

# OPL Performance Calculator for a L-39ZA Light Attack Aircraft

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# Background

## Operator Performance Laboratory (OPL)

- Part of the Iowa Technology Institute (ITI)
- Flight test laboratory specializing in:
  - Human-in-the-loop systems
  - Intelligent autonomous systems
- Projects center around Public Aircraft Operations (PAO) of OPL aircraft as well as their associated simulators

## L-39ZA Light Attack Aircraft

- Manufactured in Czechoslovakia and designed to handle armed training and light attack missions
- Equipped with four wing pylons and a center mount that can be used for armament/noncombatant arrangements
- L-39ZA has a maximum flight weight of about 5580 kg (12,300 lbs)
- Performance Parameters:
  - Takeoff Speed and Distance, Accel-Stop Distance, Landing Reference Speed and Distance, Ground Run, Crosswind Component



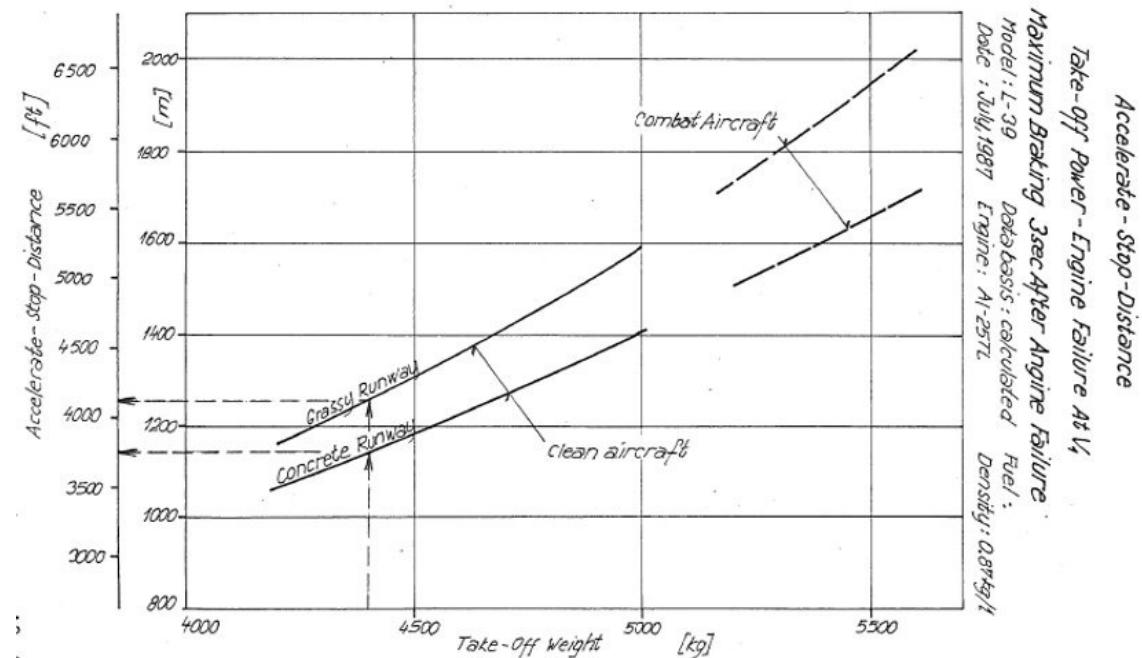
# Problem Statement

*Problem* – Hand-held graphical lookup charts used in calculating the required performance parameters have several drawbacks:

1. Traditionally use Metric Units
2. Relatively Inaccurate
3. Tedious and Inaccessible
4. Prone to Human Error

*Solution* – A web-hosted, electronic performance calculator capable of taking in aircraft and environmental characteristics and producing their respective performance parameters will help to:

1. Improve Accuracy
2. Decrease Calculation Time
3. Reduce Human Error
4. Increase Accessibility for all OPL Members



# Project Objectives

Primary  
Objective

- Goal: Streamline performance parameter calculation(s) by reducing interpretation time and calculation error while increasing calculation accuracy

Secondary  
Objective

- Goal: Host the performance calculator on an easily accessible web interface, whose design is readable, concise, and encourages usability

