Small Aircraft Runway Length Analysis Tool Case Studies

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Case Study # 1
Runway Analysis for an Airport Master Plan

Scenario Description

- A small rural airport is revising its Master Plan
- The airport is equipped with a single, paved primary runway
- The aircraft fleet mix was developed for the new airport (see the next slide)
- No aircraft operations under Part 135 regulations are anticipated at this airport, nor is an AWOS planned (so, Part 135 operations are not selected in the analysis)
- The proposed airport will be built at an elevation of 2,029 feet Mean Sea Level (MSL)
- The design temperature, the mean daily maximum temperature of the hottest month of the year, is projected to be 88 degrees Fahrenheit (in July)
- Wind conditions were assumed to be calm for the analysis
- The existing runway has a gradient of 0.8%

- In this example, we use SARLAT's Runway Design Mode to estimate takeoff and landing runway lengths

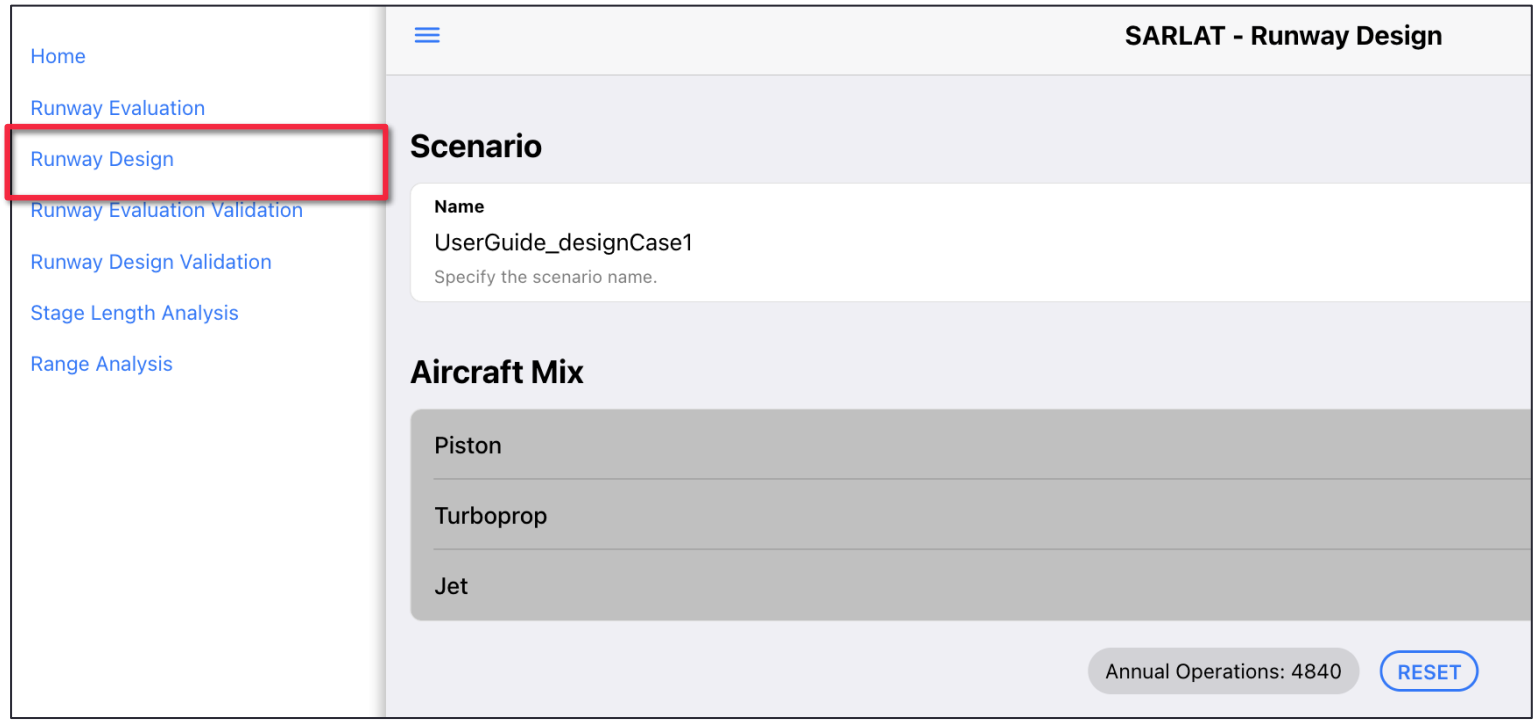
Fleet Mix and Design Conditions

Aircraft Name (FAA 7360.1 Identifier)	Useful Load (%)	Annual Operations
Piston		
BE55	100	520
C172	100	1540
C182	100	670
SR22	100	520
M20P	100	410
RV12	100	240
Turboprop		
BE20	90	540
PC12	100	180
TBM7	100	220

Airport Design Conditions	Value
Pressure Altitude (Field Elevation) (ft)	2029
Design Air Temperature (F)	88
Wind Speed (knots)	0
Runway Gradient (%)	0.8
Surface Type	Paved

Critical Aircraft Operational Capability

- Go to the **Runway Design** module in SARLAT to estimate the design runway length required by a known aircraft fleet mix
- Define the airport environmental conditions, fleet mix, runway grade and runway surface type
- **Design runway length** is that needed by the critical aircraft when operating at the environmental factors and payload parameters as specified to AC 150/5325-4.



New Airport Case Study: Aircraft Fleet Mix and Airport Conditions

SARLAT - Runway Design

Piston

Aircraft Name	Annual Operations	Takeoff Useful Load (%)
BE36 - Beech Bonanza 36	0	100
BE55 - Beechcraft 55 Baron	0	100
BE58 - Beechcraft 58 Baron	520	100
C150 - Cessna 150	0	100
C152 - Cessna 152	0	100
C172 - Cessna 172 Skyhawk	1540	100
C177 - Cessna 177 Cardinal	0	100
C180 - Cessna 180 Skywagon	0	100
C182 - Cessna 182 Skylane	670	100

Aircraft Name	Annual Operations	Trip Distance with Average Passenger Load (nm)	Takeoff Useful Load (%)	Part 135	Landing Weight (% of MALW)
AT5T - AirTractor 502	0		100	No	
AT8T - AirTractor 802	0		70	No	
BE30 - Beechcraft 300 Super King Air	0	914	70	No	77
B350 - Beechcraft King Air 350ER		1026	70	Yes	74
BE20 - Beechcraft King Air B200GT	540	755	90	No	77
BE9L - Beechcraft King Air C90	0		100	No	
C208 - Cessna 208 Caravan	0		100	No	
C408 - Cessna 408	0	422	70	No	92
PC12 - Pilatus PC 12 NG	180		100	No	
P46T - Piper 46 Malibu Meridian	0		100	No	
AC90 - Rockwell Commander 690B	0		100	No	
TBM7 - Socata TBM 700	220		100	No	

SARLAT - Runway Design

Piston

Turboprop

Jet

Annual Operations: 4840 RESET

Environmental Factors

Pressure Altitude (Field Elevation) (ft)

2029

Specify the runway's pressure altitude (field elevation).

Air Temperature (F)

88

Specify the runway's mean daily maximum temperature of the hottest month of the year.

Wind Speed (kts)

0

Headwind is negative. Tailwind is positive.

