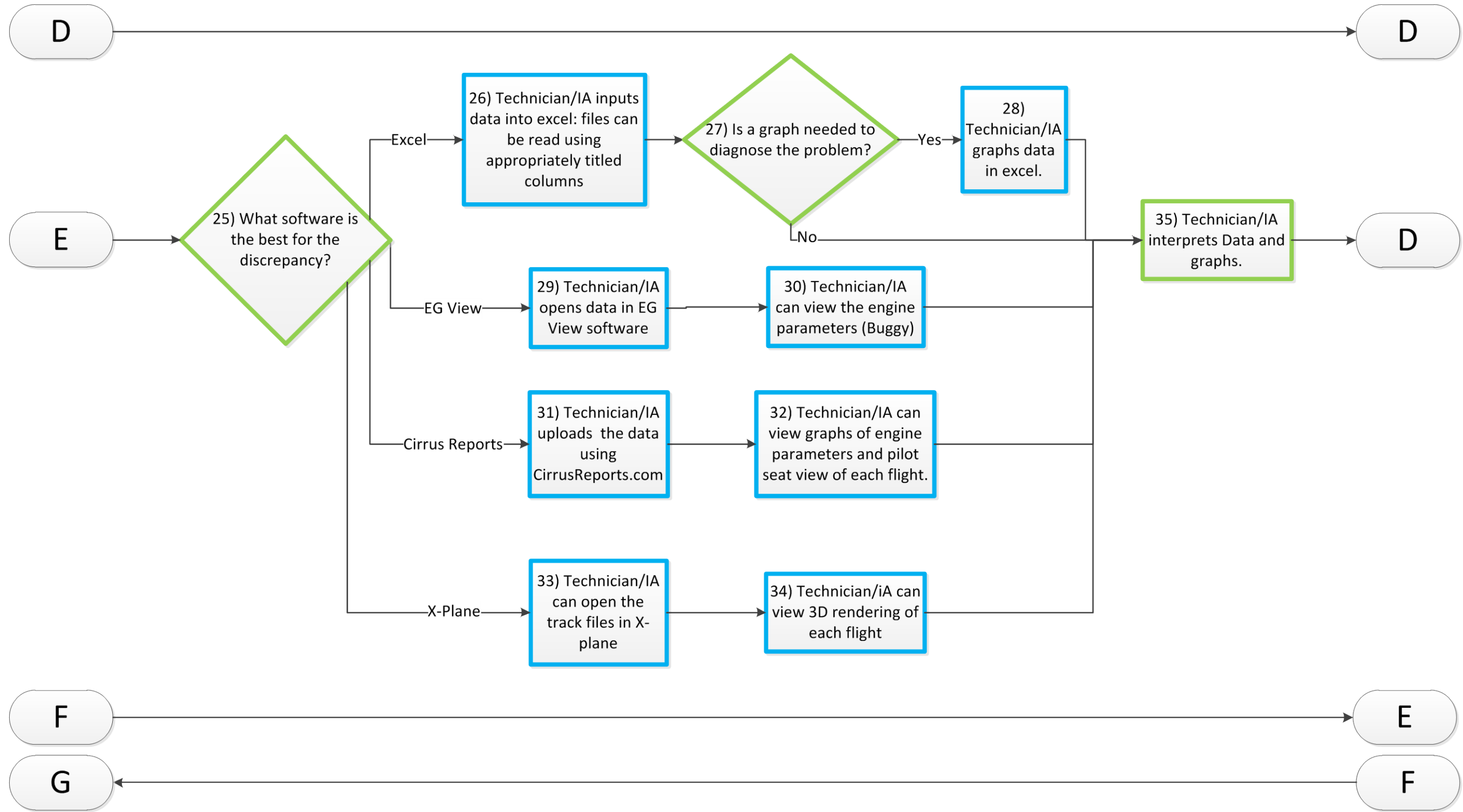
Appendix C. Scheduled Inspection Process with GA-FDM Technology

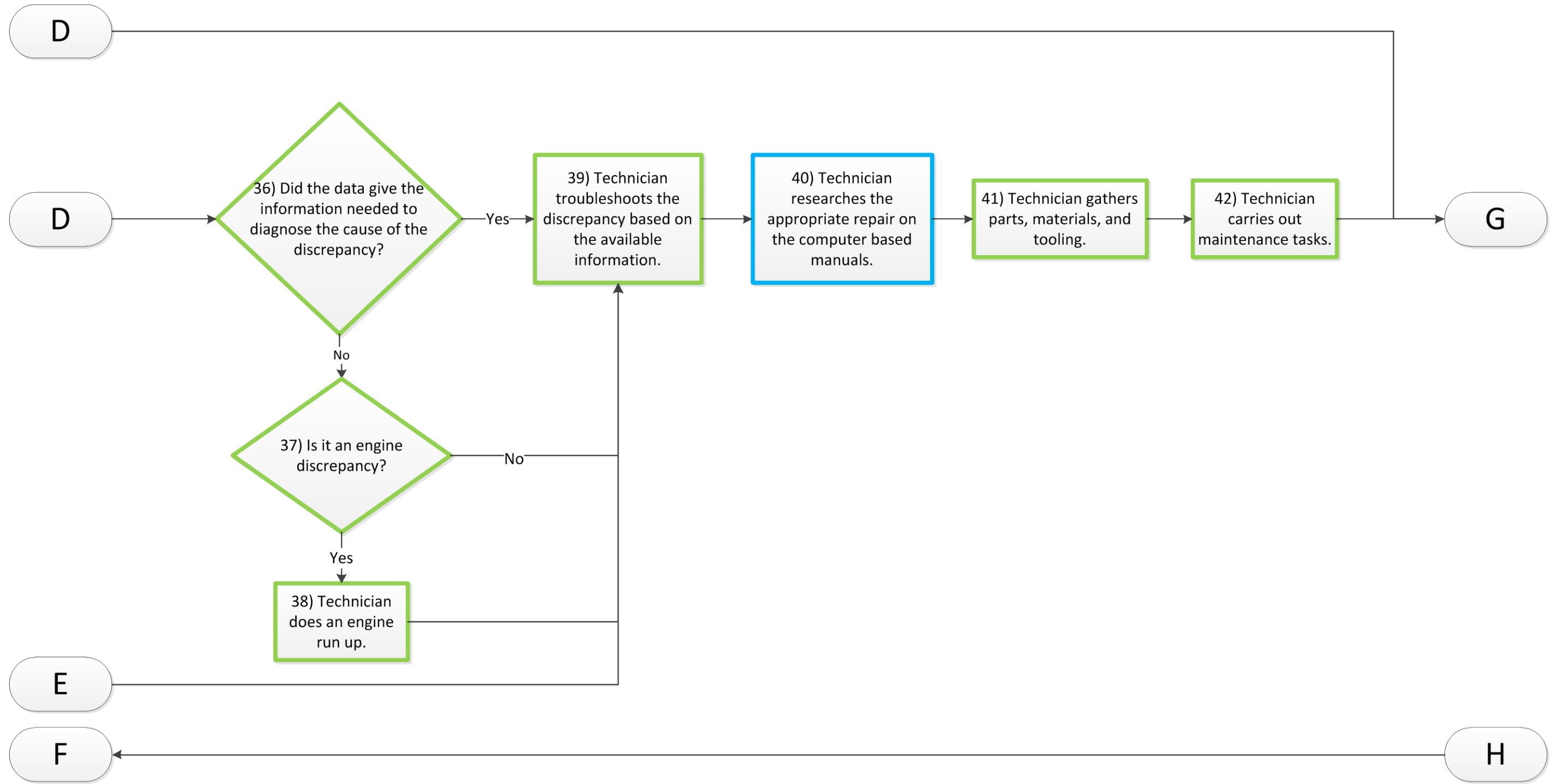
Schedule Phase Check Inspection without GA-FDM Technology