# Project Phases



1. Analysis & Preliminary Work



2. Detail Design



3. Implementation



4. Test & Validation

# Analysis & Preliminary Work

## Capture Client Requirements

- Initial client meeting was used to introduce the team
- Introductory meeting helped to:
  - Define the problem and desired solution
  - Establish information resources
  - Determine project expectations

## Capture Engineering Requirements

- Evaluated potential methods to digitize the graphical lookup curves utilized in the algorithm's calculations
- Determined the primary programming languages/frameworks used in the application's development
  - Python and Java – Back-End Functionality
  - Angular – Front-End Functionality

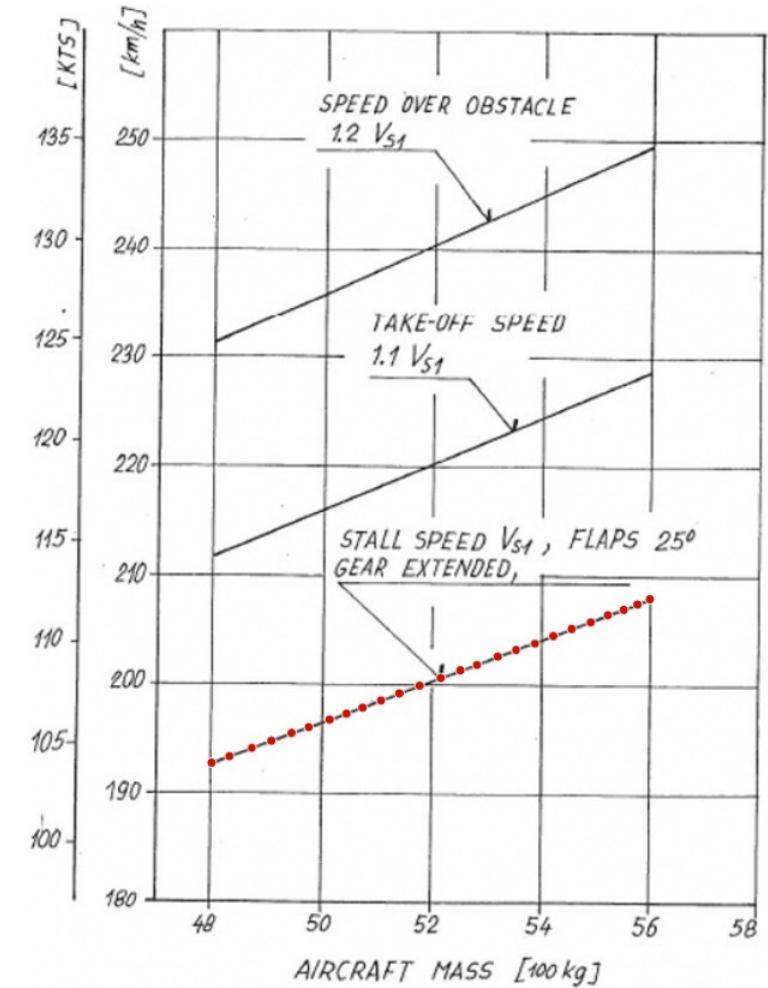


Fig. A2-1/2

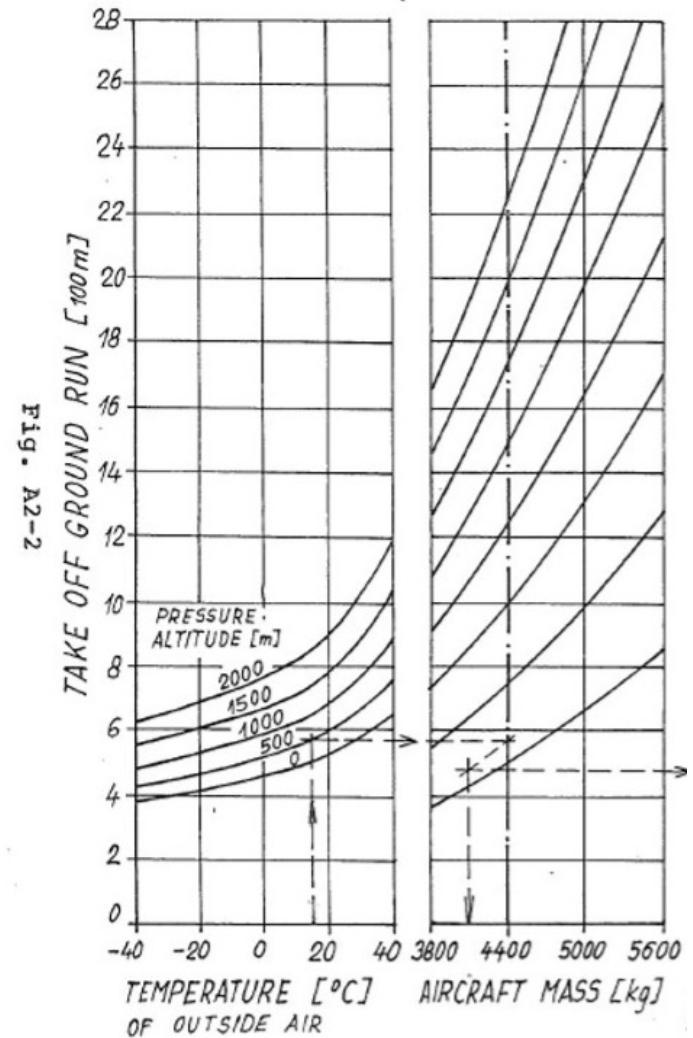
# Analysis & Preliminary Work

## Design Overall Architecture & Functions

- Plot tracing and polynomial interpolation were selected to calculate the necessary performance parameters due to its efficiency
- Token authentication, activity tracking, and secure login functionalities were also developed to uphold OPL's request for a private application

