Oregon State University Design/Build/Fly

Team 1.1: Aerodynamics and Structures

Technical Portfolio Rev. 4

3/20/2020

Team members:

Ajay Mohan

Edgar Jimenez

Jehad Aljasem

Project sponsor:

OSU AIAA

Sponsor mentor(s):

N/A

MIME advisor(s):

Dr. Roberto Albertani

Supervising instructor:

Dr. Nancy Squires

OREGON STATE UNIVERSITY

VIII

DESIGN BUILD FLY

2019-2020

Aerodynamics and Structures Team Charter

Team Purpose

The purpose of the aerodynamics and structures subteam is to understand the DBF, (Design/Build/Fly) mission requirements to design an aircraft with appropriate aircraft characteristics for all of the missions. This subteam was created to design and manufacture the overall structure of the aircraft, this includes the wing, empennage, fuselage, and control surfaces.

Stakeholders of our team expect the structure of the aircraft to successfully complete all missions at competition. There are three main stakeholders: the competition judges, our capstone advisors, and the DBF team members. The other team members rely on the subteam to design an aircraft that creates enough lift to account for payload weight and limit the drag for the propulsion thrust to operate at high efficiencies to account for the additional drag due to the banner. The team also relies on the subteam to design for ease of manufacturing, so building and repairing the aircraft is a streamlined and efficient process. The competition judges are expecting us to design the structure to complete the missions assigned and to comply with all competition rules.

Team Goals

The aerodynamics and structures team is devoted to designing and manufacturing an aircraft structure that will fulfil the proper flight characteristics, as well as all other subsystems integration. We are dedicated to constructing an aerodynamic and aesthetically pleasing aircraft structure to represent our program in competition.

Roles and Responsibilities

Ajay: Safety manager, Documentation lead, Project Manager, Author 2, Editor 2
Edgar: Subteam lead, point of contact, meeting coordinator, Author 1, Editor 3
Jehad: Manufacturing coordinator, rule compliance manager, Author 3, Editor 1

Ground Rules

Regular team meeting time and location = Tuesdays at 2pm in AIAA Lab
Regular advisor meeting time and location = Weekly check in via Email
Primary method of communication = Text and Slack
Secondary method of communication = Email

1. Mutual respect will always be shown between all team members.
2. Constant communications. CC Team leader in all emails.
3. All design changes communicated with the entire subteam.
4. Respond to emails within 24 hrs.
5. Be direct and honest.

6. Majority vote will decide disagreements when necessary.
7. Accept responsibilities.
8. Be professional.
9. Conduct Safety practices at all times.
10. Document all testing procedures and data.

Potential Barriers and Coping Strategies

As a team, there may be times where disagreement may rise. It is important that we respect one another and discuss conflicts in a professional manner. There will also be a large workload that each team member will need to contribute to as evenly as possible. It is important to be mindful of all contributions and to discuss disagreements in workload.

If a conflict arises, team members should meet up at a future time to discuss resolutions with a level head. Design changes that cause differences in opinion should be presented to the subteam with proper drawings and models, followed by a discussion of the pros and cons to a design change.

Team member signatures/dates

________________________ _______________

Ajay Mohan

________________________ _______________

Edgar Jimenez

________________________ _______________

Jehad Aljasem

Team Roles and Responsibilities

<table>
<tr><th>Team member</th><th>Role and Responsibility</th></tr>
<tr><td>Ajay Mohan</td><td>Roles:
Safety manager
Documentation lead
Project manager
Responsibilities:
Selecting overall aircraft configuration
CAD modeling
Building prototypes
Fixture design
Documentation control
3D print/rapid prototype lead
Fuselage design/Manufacturing</td></tr>
<tr><td>Edgar Jimenez</td><td>Roles:
Team lead
Sub-team lead
Point of contact
Meeting coordinator
Responsibilities:
Selecting overall aircraft configuration
Building prototypes
Reviewing work process
Lift analysis
Airfoil selection/Wing manufacturing
Preflight checks</td></tr>
<tr><td>Jehad Aljasem</td><td>Roles:
Manufacturing coordinator
Rule compliance manager
Responsibilities:
Selecting overall aircraft configuration
Building prototypes
Scoring analysis
Stability analysis
Empennage design/Manufacturing</td></tr>
</table>