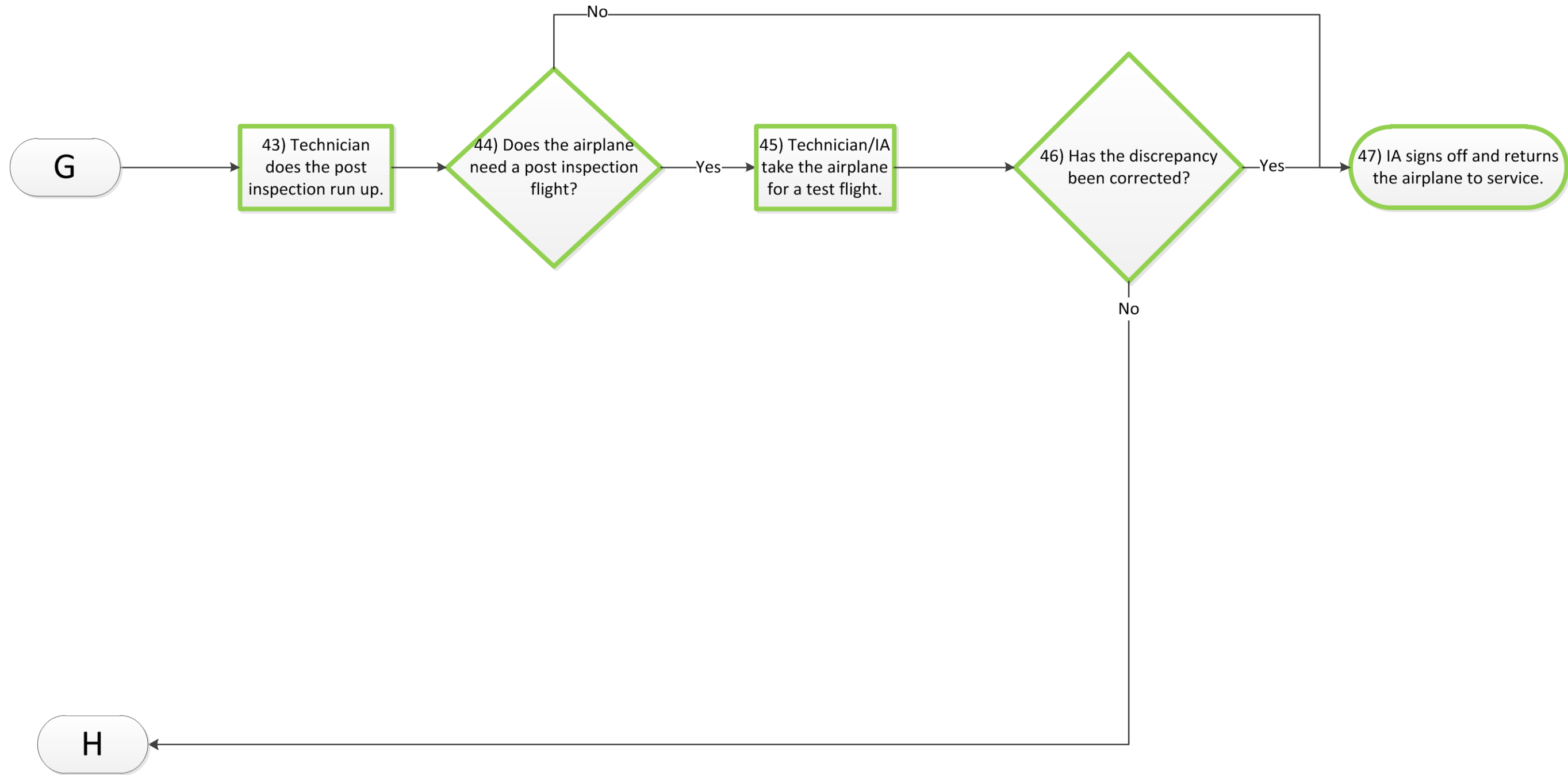






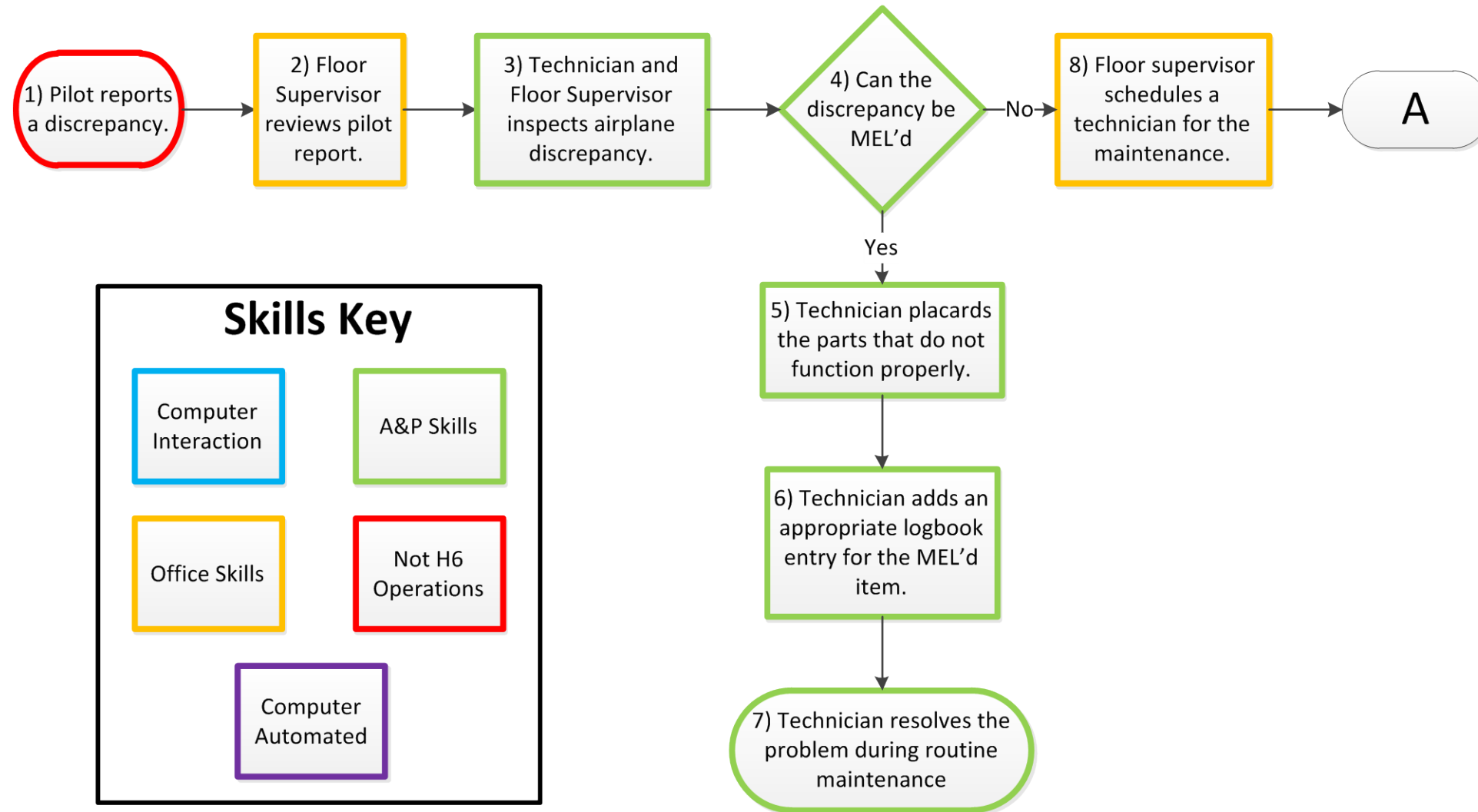