Runway Information

Runway Gradient (%)

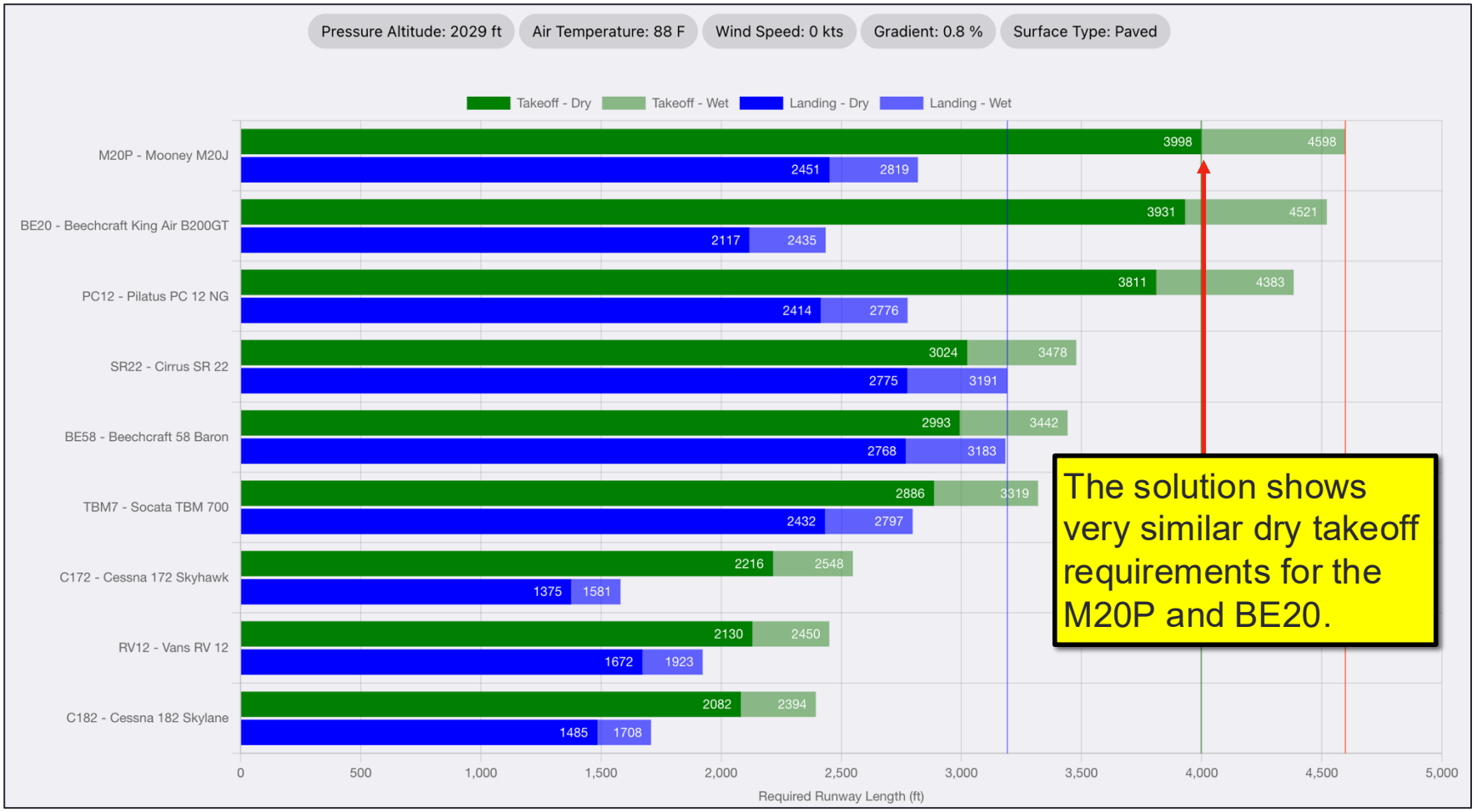
0.8

Downhill is negative. Uphill is positive.

Surface Type

Paved

Runway Length Requirements: Graphical Output



Note: For AIP projects, use **wet landing** and **dry takeoff** performance.

Takeoff and Landing Distances Table Output

- The table summarizes the takeoff and landing requirements for each aircraft
- Note that the dry runway takeoff distance requirement for the M20P (Mooney M20J) and the BE20 (King Air B200GT) are very similar

Aircraft Name	Takeoff Useful Load (%)	Landing Useful Load (%)	Takeoff (ft)		Landing (ft)					
					Part 91		Part 135 EOD		Part 135/91K	
			Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Piston										
BE58 - Beechcraft 58 Baron	100	100	2993	3442	2768	3183				
C172 - Cessna 172 Skyhawk	100	100	2216	2548	1375	1581				
C182 - Cessna 182 Skylane	100	100	2082	2394	1485	1708				
SR22 - Cirrus SR 22	100	100	3024	3478	2775	3191				
M20P - Mooney M20J	100	100	3998	4598	2451	2819				
RV12 - Vans RV 12	100	100	2130	2450	1672	1923				
Turboprop										
BE20 - Beechcraft King Air B200GT	90	77	3931	4521	2117	2435				
PC12 - Pilatus PC 12 NG	100	100	3811	4383	2414	2776				
TBM7 - Socata TBM 700	100	100	2886	3319	2432	2797				

Master Plan Study: Critical Aircraft Table

- The table below identifies the BE20 as the critical aircraft for runway length, using similar characteristics per AC 150/5000-17
- The table ranks the takeoff distance requirements and shows the cumulative number of annual operations (ninth column of the table below)
- A 4,000-foot runway is the design runway length for the critical aircraft (rounding up from 3,931 feet for the BE20.

Critical Aircraft for Runway Length

TAKEOFF DRY | TAKEOFF WET | LANDING DRY | LANDING WET

BE20 - Beechcraft King Air B200GT is the critical aircraft and requires **3931 ft** of runway to be fully accommodated in the full range of specified operating conditions.