<u>Customer Requirements</u>
DBF 2019-2020

Global Requirements:

#	DBF 2020 Global Customer Requirements	Weight
1	DBF proposal must be completed by Oct. 28th (due 31st)	10
2	DBF competition report must be completed by March 10th (10 days before due date)	35
3	Aircraft must comply with all AIAA and competition rules	20
4	Aircraft must pass technical inspection to ensure everyone's safety	20
5	Aircraft must complete all missions	45
6	Aircraft must have a mass of 5kg or less	15
7	Aircraft must be aesthetically pleasing	5
8	Aircraft must be completed within specified budget	15
	Global Total Weight	**165**

Team 1.1 Aerodynamics and Structures

#	Aerodynamics & Structures: Customer Requirements	Weight
9	Airfoil design must be appropriate for max lift for flight mission requirements	20
10	Aircraft must be statically stable in flight.	15
11	Aircraft design must be designed for ease of manufacturing.	10
12	Aircraft structure must be designed for ease of internal electronic installation.	10
13	Design aircraft structure for reliable loading conditions	20
14	Design aircraft for safe landing conditions	10
	Subteam Total Weight	**85**
	Total Weight	**250**

<u>Engineering Specifications</u>
DBF 2019-2020

Global Specifications:

#	DBF 2020 Global Engineering Specifications	Value
1	Proposal completed by date	≤ Oct. 29th
2	DBF competition report completed by date	≤ March 10th
3	Percentage of AIAA and competition rules complied to	= 100%
4	Percentage of technical inspection score	= 100%
5	Number of safety violations reported	= 0
6	Number of missions completed	= 4
7	Aircraft gross weight	≤ 11 lb
8	Average aesthetic survey result (scale 1-10)	≥ 7.5
9	Aircraft budget amount	≤ $3200

Team 1.1 Aerodynamics and Structures

#	Aerodynamics & Structures: Engineering Specifications	Value
10	CL max	≥ 1.6
11	Wing tip deflection at max payload	≤ 10°
12	Time it takes to manufacture the aircraft	≤ 24 hr
13	Number of unique parts	≤ 60
14	Time to integrate electrical components	≤ 8 hr
15	Wing load test	≥ 60 lbf
16	Fuselage energy absorption from landing gear	≥ 25 lbf

Engineering Specification Justifications:

6. There are four total missions, therefore the specification is to complete all missions.

8. We will survey random students and ask them to rate the aesthetics of our airplane out of 10. We want an aesthetically pleasing aircraft so our minimum specification is 7.5/10.

10. Based on our airfoil selection for our desired cruising speed, we want the coefficient of lift to be at least 1.6. This is a value recommended by our advisor, Dr. Albertani, to be a minimum value to maximize lift properties of the aircraft for our specific takeoff distances and estimated max takeoff weight.

11. Wing tip deflection is the angle that the wing will deflect when maximum payload is applied. We want to keep this to less than 10 degrees to ensure that the wing does not experience wing flutter or wing failure under heavy loads. Keeping this angle to a minimal amount ensures that the strength of the wing is adequate for technical inspection and high loading conditions in flight. The 10 degree value was recommended by a mentor, Dave Patana, an amateur RC pilot with many years of experience to ensure that the original wing characteristics are not changed from adding a dihedral to the wing.

15. Wing loading test is the amount of load applied to the center, while supporting the tips of the wing, before failure occurs. This helps simulate aerodynamic loads and due to anticipated small turns of about 44 feet radii in flight at 60 mph we are estimating the load to be about 6g's which is approximately 66 lbf. This means that the wing will need to be able to withstand 66 lbf in a static aerodynamic load test.

16. Fuselage energy absorption is the energy dissipated throughout the fuselage directly from the landing gear hitting the ground. We want the fuselage to withstand values greater than 25 ft-lbf without any significant or critical damages to the fuselage. This allows for safe landing conditions up to two feet of vertical dropping and a max anticipated vertical drop is approximately three feet in height, which would result in energy values of about 33 ft-lbs. These values are anticipated only for when the aircraft is coming in for a normal landing, not necessarily for any catastrophic in flight failures.