## Describe Concept of Operations (CONOPS)

- User interviews with members of the OPL were used to better understand the process in which mission configurations were chosen
  - (Ex: a plane loadout in the cold winter might not be able to safely fly in the summer)



# Detail Design

## Create & Design User Interface

- Designed UI mock-ups that helped to form the basis for finalized performance calculator UI

## Design Data Storage & Framework

- Java used extensively to provide the back-end with its functionality
- The Angular Framework, CSS, and HTML are used to produce the UI display
  - Angular uses GET and POST requests to retrieve information from the server before processing and displaying it

## Design Functions

- Developed functions to create and authenticate new and existing users using tokens
- Pre-saved profiles for pilots and aircrafts were also created
- Print Functionality for the outputted parameters was also included

# Detail Design – UI Mockups

### Pilot & Aircraft Profile

**Pilot Profile List:**

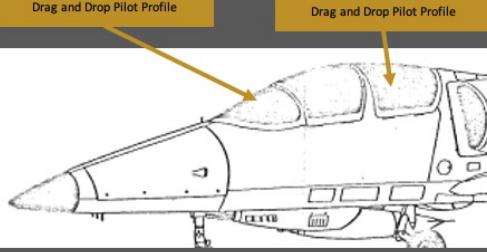
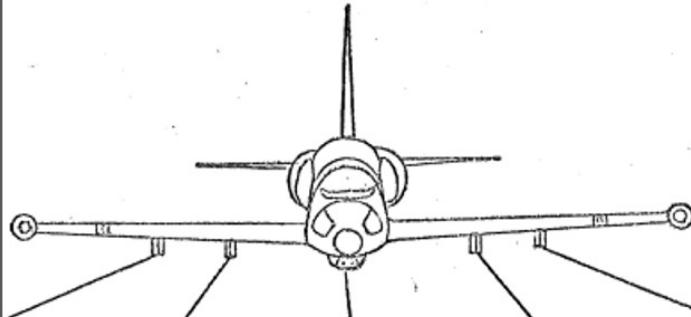
- Pilot Profile 1
- Pilot Profile 2
- Pilot Profile 3