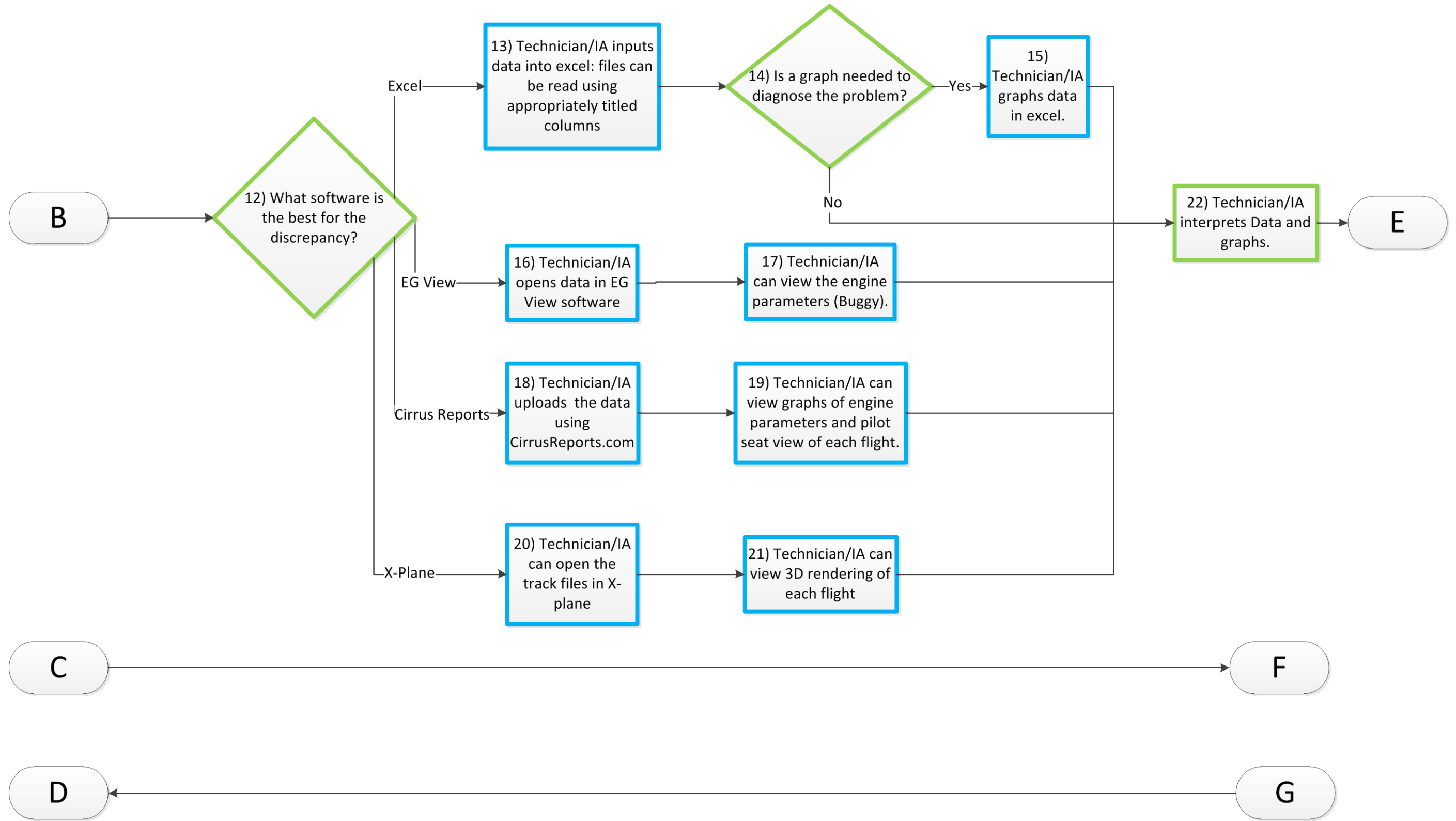


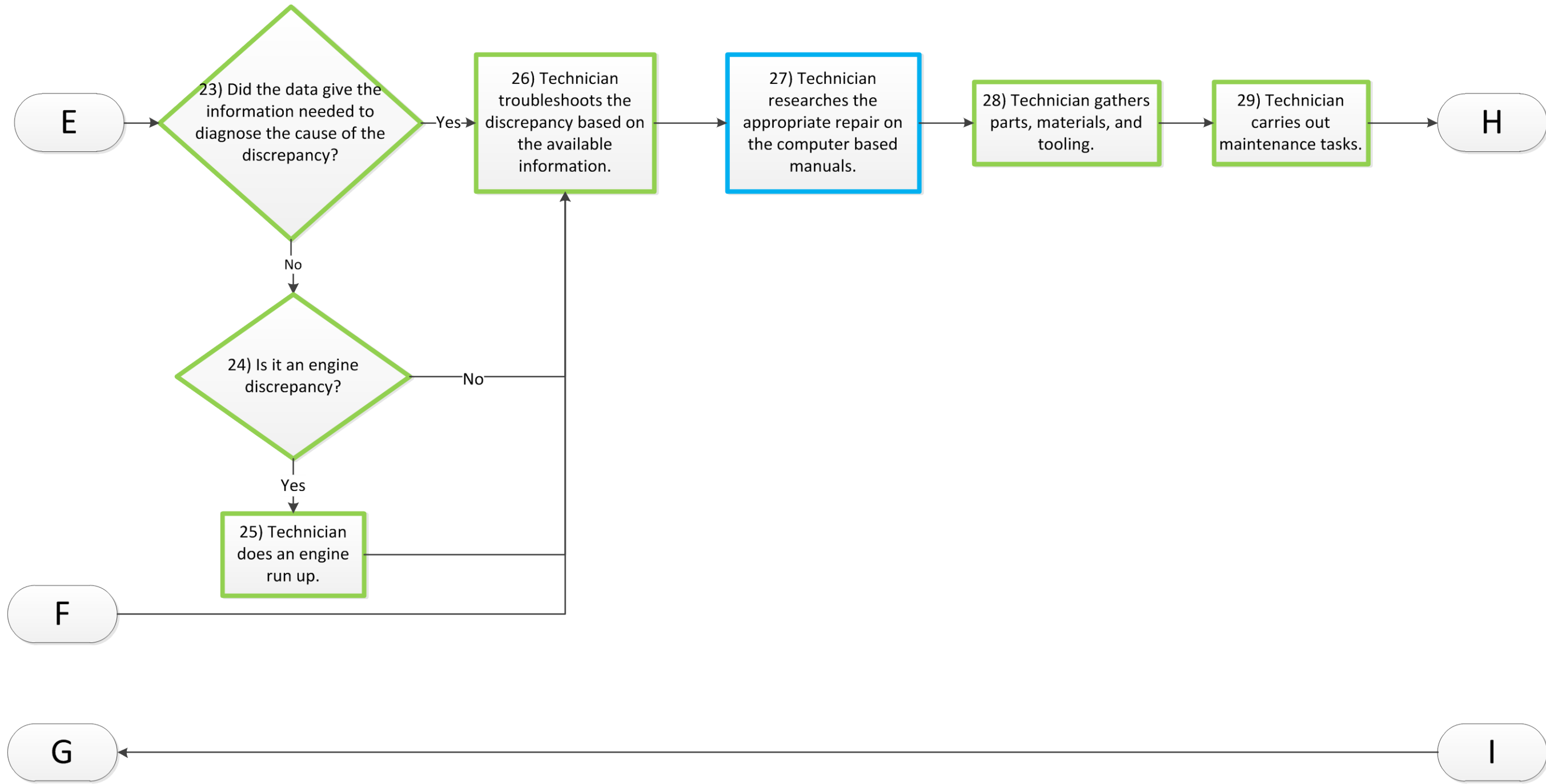