Code or Standard Name: Academy of Model Aeronautics National Model Aircraft Safety Code: General
Code Description/Summary: The model aircraft must not be flown in a careless or reckless manner. The aircraft may also not be flown at locations where model aircraft are prohibited.
Reference: Academy of Model Aeronautics National Model Aircraft Safety Code, Feb 2018
Implications to this project: The team will only allow an experienced pilot who has obtained a certified membership with the Academy of Model Aeronautics. Test flights will also be conducted in locations suitable for model aircraft flight.

Code or Standard Name: Academy of Model Aeronautics National Model Aircraft Safety Code: Radio Control
Code Description/Summary: A successful equipment check must be done before the first flight of a new or repaired model aircraft. The RC model Aircraft may only use radio-controlled frequencies allowed by the Federal Communications Commission.
Reference: Academy of Model Aeronautics National Model Aircraft Safety Code, Feb 2018
Implications to this project: For the start of each prototype test flight, the team will fully inspect the aircraft. The team will also use a FrSky receiver which is approved by the Federal Communications Commission.

Code or Standard Name: Academy of Model Aeronautics National Model Aircraft Safety Code: Free Flight
Code Description/Summary: There must be a minimum of 100 foot distance between the launch site and any spectators and automobile parking. The launch area must be clear of all individuals except for mechanics, officials, and other fliers.
Reference: Academy of Model Aeronautics National Model Aircraft Safety Code, Feb 2018.
Implications to this project: The team will perform test flights in large open spaces and will allow only the flight mechanic and pilot near the launch area.

Code or Standard Name: Federal Aviation Administration: Unmanned Aircraft Regulations
Code Description/Summary: Unmanned aircraft must be flown to avoid manned aircraft, maximum 400 feet above ground, maximum speed of 100mph, not above any non-participating individuals or near airports. Flight must be maintained within unaided eyesight by an observer and/or pilot.
Reference: Federal Aviation Administration Recreational Flyers & Modeler Community-Based Organizations, Aug 2019
Implications to this project: The team will check that each test flight is conducted in a way, and in a zone, that complies with the regulations stated by the Federal Aviation Administration.

Code or Standard Name: Federal Aviation Administration: UAS registration
Code Description/Summary: Unmanned Aircraft must have its registered FAA number clearly displayed on the body if it is over 0.55 pounds. Unmanned Aircraft cannot exceed 55 pounds.
Reference: Federal Aviation Administration Register Your Drone, July 2019
Implications to this project: The team will register the aircraft via the Federal Aviation Administration website and will construct a craft under 55 pounds.

Code or Standard Name: Standards for Universal Waste Management
Code Description/Summary: A small quantity handler of universal waste must manage the waste of the batteries in a way that prevents the release of universal waste to the environment.
Reference: Electronic Code of Federal Regulations, Oct 2017.
Implications to this project: The team is planning on utilizing Best Buy's recycling program in order to properly dispose of the Lithium Polymer batteries.

Design Specifications

The following section consists of the aerodynamics and structures CAD drawings and renderings.

All of the team’s structures are manufactured in-house so no components are purchased besides fasteners and adhesives.

The first section shows the competition revision of the aircraft. The first image is a rendering of the aircraft followed by drawings of the: nosecone, fuselage, wing, and empennage. The wing and empennage drawings include our airfoil selections. The empennage drawings show the overall assembly and an example of the individual rib.

Testing Procedure #10

Purpose: The purpose of testing procedure 10 is to ensure that the wing airfoil can produce a high lift coefficient while maintaining a low coefficient of drag at an angle of attack of zero..

Engineering Specifications Addressed: C_L max value ≥ 1.6

Testing Equipment:

- Airfoil data for SD7062 (refer to appendix for data)
- Calculator to estimate Reynolds number

Testing Procedure:

1. Calculate expected Reynolds numbers that the airfoil data is needed.
2. Refer to airfoil data for SD7062 and look at graphs for anticipated Reynolds number.
3. Locate C_L max value and confirm that the value is higher than 1.6 while maintaining a low C_D.