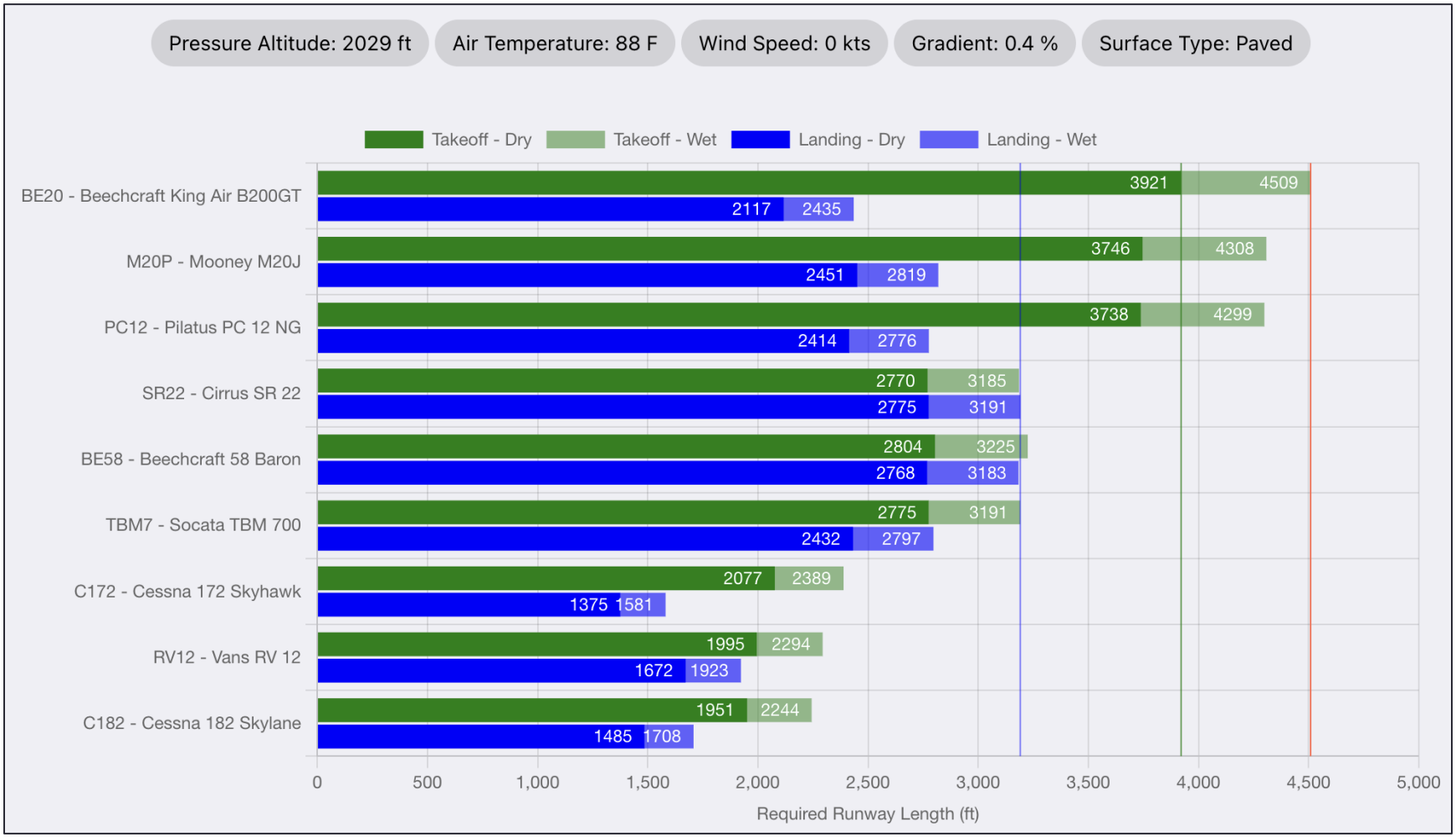
Aircraft Name	Engine Type	Aircraft Design Group (ADG)	Aircraft Approach Category (AAC)	Taxiway Design Group (TDG)	Takeoff Useful Load (%)	Landing Useful Load (%)	Annual Operations	Cumulative Annual Operations	Takeoff Dry (ft)	Takeoff Wet (ft)	Landing Dry (ft)	Landing Wet (ft)
M20P - Mooney M20J	Piston	I	A	1A	100	100	410	410	3998	4598	2451	2819
BE20 - Beechcraft King Air B200GT	Turboprop	II	B	2A	90	77	540	950	3931	4521	2117	2435
SR22 - Cirrus SR 22	Piston	I	A	1A	100	100	520	1470	3024	3478	2775	3191
BE58 - Beechcraft 58 Baron	Piston	I	B	1A	100	100	520	1990	2993	3442	2768	3183
PC12 - Pilatus PC 12 NG	Turboprop	II	A	2A	85	100	180	2170	3155	3628	2414	2776

Master Plan Study

- The analysis shows that a 4,000-foot runway satisfies the dry pavement requirements for the BE20 critical aircraft
- This example demonstrates that, even for modest airport elevation and temperature conditions, piston aircraft may require longer runways than some turboprop aircraft
- Piston aircraft performance can be very sensitive to runway grades as demonstrated in the following sensitivity analysis:
- Reducing the runway effective grade from 0.8% to 0.4%, the takeoff distance requirements of the BE20 would be greater than the M20P
- The new solution is presented in the following slide.

Runway Length Requirements: 0.4% Grade

With a reduced grade of 0.4%, the King Air B200GT (BE20) requires more takeoff distance than the Mooney M20J (M20P)



Master Plan Runway Length Requirements: 0.4% Grade

- With a reduced grade of 0.4%, the BE20 is still the critical aircraft because we expect more than 500 annual operations for that aircraft type at the new airport
- The BE20 requires 3,921 feet of runway (typically rounded down to 3,900 feet)

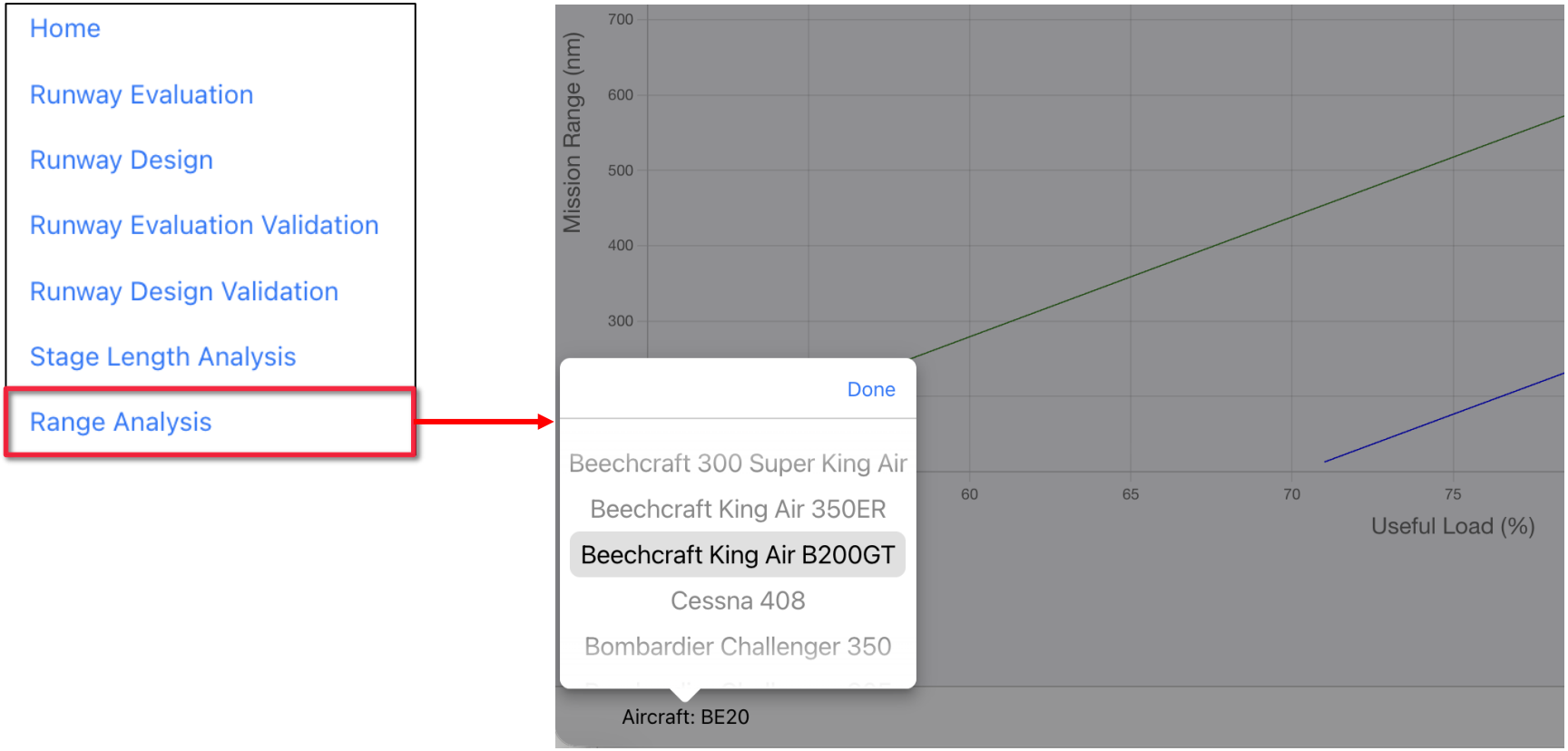
TAKEOFF DRY | TAKEOFF WET | LANDING DRY | LANDING WET

BE20 - Beechcraft King Air B200GT is the critical aircraft and requires **3921 ft** of runway to be fully accommodated in the full range of specified operating conditions.