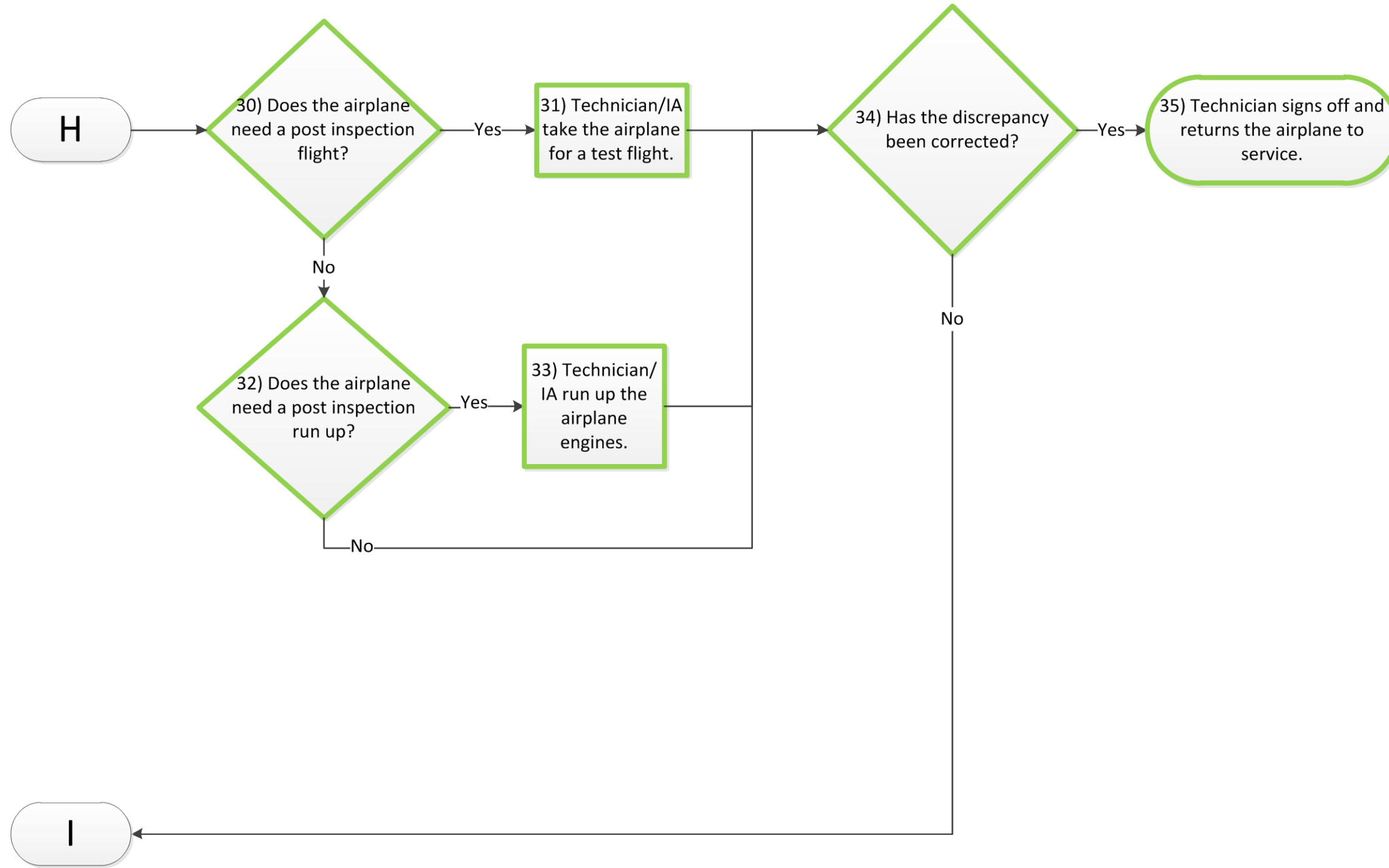
Appendix D. Unscheduled Inspection Process without GA-FDM Technology