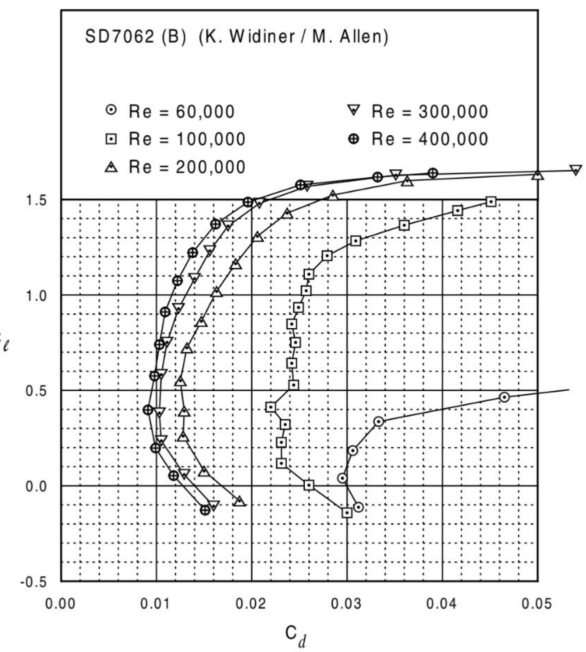
Safety Protocol: This procedure does not have any risks of safety.

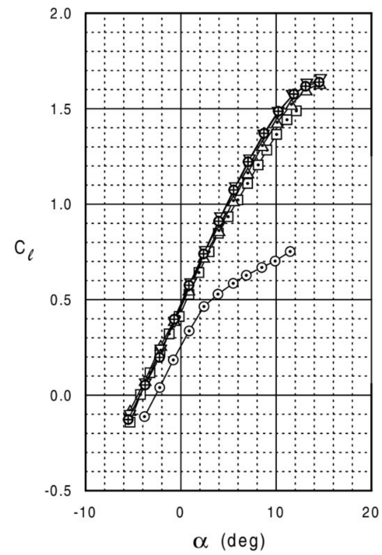
Passing Condition: C_L is ≥ 1.6

Test Results: Pass

From the analysis we confirmed that at a cruise speed of 60 mph we would be in a Reynolds number regime of about 300,000. Comparing the data to the graphs for the SD7062 airfoil data, we concluded that the C_L is about 1.65 and results in a low C_D of .01 at steady level flight.

Test Verification:





This testing procedure can be validated with the use of the airfoil data as well verified with flight tests. Flight characteristics and proper lift for takeoff can be verified from the video link provided.

https://youtu.be/DhmGocGdSd4

Testing Procedure #11

Purpose: The purpose of a wing tip deflection test is to test the stiffness of the wing when the aircraft is fully loaded and to ensure that the wing can pass technical inspection and to verify the strength of the wing structure.

Engineering Specifications Addressed:
ES #11: Wing tip deflection at max payload

Testing Equipment:
- Measuring calipers or measuring tape
- Weight scale
- Flat bar or straight edge
- Bucket with known mass

Testing Procedure:
1. Suspend wing at the wing tips no further than 1 inch inward at each side.
2. Place straight edge across the wing and measure the starting point for zero weight deflection.
3. Remove straight edge from top of wing.
4. Load weight in the center of the wing.
5. Place straight edge on the top of the wing and use the same measuring point from step 2 to measure the distance between the wing and the straight edge.
6. Use measured vertical deflection to calculate angle deflection.

Safety Protocol: The use of safety glasses and closed toed shoes are required for this testing procedure.

Passing Condition: The deflection angle must be less than or equal to 10 degrees.

Test Results: Pass
Increasing weight was added to the wing tip test to gather some information on the strength of the wing and to ensure that at max takeoff weight (11 lbs) the deflection was within specification.

Weight (lbs)	Vertical Deflection (inch)	Angle (degrees)
0	**0**	**0**
10	**1.335**	**2.55**
12.5	**1.493**	**2.85**
20	**1.990**	**3.80**
30	**2.622**	**4.99**

Test Verification:

Testing Procedure #12

Purpose: The purpose of testing procedure 12 is to measure how much time it takes to manufacture the aircraft.

Engineering Specifications Addressed:
ES# 12: Time it takes to manufacture the aircraft.

Testing Equipment:

- Work Log of hours spent manufacturing

Testing Procedure:

1. Record how much time it takes to manufacture each component.

Safety Protocol: This procedure does not have any risks of safety.

Passing Condition:
If the time it takes to manufacture the aircraft is less than or equal to 24 hours.

Test Results: Pass

Component	**Time of manufacturing (hrs)**
Fuselage	6
Wing	6
Empennage	4
Nosecone	1
Landing gear	3
Total time to manufacture the aircraft	**20**

With a total of 20 hours to manufacture our aircraft, we managed to manufacture faster than our target of 24 hours.