Aircraft Name	Engine Type	Aircraft Design Group (ADG)	Aircraft Approach Category (AAC)	Taxiway Design Group (TDG)	Takeoff Useful Load (%)	Landing Useful Load (%)	Annual Operations	Cumulative Annual Operations	Takeoff Dry (ft)	Takeoff Wet (ft)	Landing Dry (ft)	Landing Wet (ft)
BE20 - Beechcraft King Air B200GT	Turboprop	II	B	2A	90	77	540	540	3921	4509	2117	2435
M20P - Mooney M20J	Piston	I	A	1A	100	100	410	950	3746	4308	2451	2819
SR22 - Cirrus SR 22	Piston	I	A	1A	100	100	520	1470	2770	3185	2775	3191
BE58 - Beechcraft 58 Baron	Piston	I	B	1A	100	100	520	1990	2804	3225	2768	3183
PC12 - Pilatus PC 12 NG	Turboprop	II	A	2A	85	100	180	2170	3098	3563	2414	2776

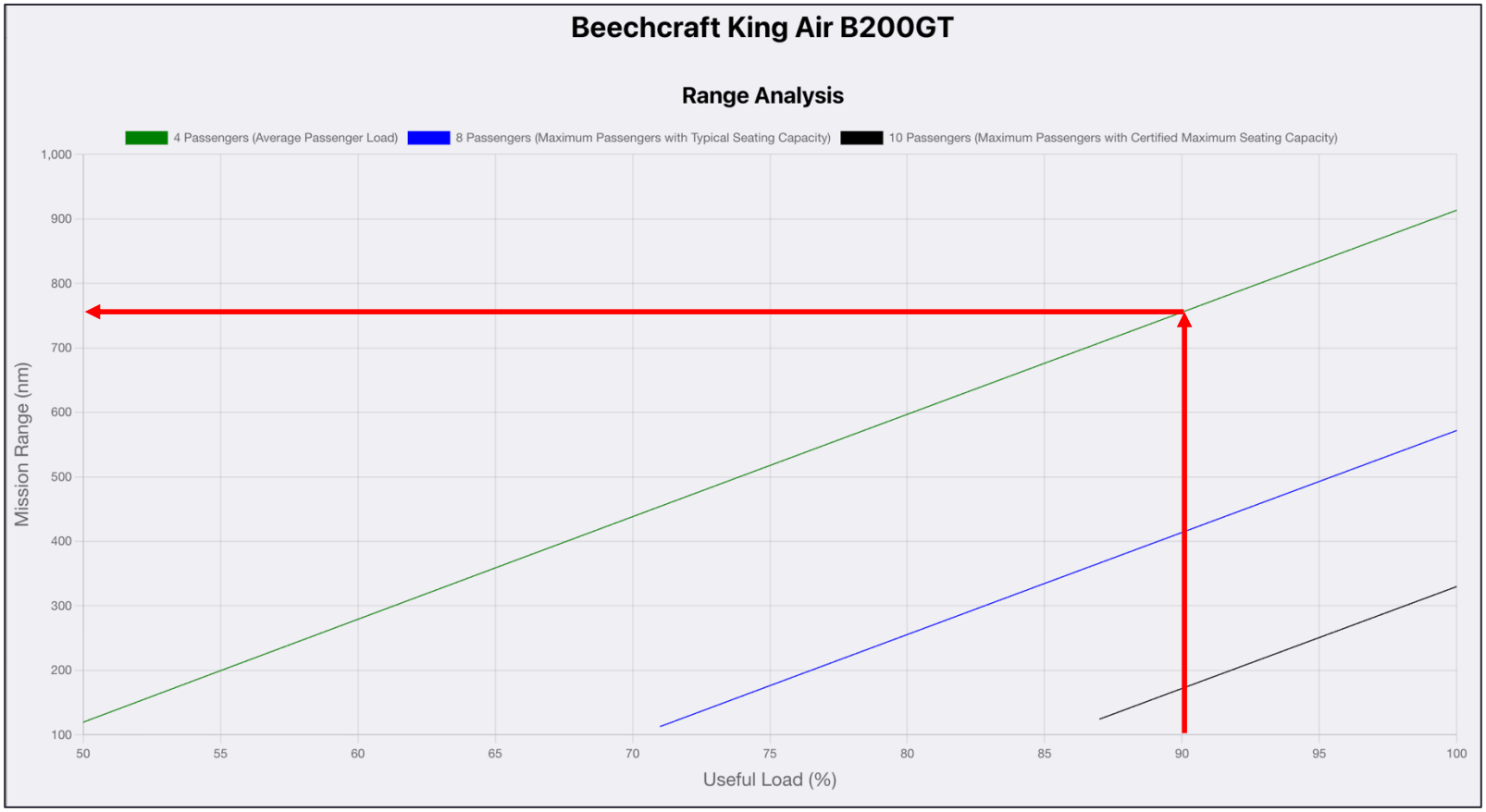
Master Plan: Critical Aircraft Operational Capability

- Go to the **Range Analysis** in SARLAT to examine the operational capabilities of the critical aircraft (BE20) operating from the existing runway
- Select the critical aircraft in the scrolling list at the lower left of the analysis (see graphic)



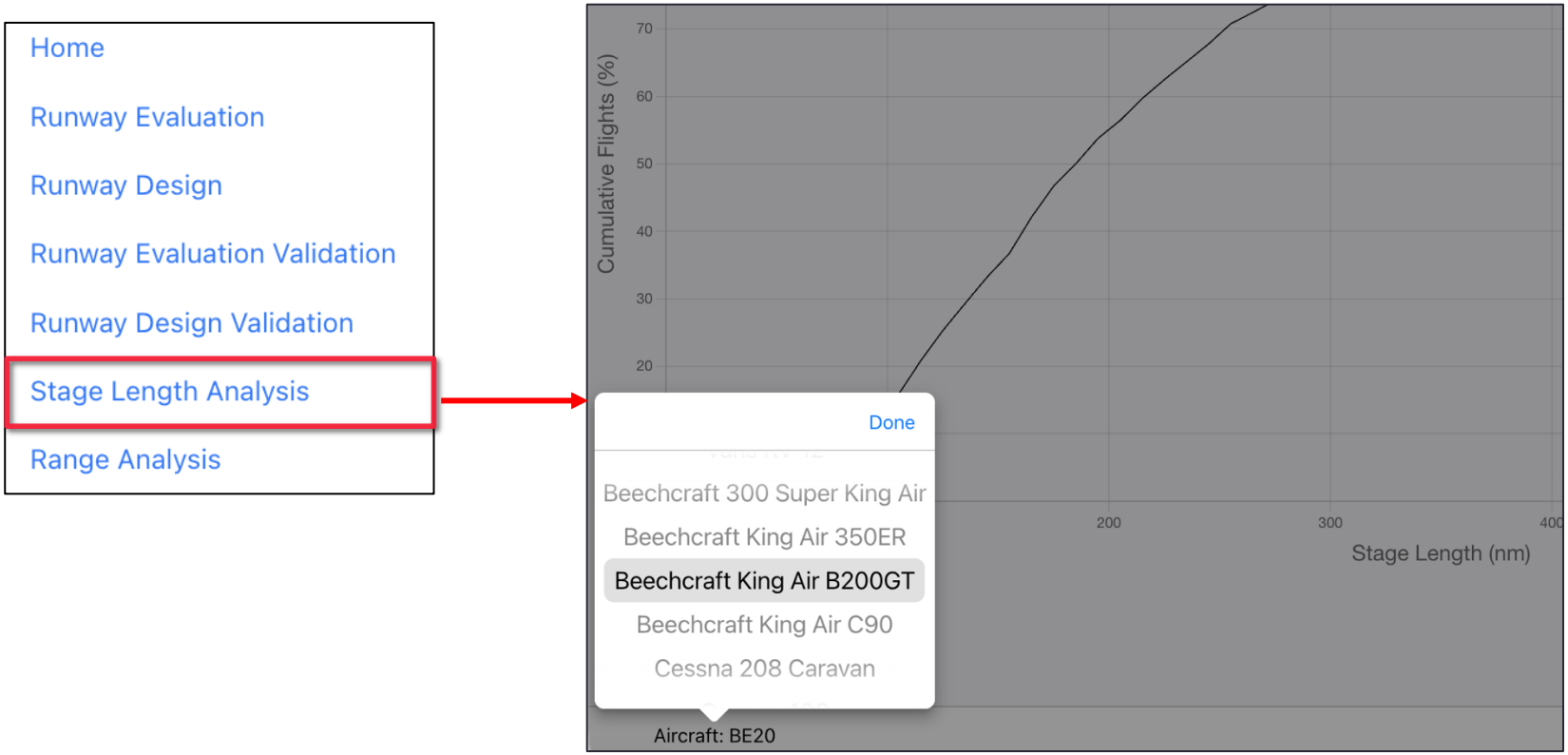
Master Plan: Critical Aircraft Operational Capability