Unscheduled Maintenance without the GA-FDM Technology



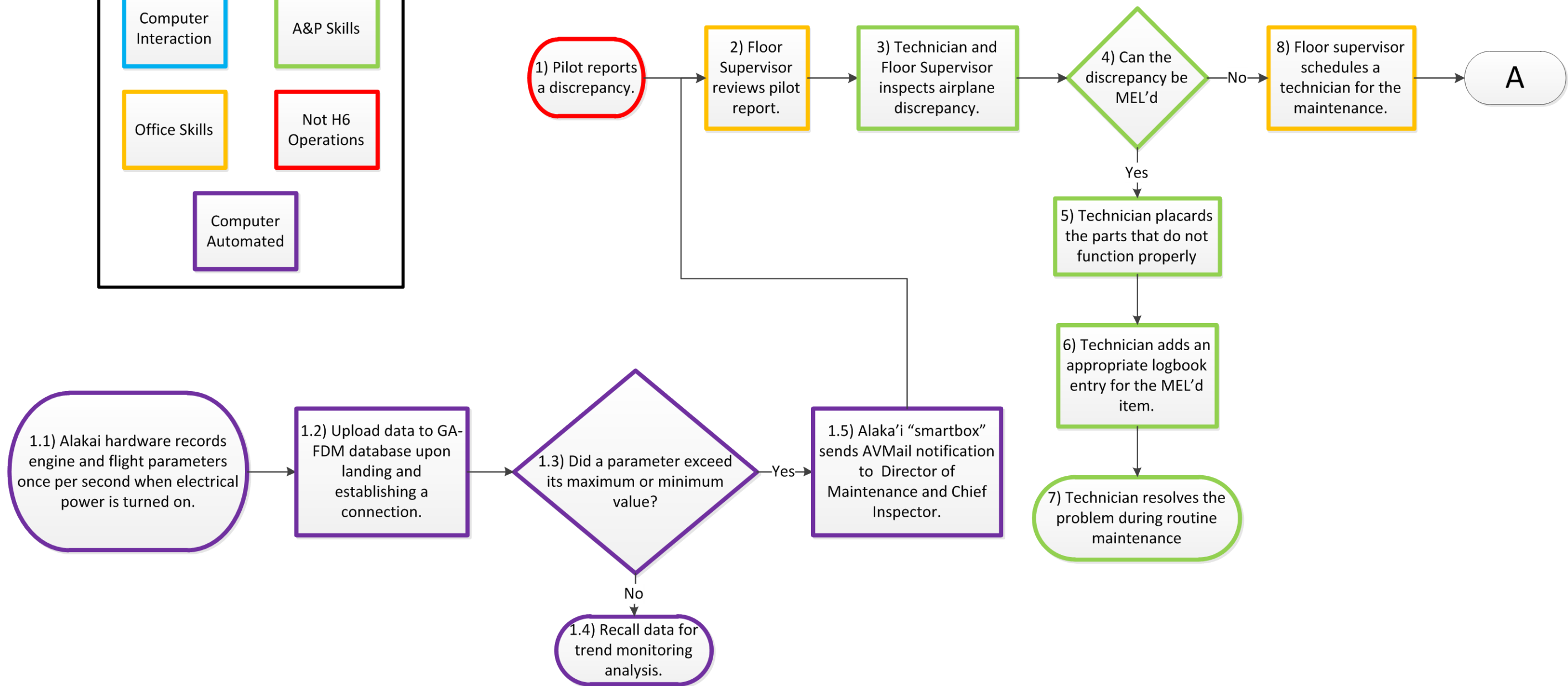
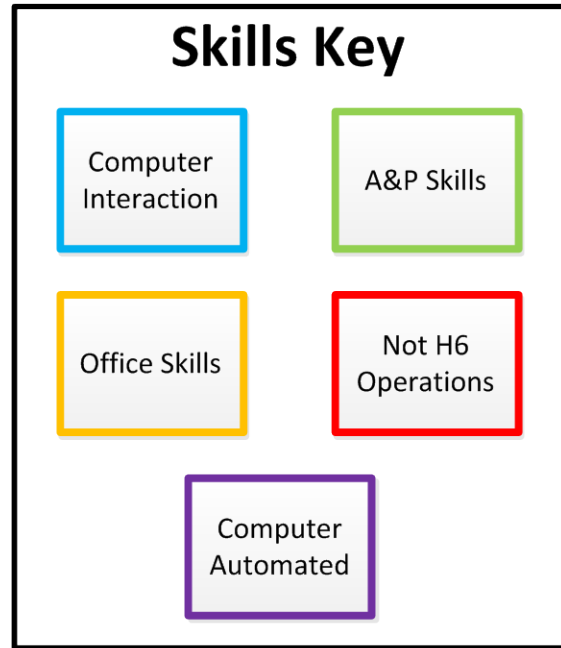