Add New Profile

**Loadout Profile List:**

- Loadout 1
- Loadout 2
- Loadout 3
- Loadout 4
- Loadout 5

Add New Loadout

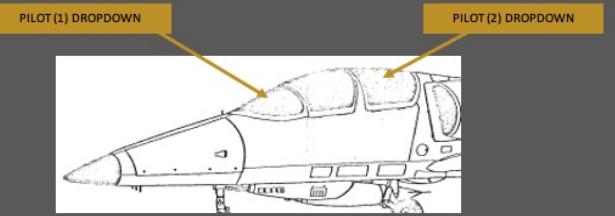
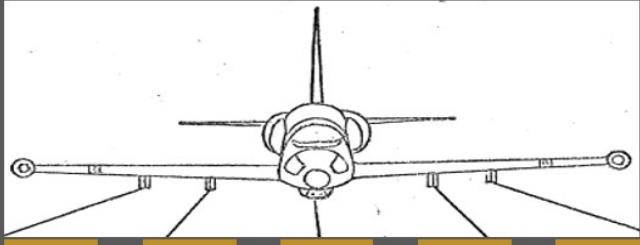



**INPUT PARAMETERS**

Takeoff Mass	dropdown
Landing Mass	dropdown
Temperature	dropdown
Drag	dropdown
Slope	dropdown
Friction	dropdown
Runway Type	dropdown
PSI	dropdown
Wind	dropdown
Aircraft Type	dropdown

**OUTPUT PERFORMANCE PARAMETERS**

Takeoff Speed	dropdown
Touch-Down Speed	dropdown
Stall Speed	dropdown
Takeoff Distance	dropdown
Landing Distance	dropdown
Ground Run Distance	dropdown
Approach Speed	dropdown
Speed Over Obstacle	dropdown
Accel-Stop Distance	dropdown
Stall Speed (Gear Up)	dropdown
Stall Speed (Gear Down)	dropdown

# Detail Design – UI Mockups

**Calculator**

**Manual Input**

Takeoff Mass	Landing Mass
Temperature	Drag
Slope	Friction
Runway Type	PSI
Wind	Aircraft Type

**Automatic Input**

- Selected Airport ID
- Selected Runway
- Select Pilot Profile
- Dropdown - Selected Mission Pilot Profile
- Select Mission Loadout
- Dropdown - Selected Mission Loadout Profile

**Performance Parameters**

- Takeoff
- Landing
- Stall Speeds
- Takeoff Speed
- Takeoff Distance
- Ground Run Distance
- Speed Over Obstacle
- Accel-Stop Distance

Runway Distance

**SEARCH Function – help expedite profile selection**

**Manual**      **Automatic**

**Airport ID**

- 4 Digit Code
- Find Runways
- Select Takeoff Runway
- Display Runway Options
- Select Runway Starting Side
- Display Runway Side Options