- Review the **Useful Load Mission Range** diagram for the BE20
- The BE20 can fly 760 nm departing with a 90% useful load and four passengers plus a single pilot



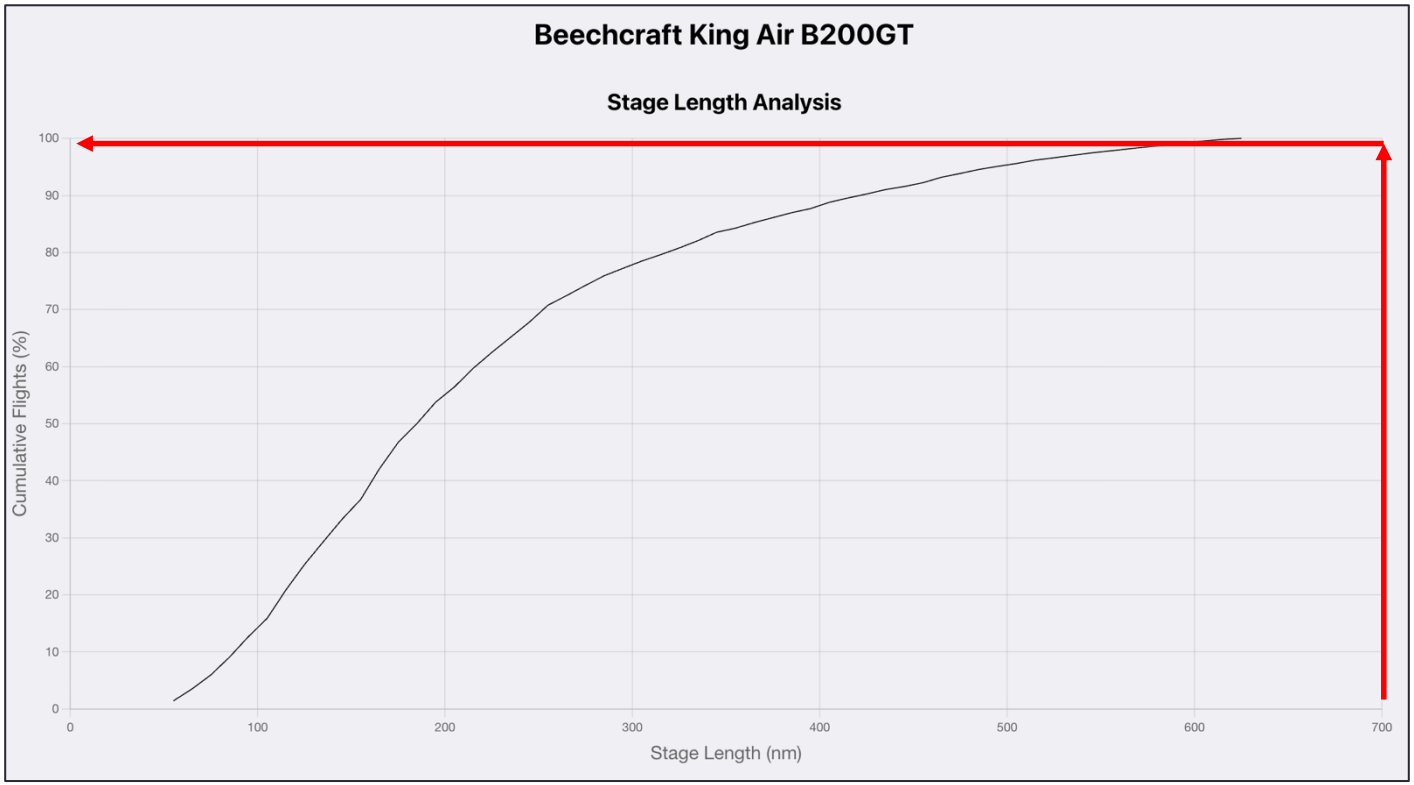
Master Plan: Critical Aircraft Operational Capability

- Go to the **Stage Length Analysis** in SARLAT to examine the operational capabilities of the critical aircraft operating from the new runway
- Select the critical aircraft (BE20) in the scrolling list at the lower left of the Stage Length Analysis window (see graphic)



Master Plan: Critical Aircraft Operational Capability

- Examine the **Cumulative Flights Stage Length** diagram for the critical aircraft (BE20)
- Based on historical data, the BE20 can fly 100% of missions in the National Airspace System with a 90% useful load and four passengers plus a single pilot while departing a 4,000-foot runway.



Master Plan Analysis Conclusions

- For the new airport design conditions, the SARLAT Design Analysis shows that a 4,000-foot runway meets the needs for the critical aircraft, the BE20, using parameters aligned with AC 150/5325-4 and acceptable for AIP justification
- This example is for a primary runway at a new airport, but the analysis would be similar for an existing runway at an airport also that is assessing the need for a runway extension
- Supplemental metrics help an airport to understand the benefit of the calculated runway length, though do not change the justified AIP runway length:
  - Using SARLAT's Useful Load Mission Range diagram, the critical aircraft can fly 760 nm departing with a 90% useful load and four passengers plus a single pilot
  - Using SARLAT's Cumulative Flights Stage Length Analysis, the critical aircraft can fly 100% of missions in the National Airspace System with a 90% useful load and four passengers plus a single pilot while departing a 4,000-foot runway.
- AC 150/5325-4B does not specify thresholds for either of these metrics for AIP justification. If there is an operational need for a higher payload or longer mission range with regular use (250 annual departures), then input that useful load percentage or trip distance into the design module.

Case Study # 2: Runway Evaluation

Airport Runway Evaluation

- Existing airport with a 5,300-foot paved runway
- The airport manager is interested in understanding how the existing runway length supports aircraft using the airport
- The existing aircraft fleet mix was developed using ADS-B, TFMSC, and ATCT counts
- Operators of certain aircraft use Part 135/91K regulations, so Part 135/91K operations are selected for those aircraft types in the analysis
- The airport is located at an elevation of 2,960 feet Mean Sea Level (MSL)
- Evaluate both the annual average daily daytime temperature (70 F) and a hot temperature, the mean daily maximum temperature of the hottest month of the year, 89 degrees Fahrenheit (in July) to understand how performance varies seasonally since not all operations occur during hot conditions
- Wind conditions were assumed to be calm for the analysis
- The existing runway has a gradient of 0.6%.