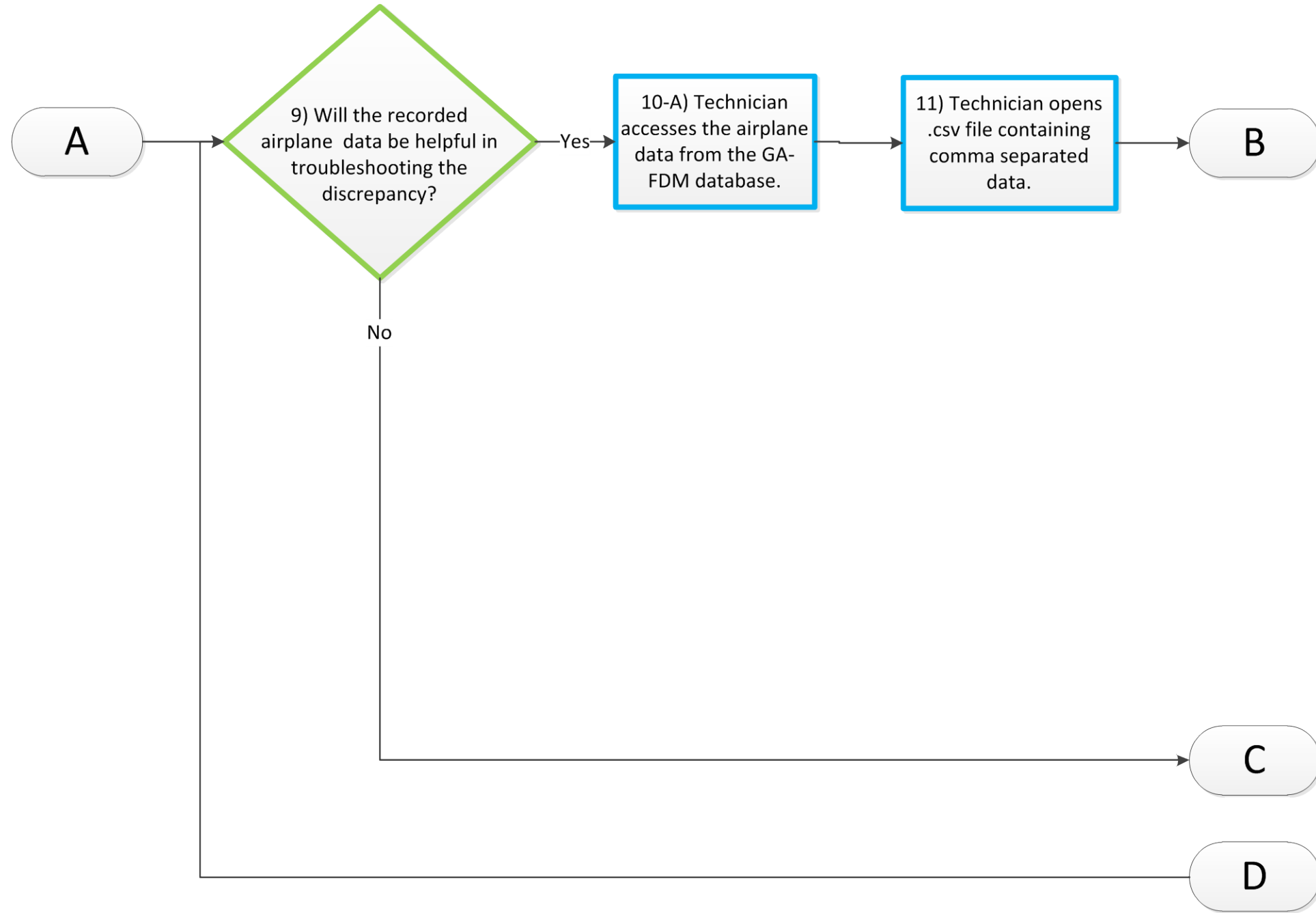


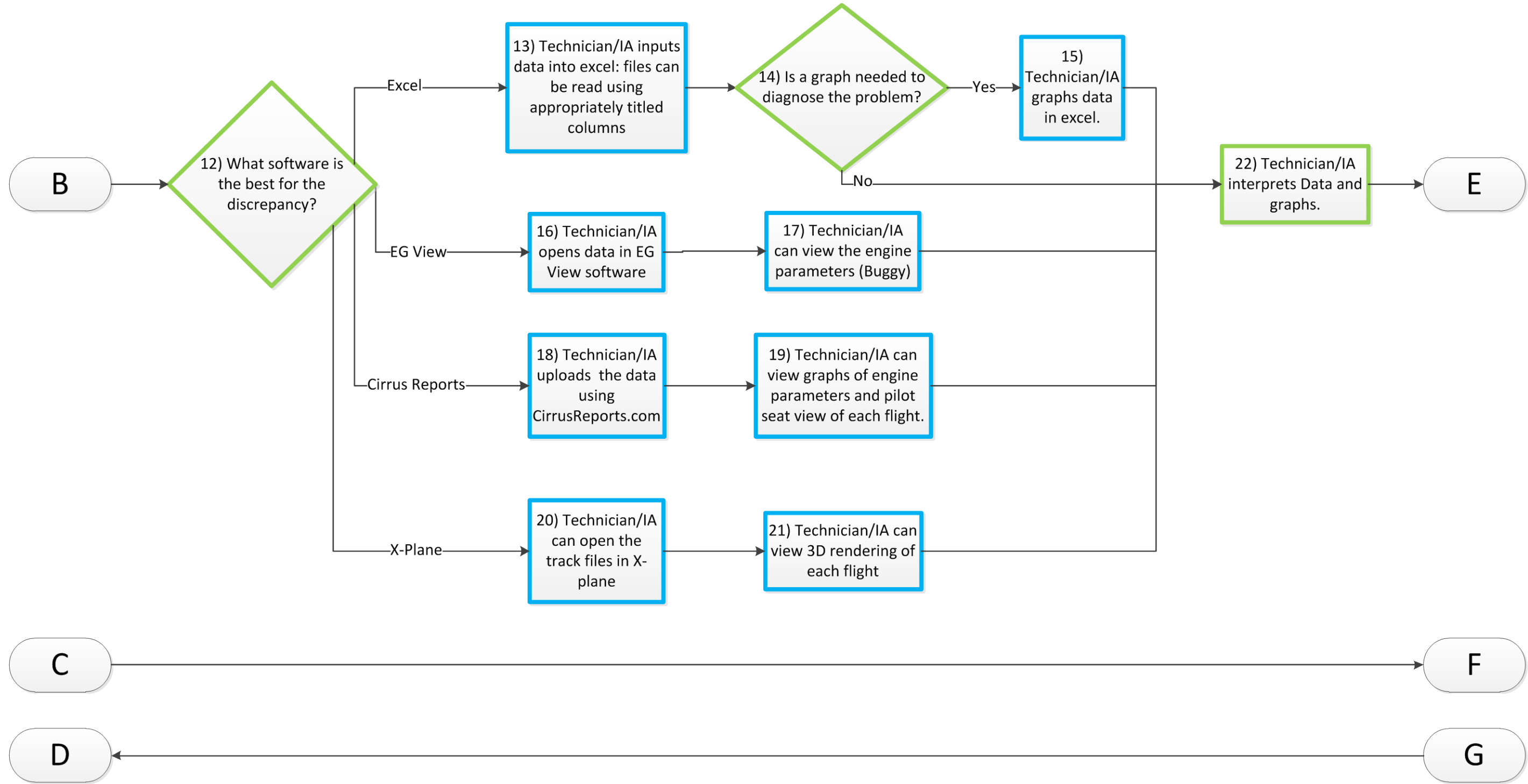


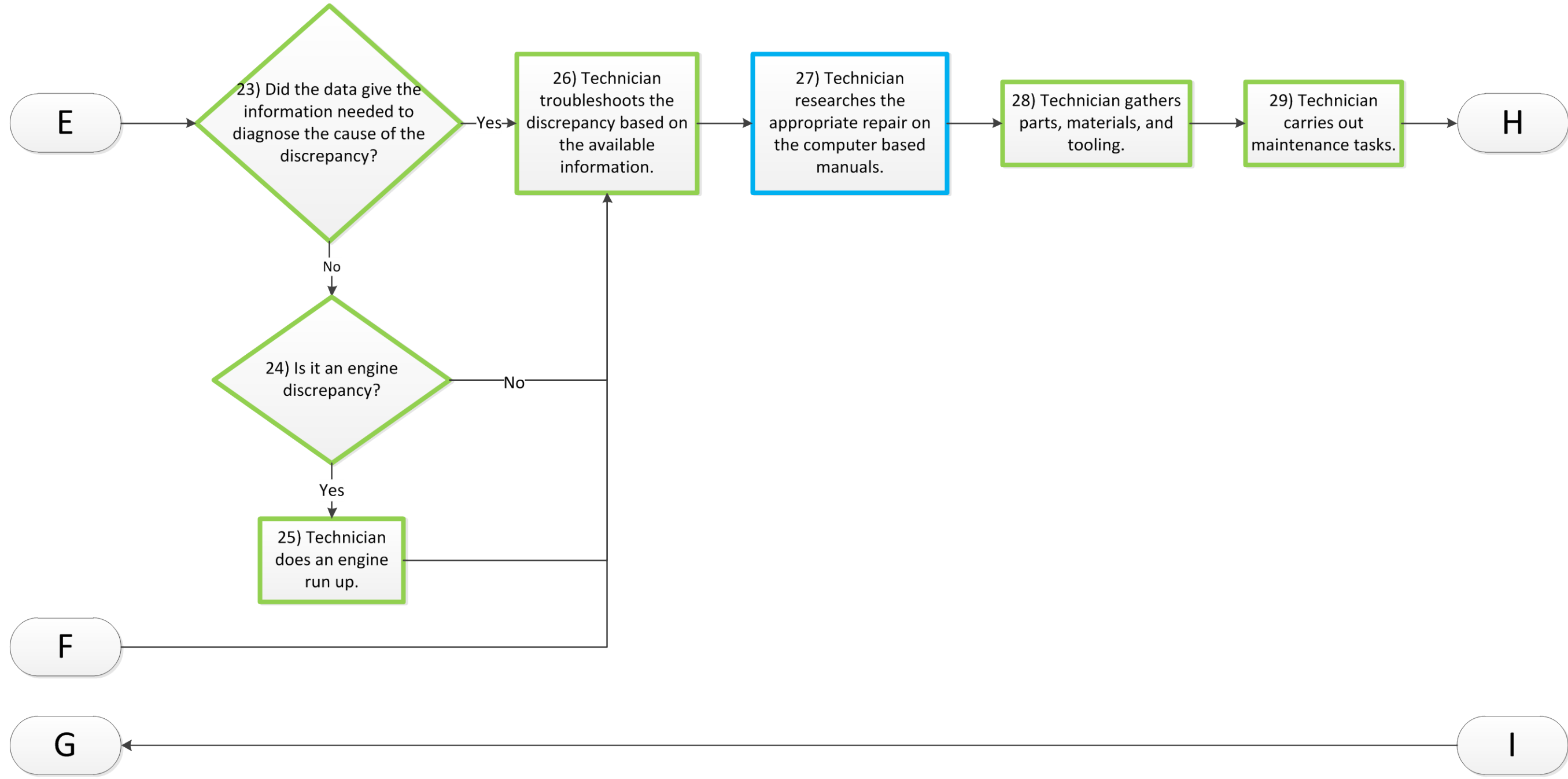
Appendix E. Unscheduled Inspection Process with GA-FDM Technology