**Temperature**

**Pressure Altitude**

**Precipitation**

**Head Wind**

**Runway Length**

**Runway Type**

**Slope**

**Drag and Drop Pilot Profile**

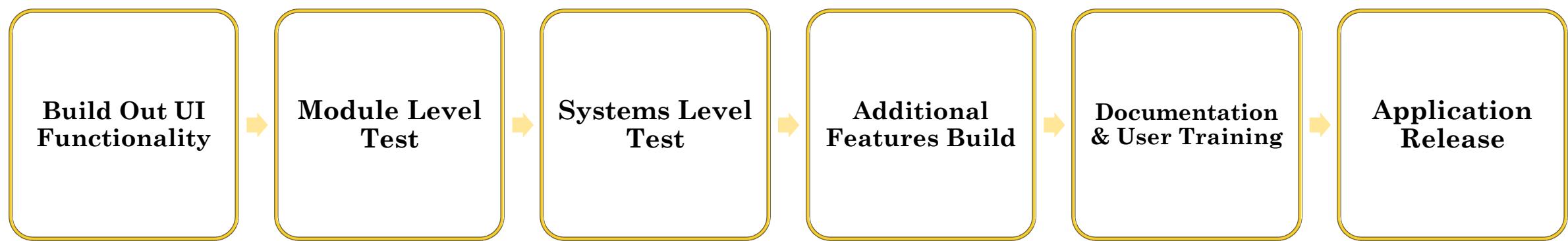
**L-39ZA Sample Loading**

	Gallons	Pounds	A.O.L.	Moment	%MAC
Basic Empty Aircraft	200	288.53	1,819,423.54		24.89%
Pilot (1)	210	121.03	25,410.00		
Pilot (2)	-	181.03	0.00		
Pilot (3) (2)	(36)	181.03	-6,831.20		
Baggage (1)	-	36.35	0.00		
Baggage (2)	-	63.25	0.00		
Zero Fuel C.G.	8.183	236.75	1,937,281.34		21.51%
Minimum Fuel	60	406	243.50	99,567.10	
		8,092	237.37	2,036,848.49	21.99%
Full Fuel	288	1,963	243.50	477,922.32	
		10,146	238.05	2,415,203.66	23.15%
Full Fuel and Tip Fuel	52	354	243.50	88,291.53	
		10,500	238.24	2,581,495.19	23.37%

**Performance Parameters**

- Takeoff
- Landing
- Stall Speeds
- Takeoff Speed
- Ground Run Distance
- Takeoff Distance
- Speed Over Obstacle
- Accel-Stop Distance

# Implementation



# Implementation

## 1. Build Out User Functionality

- Since all design decisions had been made, team could now start building out functionality

## 2. Module Level Test

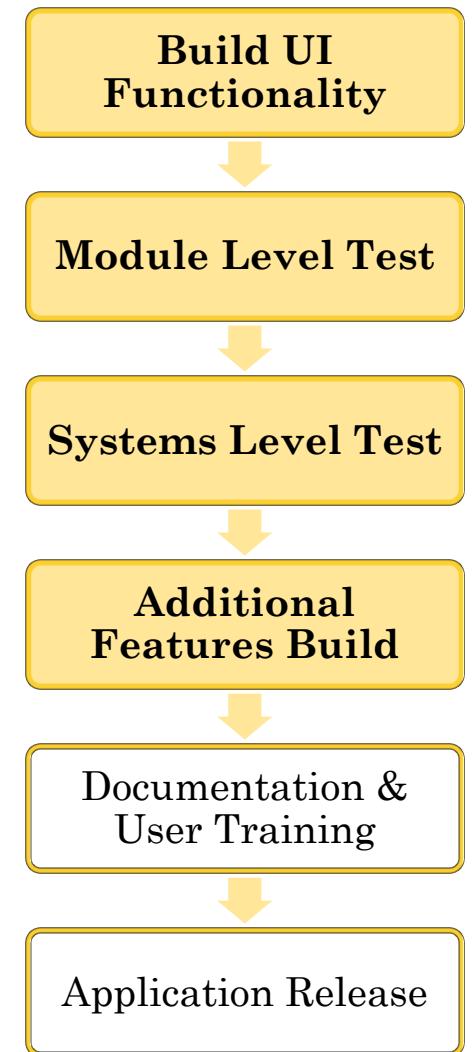
- Test cases were used to compare calculator outputs to those of known graphical lookup chart results
- Ensured back-end functionality was operating correctly by uncovering bugs and inconsistencies in the calculator's algorithm

## 3. Systems Level Test

- RESTful API used to connect the back-end with the front-end
- Confirmation tests using HTTP requests were used to verify front-end and back-end connection was working appropriately

## 4. Inclusion Build with Additional Features

- Features Added:
  - Pilot Profiles
  - Common Aircraft Store Loadouts
  - Performance Parameter Print Functionality
  - Automatic Entry of Airport Weather Conditions
  - Visual Display for Takeoff and Landing Buffers



# Detail Design – Original UI

Aircraft Performance Calculator

[Logout](#)

Takeoff Mass:	<input type="text"/>	Airport ID:	<input type="text"/>
Landing Mass:	<input type="text"/>	Runway Number:	<input type="text"/>
Temp:	<input type="text"/>	09_27	
Drag:	<input type="text"/>	<b>Query</b>	
Slope:	<input type="text"/>	"Temperature = 5.0 C Pressure Altitude = 232.7839447999992m Precipitation = 0.0 inches Head Wind = -0.7660433853386315 m/s Runway Length = 8600ft Runway Type = CONC\n"	
Friction:	<input type="text"/>		
Runway Type:	<input type="text"/>		
PSI:	<input type="text"/>		
Wind:	<input type="text"/>		
Aircraft Type:	<input type="text"/>		
<b>None</b> <b>Submit</b> <b>Save</b>			