Existing Airport Fleet Mix

Aircraft Name	FAA / ICAO Code	Annual Operations	Part 135
Piston	**Piston**		
Cessna 152	C152	16500	No
Cessna 172 Skyhawk	C172	18600	No
Cessna 182 Skylane	C182	7600	No
Piper Archer	P28B	8900	No
Cirrus SR22	SR22	10300	No
Cessna 421	C421	1650	No
Piper Seminole	PA44	2350	No
Turboprop	**Turboprop**		
Beechcraft King Air 350ER	B350	585	Yes
Pilatus PC12	PC12	1260	Yes
Air Tractor 502	AT5T	135	No
Beechcraft King Air C90	BE9L	630	No
Cessna 208	C208	410	No
Cessna 408	C408	230	Yes

Existing Airport Fleet Mix (2)

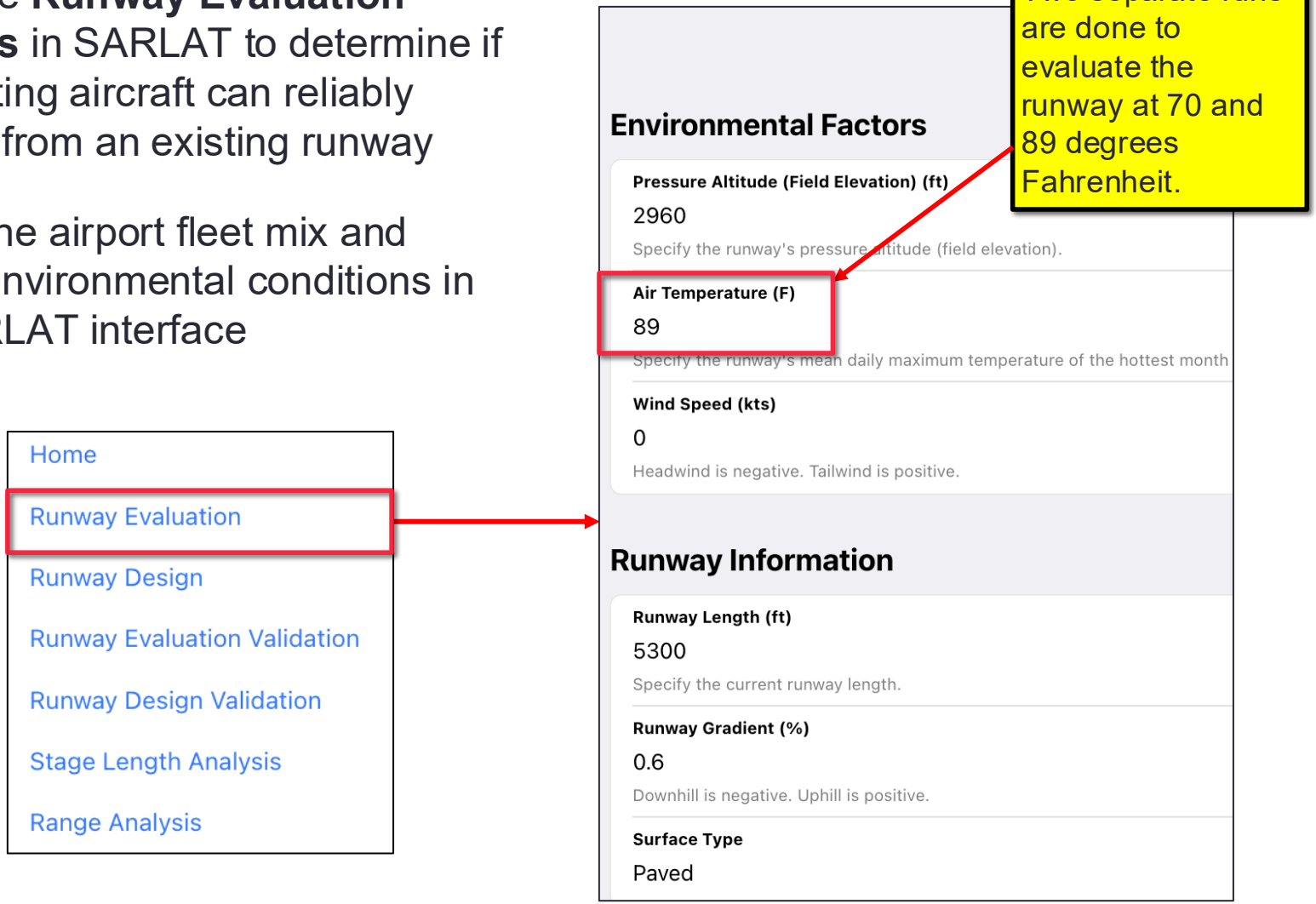
Aircraft Name	FAA / ICAO Code	Annual Operations	Part 135
Jet	**Jet**		
Bombardier Challenger 350	CL35	430	Yes
Cessna Citation 560XL	C56X	530	Yes
Cessna Citation Latitude	C68A	490	Yes
Cessna Citation CJ3	C25B	1100	No
Cessna Citation X	C750	120	Yes
Falcon 2000EX	F2TH	260	Yes
Hawker 800XP	H25B	450	Yes
Honda Jet 420	H420	135	No
Embraer Phenom 300	E55P	570	Yes

Airport Design Conditions

Parameter	Value
Existing Runway length (ft)	5,300
Pressure Altitude (Field Elevation) (ft)	2,960
Design Temperature (F)	89
Mean Annual Temperature (F)	70
Wind Speed (knots)	0
Runway Gradient (%)	0.6
Surface Type	Paved

Runway Evaluation Case Study

- Go to the **Runway Evaluation Analysis** in SARLAT to determine if the existing aircraft can reliably operate from an existing runway
- Define the airport fleet mix and airport environmental conditions in the SARLAT interface



Runway Evaluation Results: Piston Aircraft Operating at 70 Degrees Fahrenheit

Runway Takeoff and Landing Restrictions

Pressure Altitude: 2960 ft | Air Temperature: 70 F | Wind Speed: 0 kts | Runway Length: 5300 ft | Gradient: 0.6 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135/91K	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Piston											
C152 - Cessna 152	22%			100 % 1670 lbs	100 % 1670 lbs	✓	✓				
C172 - Cessna 172 Skyhawk	25%			100 % 2300 lbs	100 % 2300 lbs	✓	✓				
C182 - Cessna 182 Skylane	10%			100 % 2950 lbs	100 % 2950 lbs	✓	✓				
C421 - Cessna 421 Golden Eagle	2%			100 % 7450 lbs	100 % 7450 lbs	✓	✓				
SR22 - Cirrus SR 22	14%			100 % 3600 lbs	100 % 3600 lbs	✓	✓				
P28B - Piper 28B Dakota	12%			100 % 3000 lbs	100 % 3000 lbs	✓	✓				
PA44 - Piper 44 180 Seminole	3%			100 % 3800 lbs	100 % 3800 lbs	✓	✓				

Observations at 70 degrees Fahrenheit operating conditions:

1) All piston aircraft can operate at 100% useful load from the 5,300-foot runway

Runway Evaluation Results: Piston Aircraft Operating at 89 Degrees Fahrenheit

Pressure Altitude: 2960 ft | Air Temperature: 89 F | Wind Speed: 0 kts | Runway Length: 5300 ft | Gradient: 0.6 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135/91K	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Piston											
C152 - Cessna 152	22%			100 % 1670 lbs	100 % 1670 lbs	✓	✓				
C172 - Cessna 172 Skyhawk	25%			100 % 2300 lbs	100 % 2300 lbs	✓	✓				
C182 - Cessna 182 Skylane	10%			100 % 2950 lbs	100 % 2950 lbs	✓	✓				
C421 - Cessna 421 Golden Eagle	2%			100 % 7450 lbs	100 % 7450 lbs	✓	✓				
SR22 - Cirrus SR 22	14%			100 % 3600 lbs	100 % 3600 lbs	✓	✓				
P28B - Piper 28B Dakota	12%			100 % 3000 lbs	100 % 3000 lbs	✓	✓				
PA44 - Piper 44 180 Seminole	3%			100 % 3800 lbs	100 % 3800 lbs	✓	✓				