Test Verification:

The Signatures below verify the number of hours spent manufacturing a sub assembly to the best of the team members knowledge.

Name	Date	Signature	Component	Time to Manufacture
Edgar Jimenez	02/28/20		Wing Assembly	6 hours
Jehad Aljasem	02/28/20		Empennage Assembly	4 hours
Ajay Mohan	03/14/20		Fuselage Manufacture	6 hours
Ajay Mohan	03/14/20		Nose Cone Manufacture	1 hour
Desmond Aiello	03/14/20		Landing gear	3 hours

Testing Procedure #13

Purpose: The purpose of testing procedure 13 is to ensure the sub-team keeps track of the unique number of parts used to manufacture the aircraft structure. Increasing the number of unique parts increases the time to manufacture the aircraft and we want to reduce the time to manufacture as much as possible.

Engineering Specifications Addressed:
ES # 13: Number of unique parts

Testing Equipment:

- Excel sheet with all the unique number of parts

Testing Procedure:

1. List the number of unique components needed to manufacture the wing, fuselage, empennage, and nosecone.
2. Record the number of parts.

Safety Protocol:

- This procedure does not have any risks of safety.

Passing Condition:
The number of parts used is less than or equal 80 parts.

Test Results: Pass

Test Verification:

The table below shows the number of parts for each sub assembly to the best of the sub-team's knowledge and has been verified and signed for each sub-team member.

Team Member	Signature
Edgar Jimenez	
Ajay Mohan	
Jehad Aljasem	

Component	**Number of Parts**
Fuselage	**2**
Top Section	1
Bottom Section	1
Wing	**16**
Unique Ribs	3
Spar	1
Balsa leading edge	2
Bolts	4
Winglet	2
Control Surfaces	2
Wing mounting	1
Mylar	1
Empennage	**42**
Inner Structure	2

Horizontal Stabilizer Ribs	16
Vertical Stabilizer Ribs	12
Balsa leading edge	2
Bolts	6
Mylar	2
Control Surfaces	2
Nosecone	**7**
Brackets	2
Bolts	4
Cone	1
Total Number of Parts	**67**

Testing Procedure #14

Purpose: The purpose of testing procedure 14 is to ensure the team keeps track of the time it takes to integrate electrical components in case the team needs to make adjustments to the aircraft during competition.

Engineering Specifications Addressed:
ES # 14: Time it takes to integrate electrical components.

Testing Equipment:

- Work log from propulsion and systems of hours it takes to integrate electrical components and systems.

Testing Procedure:

1. Measure the time it takes the propulsion and systems sub-team to integrate all electrical components.
2. Document and have the propulsion and systems team lead sign to confirm the time.

Safety Protocol: This procedure does not have any risks of safety.

Passing Condition:
The time it takes to integrate electrical components is less than or equal 8 hours.

Test Results: Pass

Time to integrate electrical components	**3 hours**

Test Verification:

Name	Date	Signature	Number of hours Spent to integrate Electrical components
Sam Wiewel	03/15/20	[illegible]	3

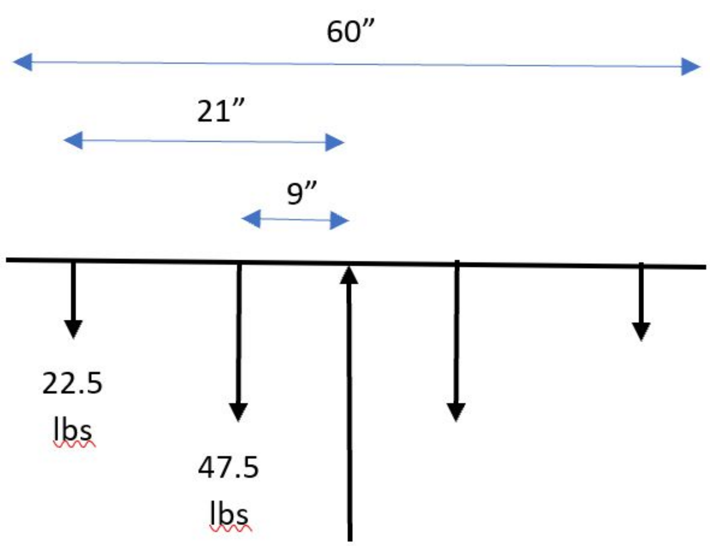
Testing Procedure #15

Purpose: The purpose of testing procedure 15 is to ensure that the materials used to build the wing are strong enough to withstand the aerodynamic loads applied on the wing during flight.