# Detail Design – First Full UI

**CORE**

- Calculator
- Add Profiles

**ADD-ONS**

- Solver
- Airport Information

Logged in as:  
peytonhobson

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## Calculator

**Runway Conditions**

Manual Automatic ✓

**Mission Specific Info**

peyton Approximate Flight Time: 60 minutes

None

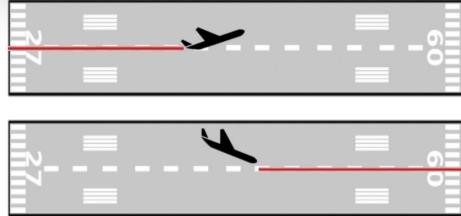
**Aircraft Profile**

profile1 Info

**Calculate**

**Performance Parameters** Print

Takeoff	Landing	Stall Speeds
Imperial	Metric	
Takeoff Speed	119.5	kts
Takeoff Distance	3312.4	ft
Ground-Run Distance	1596.52	ft
Accel-Stop Distance	5015.72	ft
Speed Over Obstacle	130.43	kts



# Detail Design – Final UI

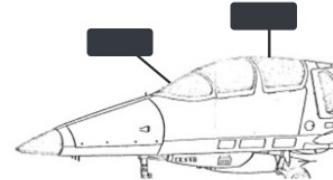
**OPL**

- CORE
  - Calculator
  - Profiles
- ADD-ONS
  - Solver
  - Runway Query
- DOCUMENTATION
  - Download Instructions

Logged in as:  
neurthonhohnsonn  
localhost:4200/dashboard

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## Calculator



**L39 Loading**

	Gallons	Pounds	ARM	Moment	%MAC
<b>Basic Empty Aircraft</b>	7777	242	1885534	28%	
Pilot (1)					
Pilot (2)					
Parachute 2					
Baggage (1)					
Baggage (2)					
<b>Minimum Fuselage Fuel</b>	60	409	244	99592	
	8186	241	1984696	28.3%	

**Actual Fuselage Fuel**

Tip Tanks				
Underwing Tanks				
Outboard				
Centerline Store				
<b>Total</b>	7777	242.4	1885534	28.3%

**Runway Conditions**

Manual      Automatic

**Pilots**

Pilot 1      Baggage Weight: 0 lbs

Pilot 2      0 lbs

**Mission Info**

Fuel Remaining at Landing: 0 gal

Parachute 2: In (radio button selected) Out (radio button)

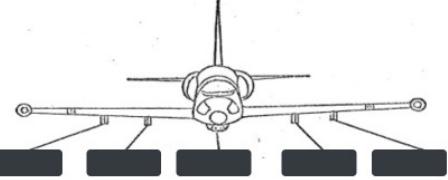
**Aircraft Profile**

Choose Profile

**Calculate**

**Airport ID:**

Temperature	°C
Pressure Altitude	ft
Precipitation	in
Head Wind	kts
Runway Length	ft
Runway Type	Slope



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# Detail Design – Demo

OPL

CORE

- Calculator
- Profiles

ADD-ONS

- Solver
- Runway Query

DOCUMENTATION

- Download Instructions

Logged in as:  
peytonhobson

Operator Performance Laboratory

Calculator

L39 Loading

	Gallons	Pounds	ARM	Moment	%MAC
<b>Basic Empty Aircraft</b>	7777	242	1885534	28%	
Pilot (1)					
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Parachute 2					
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	8186	241	1984696	28.3%	
<b>Actual Fuselage Fuel</b>					
Tip Tanks					
Underwing Tanks					
Outboard					
Centerline Store					
<b>Total</b>	7777	242.4	1885534	28.3%	

Runway Conditions

- Manual
- Automatic

Pilots

- Pilot 1
- Pilot 2

Baggage Weight:

- 0 lbs
- 0 lbs

Airport ID:

Temperature	°C
Pressure Altitude	ft
Precipitation	in
Head Wind	kts
Runway Length	ft
Runway Type	
Slope	°

Mission Info

Fuel Remaining at Landing: 0 gal

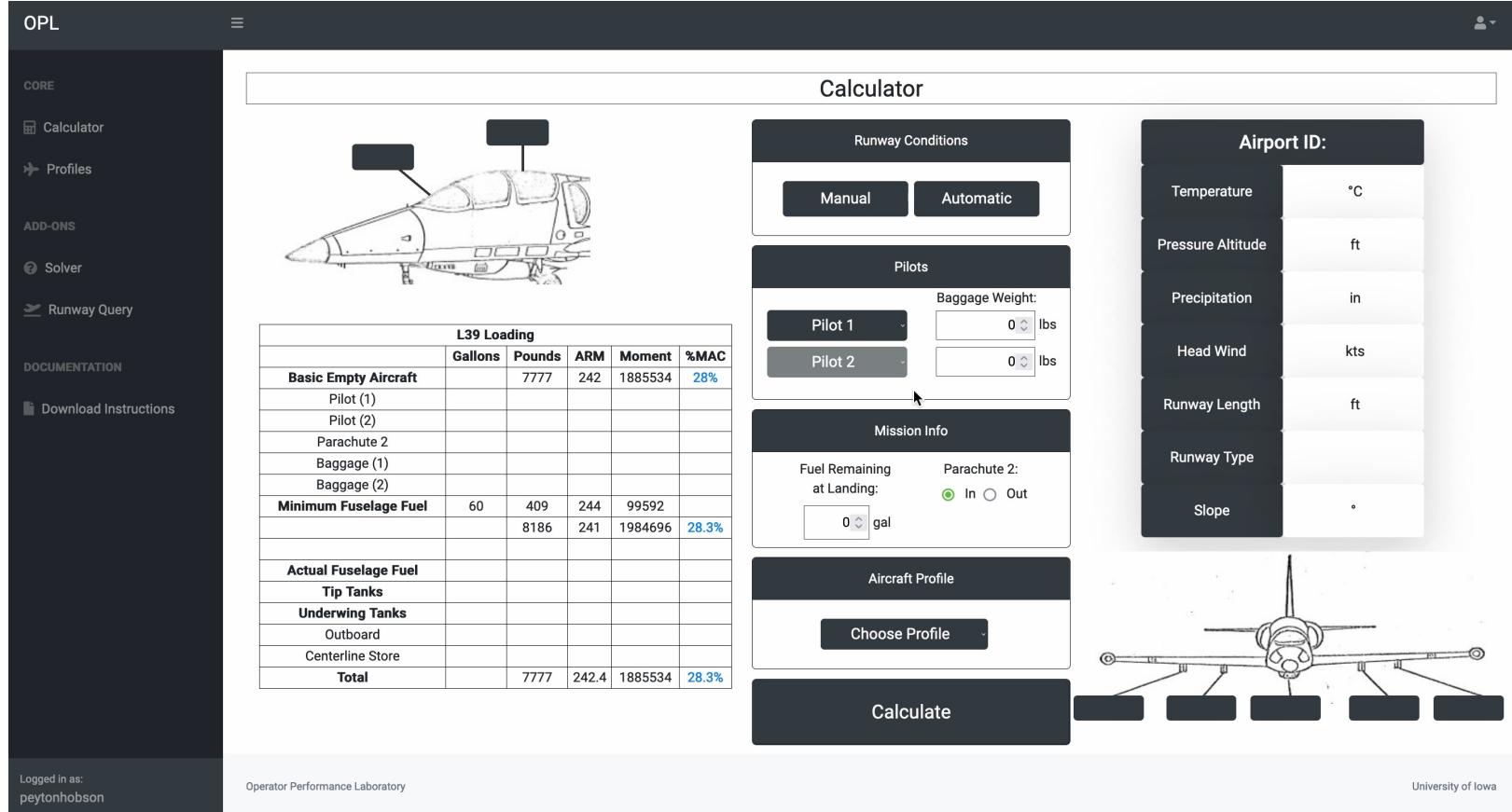
Parachute 2: In (radio button selected)