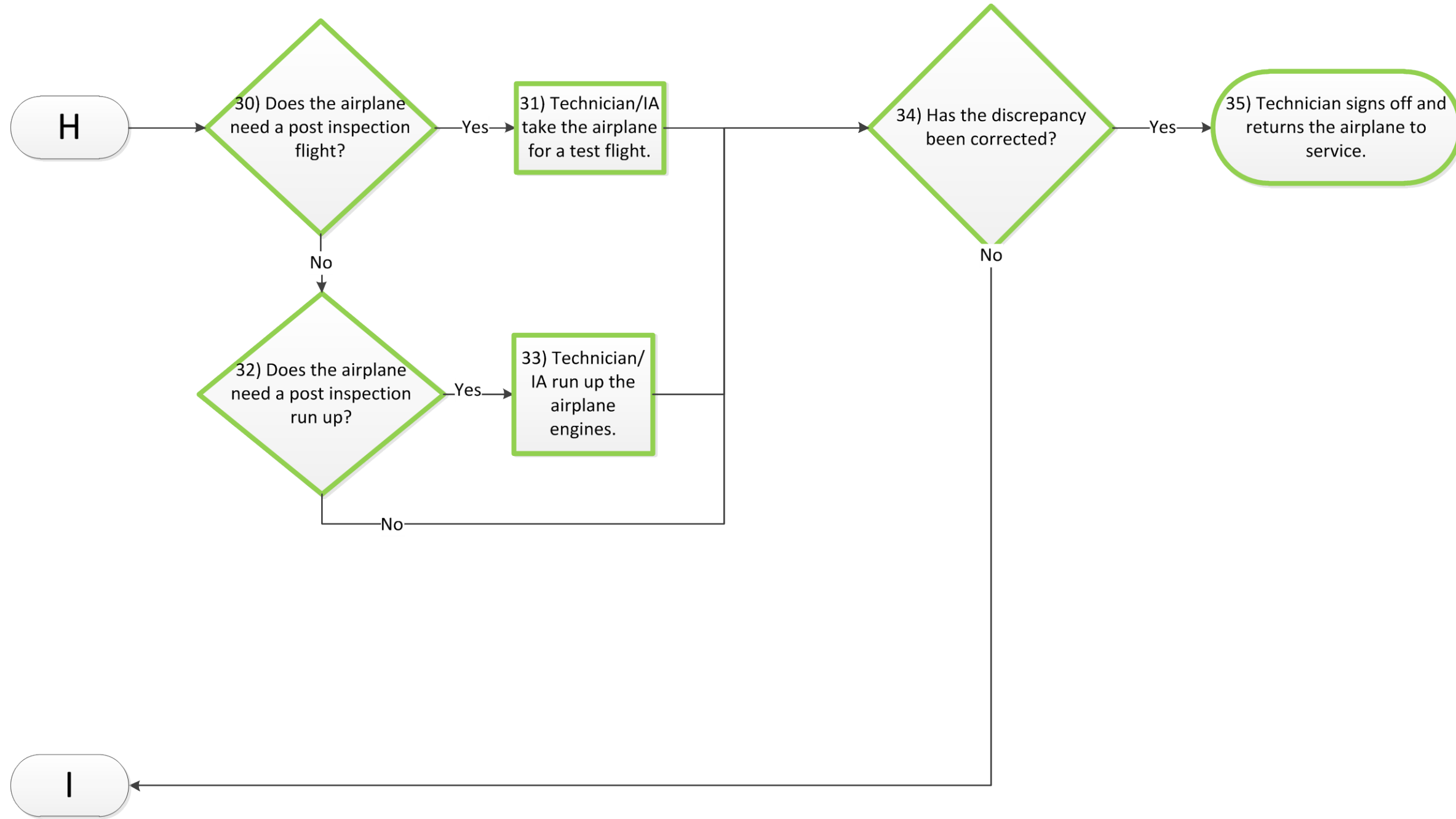
Unscheduled Maintenance with the GA-FDM Technology











Appendix F. Scheduled Inspection Computer Skills Highlight

Scheduled Phase Check Inspection Process Analysis

Process Step Number	Process Step Title	Skill Category	Specialized Computer Skills (previous box is "Computer Interaction")
1	Flight dispatch update airplane flight times in Flight Scheduler Pro.	Not H6 Operations	
1.1	Chief Inspector checks GA-FDM reports for discrepancies.	Computer Interaction	E-Mail, Internet Browsing, Basic Operating System Skills
1.2	Is there a discrepancy?	Office Skills	
1.3	No action required	Not H6 Operations	
1.4	Can the discrepancy be reviewed during a routine inspection?	A&P Skills	
1.5	Start unscheduled inspection process.	A&P Skills	
1.6	Chief Inspector logs the discrepancy for review during next inspection	Computer Interaction	Basic MS Excel, Basic Operating System Skills

2	Hangar 6 staff downloads airplane flight times from Flight Scheduler Pro every morning.	Computer Interaction	Operating System
3	Floor supervisor updates flight times on airplane status board using wax pencil.	Office Skills	
4	Is an airplane 10 hours from a scheduled inspection?	Office Skills	
5	No maintenance action required, continue to fly airplane	Not H6 Operations	
6	Chief Inspector make a copy of the appropriate master phase check sheet 10 flight hours before an airplane is due for inspection.	Office Skills	
7	Chief Inspector opens the standard discrepancy sheet file in the computer.	Computer Interaction	Basic Operating System Skills, Basic MS Excel
7.1	Chief inspector adds GA-FDM report discrepancies to the discrepancy sheet.	Computer Interaction	Basic MS Excel Skills
8	Chief Inspector adds any MEL squawks to the discrepancy list	Computer Interaction	Basic MS Excel Skills