Engineering Specifications Addressed:
ES # 15: Wing load test

Testing Equipment:
- Scale
- 4 buckets with given masses
- Stand
- Weights

Testing Procedure:
1. Place the wing spar with a support in the center.
2. Place buckets of known mass in the locations shown in the figure to represent an approximated aerodynamic load.
3. Test with a distributed total load of 60lbs and observe for failures.
4. Test with a distributed total load of 90lbs and observe for failures.
5. Test with a distributed total load of 120lbs and observe for failures.



This figure shows the weight and locations for the estimated aerodynamic loads at 60 lbs. For testing of 120 lbs, weight values were simply doubled.

Safety Protocol:

- Team members will wear safety glasses and closed toe shoes while performing the test.

Passing Condition:

If the wing can withstand a distributed load of 60 lbs.

Test Results: Pass

The wing spar held a distributed load of 120 lbs, resulting in a passed test.

Test Verification:

Testing Procedure #16

Purpose: The purpose of testing procedure 16 is to ensure that the fuselage can withstand the impact from landing at max payload.

Engineering Specifications Addressed:
ES # 16: Fuselage energy absorption from landing gear.

Testing Equipment:
- Tape measure
- Scale
- Rope
- 11 lbs of weight

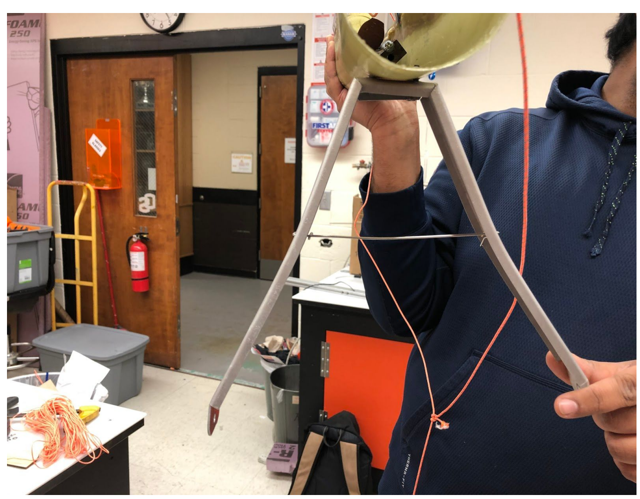
Testing Procedure:
1. Load the aircraft with max payload.
2. Hold the aircraft 1 ft above the ground.
3. Release the aircraft.
4. Repeat the test from 2 and 3 ft above the ground.

Safety Protocol:
- Wear Safety glasses and closed toe shoes.

Passing Condition:
If the fuselage can withstand the impact from a certain distance above the ground at max payload for a total of 25 ft.lbs of potential energy change.

Test Results: Pass
The fuselage passes the drop test from 3 ft above the ground at max payload resulting in energy absorption of 33 ft.lbs.

Test Verification:



Recommendations

Technical:

- Order materials and parts early and make sure to order spares.
- Make sure CAD is well organized and part numbers are used for specific subassemblies. Complete CAD early and make sure all integration fits properly.
- Have team members get certified on various machines like the ply cutter, CNC router, waterjet, etc.
- Keep track of all tools and materials. Be sure to clean up AIAA lab space after use to stay organized.

Project Management:

- Have general design completed by end of fall term and use winter term to test and optimize design.
- Start the competition documents early to leave enough time for revising. Make sure multiple people review documents before submission to catch more mistakes.
- If a team member is slacking and not contributing fairly, address this issue early so it does not become a habit. Assign them with specific tasks to encourage higher involvement.
- Make detailed weekly plans and create goals for each week to ensure progression throughout the project. This is especially important when manufacturing and testing. Plan building times ahead so the workspace does not get too crowded and people are not sitting around waiting on parts to be completed.

References

Academy of Model Aeronautics (2018). *Academy of Model Aeronautics National Model Aircraft Safety Code.* [online] Academy of Model Aeronautics. Available at: https://www.modelaircraft.org/sites/default/files/documents/100.pdf [Accessed Nov. 2019].

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