Aircraft Profile

Choose Profile

Calculate

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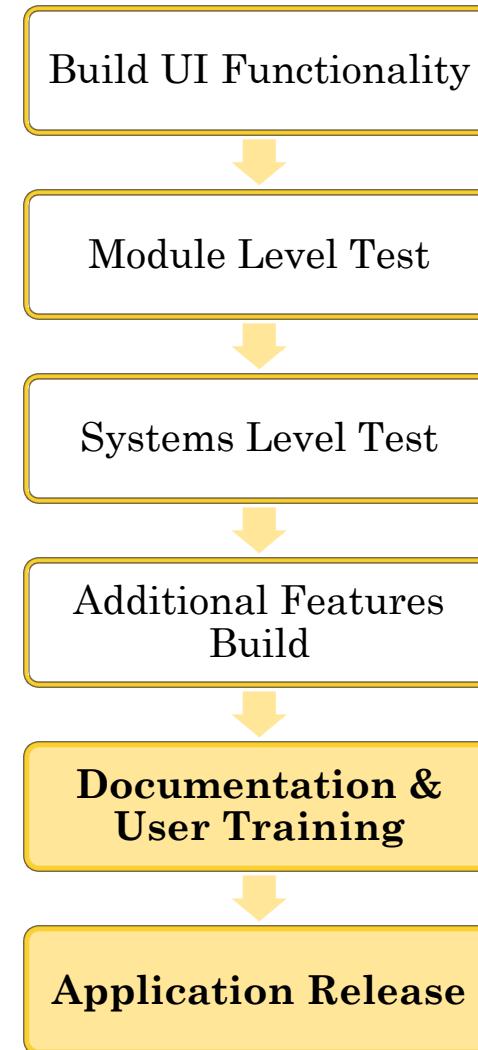
# Implementation

## 5. Develop Documentation and User Training

- Due to the complexity of the application our team developed a User Training PowerPoint that includes:
  - Comprehensive overview of the calculator's full functionality
  - Written instructions detailing how to operate the calculator
  - Picture displays and embedded video demonstrations depicting how to enter required inputs and interpret outputted performance parameters
- PowerPoint was selected due to its ability to utilize all these media platforms to provide a concise yet complete summary of the calculator's features

## 6. Application Release

- Performance calculator released in three parts:
  1. Database server
  2. Back-end service
  3. Front-end service
- The completed application and its associated resources have been turned over to the OPL for future maintenance and modification



# Test & Validation

- Initial validation done using OPL's Flight Simulator
  - The team utilized the X-Plane simulator to compare the simulator's performance parameters to the calculator's outputs
  - Most performance parameters were within  $\pm 3$  Knots, however takeoff and landing parameters saw larger differences
- Possible explanations for the larger difference in Takeoff and Landing parameters
  - X-Plane tends to misrepresent the runway friction which would account for the discrepancy in parameters pertaining to the runway while not impeding air parameters such as stall speeds
  - The pilot of the simulator was not a licensed pilot and therefore could also account for the difference in parameter outputs



# Test & Validation

- Real-world confirmatory flights are still looking to be conducted to test the fully-functioning performance calculator
  - Dr. Thomas Schnell would lead and pilot any and all confirmatory flights
- Our team is working with OPL's schedule to determine if confirmatory flights can be completed prior to the semester's end
  - In the case the team cannot find a suitable time with OPL's schedule, real-world confirmatory flights can still be conducted after the project's completion



# Resources & Constraints

- **Resources**

- Colton Thompson – Project Liaison
- Dr. Thomas Schnell – Project Liaison
- Jon Stoltz – Airport Querying Resource
- Brad Parker – OPL Web-Hosted Server(s) Resource

- **Constraints**

- Limited physical constraints due to software-based nature of the project

*Time Constraints* – Roughly 15 weeks to develop application and integrate it with a functioning user interface



Colton Thompson



Dr. Thomas Schnell

# Questions?