9	Chief Inspector adds service bulletins to the discrepancy list	Computer Interaction	Basic MS Excel Skills
10	Chief Inspector prints the airplane specific discrepancy sheet	Computer Interaction	Basic MS Excel Skills
11	Chief Inspector adds the airplane specific discrepancy sheet to the binder.	Office Skills	
12	All relevant airplane maintenance manual procedures are printed from a computer manual source.	Computer Interaction	Basic Operating System Skills, Basic Software Skills
13	Floor supervisor gathers and sets aside parts, materials, and tooling for the upcoming inspection completing the inspection package.	A&P Skills	
14	Has the airplane reached its flight hours required for inspection	A&P Skills	
15	Flight department continues to fly the airplane.	Not H6 Operations	
16	Is there available manpower for the inspection?	Office Skills	

17	Hold airplane for inspection while technicians complete priority aircraft.	Office Skills
18	Floor supervisor schedules technician to work on the airplane.	Office Skills
19	Technician collects the binder, parts, materials, and tools on the day of inspection.	A&P Skills
20	Technician performs the inspection per the binder materials	A&P Skills
21	Discrepancy found?	A&P Skills
22	Will the recorded airplane data be needed in troubleshooting the discrepancy?	A&P Skills
23	Technician pulls the SD card.	A&P Skills
23-A	Technician accesses the data through the internet.	Computer Interaction

24	Technician opens .csv file containing comma separated data.	Computer Interaction	Basic Operating System Skills
25	What software is the best for the discrepancy?	A&P Skills	
26	Technician/IA inputs data into excel: files can be read using appropriately titled columns	Computer Interaction	Basic MS Excel Skills
27	Is a graph needed to diagnose the problem?	A&P Skills	
28	Technician/IA graphs data in excel.	Computer Interaction	Basic MS Excel Skills
29	Technician/IA opens data in EG View software	Computer Interaction	Basic Software Skills
30	Technician/IA can view the engine parameters (Buggy)	Computer Interaction	Basic Software Skills
31	Technician/IA uploads the data using CirrusReports.com	Computer Interaction	Basic Software Skills, Internet Browsing

32	Technician/IA can view graphs of engine parameters and pilot seat view of each flight.	Computer Interaction	Basic Software Skills, Internet Browsing
33	Technician/IA can open the track files in X-plane	Computer Interaction	Basic Software Skills, Internet Browsing
34	Technician/IA can view 3D rendering of each flight	Computer Interaction	Basic Software Skills, Internet Browsing
35	Technician/IA interprets Data and graphs.	A&P Skills	
36	Did the data give the information needed to diagnose the cause of the discrepancy?	A&P Skills	
37	Is it an engine discrepancy?	A&P Skills	
38	Technician does an engine run up.	A&P Skills	
39	Technician troubleshoots the discrepancy based on the available information.	A&P Skills	

40	Technician researches the appropriate repair on the computer based manuals.	Computer Interaction	Basic Software Skills
41	Technician gathers parts, materials, and tooling.	A&P Skills	
42	Technician carries out maintenance tasks	A&P Skills	
43	Technician does the post inspection run up.	A&P Skills	
44	Does the airplane need a post inspection flight?	A&P Skills	
45	Technician/IA takes the airplane for a test flight.	A&P Skills	
46	Has the discrepancy been corrected?	A&P Skills	
47	IA signs off and returns the airplane to service.	A&P Skills	

Appendix G. Unscheduled Inspection Computer Skills Highlight

Unscheduled Phase Check Inspection Process Analysis

Process Step Number	Process Step Title	Skill Category	Specialized Computer Skills (previous box is "Computer Interaction")
1	Flight dispatch update airplane flight times in Flight Scheduler Pro.	Not H6 Operations	
1.1	Alakai hardware records engine and flight parameters once per second when electrical power is turned on.	Computer Automated	
1.2	Upload data to GA-FDM database upon landing and establishing a connection.	Computer Automated	
1.3	Did a parameter exceed its maximum or minimum value?	Computer Automated	
1.4	Recall data for trend monitoring analysis.	Computer Automated	
1.5	Alakai "smartbox" sends AVMail notification to Director of Maintenance and Chief Inspector.	Computer Automated	
2	Floor Supervisor reviews pilot report.	Office Skills	

3	Technician and Floor Supervisor inspects the airplane discrepancy.	A&P Skills
4	Can the discrepancy be MEL'd	A&P Skills
5	Technician placards the parts that do not function properly	A&P Skills
6	Technician adds an appropriate logbook entry for the MEL'd item.	A&P Skills
7	Technician resolves the problem during routine maintenance	A&P Skills
8	Floor supervisor schedules a technician for the maintenance.	Office Skills
9	Will the recorded airplane data be needed to troubleshoot the discrepancy?	A&P Skills
10	Technician pulls the SD card.	A&P Skills

10-A	Technician accesses the airplane data from the GA-FDM database.	Computer Interaction	Basic Internet Browsing
11	Technician opens .csv file containing comma separated data.	Computer Interaction	Basic Operating System Skills
12	What software is the best for the discrepancy?	A&P Skills	
13	Technician/IA inputs data into excel: files can be read using appropriately titled columns	Computer Interaction	Basic Excel Skills
14	Is a graph needed to diagnose the problem?	A&P Skills	
15	Technician/IA graphs data in excel.	Computer Interaction	Basic Excel Skills
16	Technician/IA opens data in EG View software	Computer Interaction	Basic Software Skills
17	Technician/IA can view the engine parameters (Buggy)	Computer Interaction	Basic Software Skills

18	Technician/IA uploads the data using CirrusReports.com	Computer Interaction	Basic Software Skills, Internet Browsing
19	Technician/IA can view graphs of engine parameters and pilot seat view of each flight.	Computer Interaction	Basic Software Skills, Internet Browsing
20	Technician/IA can open the track files in X-plane	Computer Interaction	Basic Software Skills, Internet Browsing
21	Technician/IA can view 3D rendering of each flight	Computer Interaction	Basic Software Skills, Internet Browsing
22	Technician/IA interprets Data and graphs.	A&P Skills	
23	Did the data give the information needed to diagnose the cause of the discrepancy?	A&P Skills	
24	Is it an engine discrepancy?	A&P Skills	
25	Technician does an engine run up.	A&P Skills	

26	Technician troubleshoots the discrepancy based on the available information.	A&P Skills	
27	Technician researches the appropriate repair on the computer based manuals.	Computer Interaction	Basic Software Skills
28	Technician gathers parts, materials, and tooling.	A&P Skills	
29	Technician carries out maintenance tasks.	A&P Skills	
30	Does the airplane need a post inspection flight?	A&P Skills	
31	Technician/IA take the airplane for a test flight.	A&P Skills	
32	Does the airplane need a post inspection run up?	A&P Skills	
33	Technician/IA runs up the airplane engines.	A&P Skills	

34	Has the discrepancy been corrected?	A&P Skills
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35	Technician signs off and returns the airplane to service.	A&P Skills
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