Observations at 89 degrees Fahrenheit operating conditions:

1) All piston aircraft can operate at 100% useful load from the 5,300-foot runway

VIRGINIA TECH

Runway Evaluation Results: Turboprop Aircraft Operating at 70 Degrees Fahrenheit

Pressure Altitude: 2960 ft | Air Temperature: 70 F | Wind Speed: 0 kts | Runway Length: 5300 ft | Gradient: 0.6 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135/91K	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Turboprop											
AT5T - AirTractor 502	0%			100 % 10480 lbs	100 % 10480 lbs	✓	✓			✓	✓
B350 - Beechcraft King Air 350ER	1%	100 % FLIGHTS IN NAS 1081 nm / 5 pax	38 % FLIGHTS IN NAS 183 nm / 5 pax	72 % 14779 lbs	39 % 12773 lbs	✓	✓			✓	✓
BE9L - Beechcraft King Air C90	1%			100 % 10485 lbs	100 % 10485 lbs	✓	✓			✓	✓
C208 - Cessna 208 Caravan	1%			100 % 8000 lbs	100 % 8000 lbs	✓	✓			✓	✓
C408 - Cessna 408	0%	100 % FLIGHTS IN NAS 833 nm / 10 pax	100 % FLIGHTS IN NAS 833 nm / 10 pax	100 % 19000 lbs	100 % 19000 lbs	✓	✓			✓	✓
PC12 - Pilatus PC 12 NG	2%			100 % 10450 lbs	100 % 10450 lbs	✓	✓			✓	✓
TBM7 - Socata TBM 700	0%			100 % 6579 lbs	100 % 6579 lbs	✓	✓			✓	✓

Observations at 70 degrees Fahrenheit operating conditions:

1) B350 can operate at 72% useful load from the 5,300-foot runway (dry)
2) B350 can operate at with a 39% of the useful load if the runway is wet

Runway Evaluation Results: Turboprop Aircraft Operating at 89 Degrees Fahrenheit

Pressure Altitude: 2960 ft | Air Temperature: 89 F | Wind Speed: 0 kts | Runway Length: 5300 ft | Gradient: 0.6 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135/91K	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Turboprop											
AT5T - AirTractor 502	0%			100 % 10480 lbs	100 % 10480 lbs	✓	✓			✓	✓
B350 - Beechcraft King Air 350ER	1%	66 % FLIGHTS IN NAS 265 nm / 5 pax	✗	42 % 12930 lbs	12 % 11100 lbs	✓	✓			✓	✓
BE9L - Beechcraft King Air C90	1%			100 % 10485 lbs	100 % 10485 lbs	✓	✓			✓	✓
C208 - Cessna 208 Caravan	1%			100 % 8000 lbs	100 % 8000 lbs	✓	✓			✓	✓
C408 - Cessna 408	0%	100 % FLIGHTS IN NAS 833 nm / 10 pax	100 % FLIGHTS IN NAS 833 nm / 10 pax	100 % 19000 lbs	100 % 19000 lbs	✓	✓			✓	✗
PC12 - Pilatus PC 12 NG	2%			100 % 10450 lbs	100 % 10450 lbs	✓	✓			✓	✓
TBM7 - Socata TBM 700	0%			100 % 6579 lbs	100 % 6579 lbs	✓	✓			✓	✓

Notes:

1. The “x” mark under the Part 135 columns indicate that landings are not feasible when accounting for the added landing runway length requirements in Part 135 operations
2. The orange labels are associated with moderate operational limitations (<75% useful load)
3. The red labels are associated with large operational limitations (<25% useful load)

Observations at 89 degrees Fahrenheit operating conditions:

1) B350 can operate at 42% useful load from the 5,300-foot runway (dry)
2) B350 cannot operate at with a realistic useful load (12% only) if the runway is wet
3) The red “x” mark under range for the B350 reports a limited aircraft range that is impractical.

VIRGINIA TECH

Runway Evaluation: Jet Aircraft Operating at 70 Degrees Fahrenheit

Pressure Altitude: 2960 ft | Air Temperature: 70 F | Wind Speed: 0 kts | Runway Length: 5300 ft | Gradient: 0.6 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135/91K	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Jet											
CL35 - Bombardier Challenger 350	1%	100 % FLIGHTS IN NAS 1908 nm / 5 pax	62 % FLIGHTS IN NAS 628 nm / 5 pax	69 % 35727 lbs	37 % 30602 lbs	✓	✓	✓	✓	✓	✓
C56X - Cessna 560 XL	1%	100 % FLIGHTS IN NAS 1620 nm / 4 pax	100 % FLIGHTS IN NAS 1525 nm / 4 pax	100 % 20200 lbs	96 % 19920 lbs	✓	✓	✓	✓	✓	✗
C68A - Cessna Citation Latitude	1%	100 % FLIGHTS IN NAS 2135 nm / 5 pax	100 % FLIGHTS IN NAS 1697 nm / 5 pax	100 % 30800 lbs	85 % 29002 lbs	✓	✓	✓	✓	✓	✓
C750 - Cessna Citation X	0%	90 % FLIGHTS IN NAS 1501 nm / 4 pax	67 % FLIGHTS IN NAS 915 nm / 4 pax	74 % 32441 lbs	54 % 29708 lbs	✓	✓	✓	✓	✓	✗
C25B - Cessna CitationJet 3	1%	100 % FLIGHTS IN NAS 1286 nm / 4 pax	100 % FLIGHTS IN NAS 1286 nm / 4 pax	100 % 13870 lbs	100 % 13870 lbs	✓	✓	✓	✓	✓	✓
C25C - Cessna CitationJet 4	0%	100 % FLIGHTS IN NAS 1447 nm / 4 pax	100 % FLIGHTS IN NAS 1447 nm / 4 pax	100 % 16950 lbs	100 % 16950 lbs	✓	✓	✓	✓	✓	✓
SF50 - Cirrus Vision SF50	0%	100 % FLIGHTS IN NAS 758 nm / 3 pax	87 % FLIGHTS IN NAS 566 nm / 3 pax	100 % 6000 lbs	87 % 5699 lbs	✓	✓	✓	✓	✓	✗
F2TH - Dassault Falcon 2000EX	0%	100 % FLIGHTS IN NAS 2367 nm / 6 pax	100 % FLIGHTS IN NAS 1819 nm / 6 pax	71 % 36309 lbs	60 % 34196 lbs	✓	✓	✓	✓	✓	✓
H25B - Hawker 800XP	1%	99 % FLIGHTS IN NAS 1313 nm / 5 pax	77 % FLIGHTS IN NAS 811 nm / 5 pax	67 % 24066 lbs	50 % 22019 lbs	✓	✓	✓	✗	✗	✗
HDJT - Honda Jet 420 Elite	0%	100 % FLIGHTS IN NAS 1064 nm / 3 pax	100 % FLIGHTS IN NAS 1064 nm / 3 pax	100 % 10700 lbs	100 % 10700 lbs	✓	✓	✓	✓	✗	✗
E55P - Phenom 300	1%	100 % FLIGHTS IN NAS 1521 nm / 4 pax	100 % FLIGHTS IN NAS 1521 nm / 4 pax	100 % 18387 lbs	100 % 18387 lbs	✓	✓	✓	✓	✓	✓

Notes:

1. The “x” mark under the Part 135 columns indicate that landings are not feasible when accounting for the added landing runway length requirements in Part 135 operations
2. The orange labels are associated with moderate operational limitations (<75% useful load)
3. The red labels are associated with large operational limitations (<25% useful load)

Runway Evaluation: Jet Aircraft Operating at 89 Degrees Fahrenheit

Pressure Altitude: 2960 ft | Air Temperature: 89 F | Wind Speed: 0 kts | Runway Length: 5300 ft | Gradient: 0.6 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135/91K	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Jet											
CL35 - Bombardier Challenger 350	1%	91 % FLIGHTS IN NAS 1195 nm / 5 pax		51 % 32829 lbs		✓	✓	✓	✓	✓	✓
C56X - Cessna 560 XL	1%	100 % FLIGHTS IN NAS 1454 nm / 4 pax	97 % FLIGHTS IN NAS 993 nm / 4 pax	93 % 19693 lbs	74 % 18277 lbs	✓	✓	✓	✓	✓	✗
C68A - Cessna Citation Latitude	1%	100 % FLIGHTS IN NAS 1844 nm / 5 pax	100 % FLIGHTS IN NAS 1285 nm / 5 pax	90 % 29600 lbs	71 % 27303 lbs	✓	✓	✓	✓	✓	✓
C750 - Cessna Citation X	0%	75 % FLIGHTS IN NAS 1032 nm / 4 pax	45 % FLIGHTS IN NAS 562 nm / 4 pax	58 % 30188 lbs	42 % 28017 lbs	✓	✓	✓	✓	✓	✗
C25B - Cessna CitationJet 3	1%	100 % FLIGHTS IN NAS 1286 nm / 4 pax	100 % FLIGHTS IN NAS 1138 nm / 4 pax	100 % 13870 lbs	93 % 13524 lbs	✓	✓	✓	✓	✓	✗
C25C - Cessna CitationJet 4	0%	100 % FLIGHTS IN NAS 1447 nm / 4 pax	100 % FLIGHTS IN NAS 1300 nm / 4 pax	100 % 16950 lbs	90 % 16254 lbs	✓	✓	✓	✓	✓	✓
SF50 - Cirrus Vision SF50	0%	55 % FLIGHTS IN NAS 327 nm / 3 pax		71 % 5315 lbs							
F2TH - Dassault Falcon 2000EX	0%	100 % FLIGHTS IN NAS 1869 nm / 6 pax	95 % FLIGHTS IN NAS 1310 nm / 6 pax	61 % 34347 lbs	50 % 32328 lbs	✓	✓	✓	✓	✓	✓
H25B - Hawker 800XP	1%	81 % FLIGHTS IN NAS 871 nm / 5 pax	55 % FLIGHTS IN NAS 474 nm / 5 pax	52 % 22318 lbs	39 % 20750 lbs	✓	✓	✓	✗	✗	✗
HDJT - Honda Jet 420 Elite	0%	100 % FLIGHTS IN NAS 1054 nm / 3 pax	20 % FLIGHTS IN NAS 185 nm / 3 pax	99 % 10682 lbs	50 % 8935 lbs	✓	✓	✓	✓	✗	✗
E55P - Phenom 300	1%	100 % FLIGHTS IN NAS 1370 nm / 4 pax	100 % FLIGHTS IN NAS 1244 nm / 4 pax	83 % 17200 lbs	78 % 16866 lbs	✓	✓	✓	✓	✓	✓

Notes:

1. The “x” mark under the Part 135 columns indicate that landings are not feasible when accounting for the added landing runway length requirements in Part 135 operations
2. The orange labels are associated with moderate operational limitations (<75% useful load)
3. The red labels are associated with large operational limitations (<25% useful load)

Runway Evaluation Results for Jet Aircraft

Observations:

1) On takeoff, the Bombardier Challenger 350 (CL35) can operate at 51% useful load on takeoff from a dry runway under hot temperature conditions (at 89 degrees Fahrenheit).
2) Operating at the average annual temperature of 70 degrees Fahrenheit, the CL35 can takeoff with 69% useful load from the existing runway (dry pavement conditions)
3) Departing at 51% useful load, the CL35 can fly 1,195 nm with two pilots and five passengers (covers 90% of the flights in the NAS). The mission range increases to 1,980 nm if the aircraft operates at 70 degrees Fahrenheit
4) The Bombardier Challenger 350 (CL35) cannot operate in wet pavement conditions at 89 degrees Fahrenheit limited by runway length
5) Other jets that operate with significant takeoff restrictions under hot temperature conditions include the H25B (Hawker 800XP), C750 (Cessna Citation X), and the SF50 (Cirrus SF50)
6) For example, the H25B can operate at 52% useful load operating on a dry runway. At 52% useful load, the H25B can fly 871 nm with two pilots and five passengers (covers 81% of the flights in the NAS).

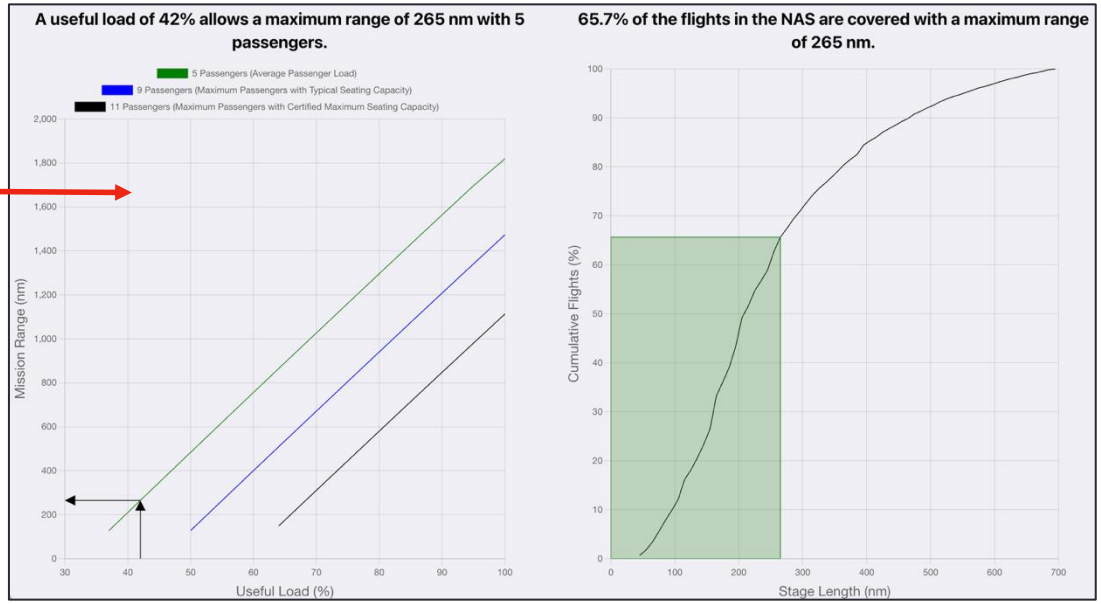
5) The Hawker 800XP (H25B) cannot land at the airport unless it is operated under Part 91 or Part 135 EOD and under dry pavement conditions.

Interpretation of Results for B350 Operating with Significant Useful Load Limitations at 89 Degrees Fahrenheit

Pressure Altitude: 2960 ft | Air Temperature: 89 F | Wind Speed: 0 kts | Runway Length: 5300 ft | Gradient: 0.6 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135/91K	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
B350 - Beechcraft King Air 350ER	1%	66 % FLIGHTS IN NAS 265 nm / 5 pax	✗	42 % 12930 lbs	12 % 11100 lbs	✓	✓			✓	✓

Click the orange area to explore the cumulative flight diagram and the useful load versus mission range diagram



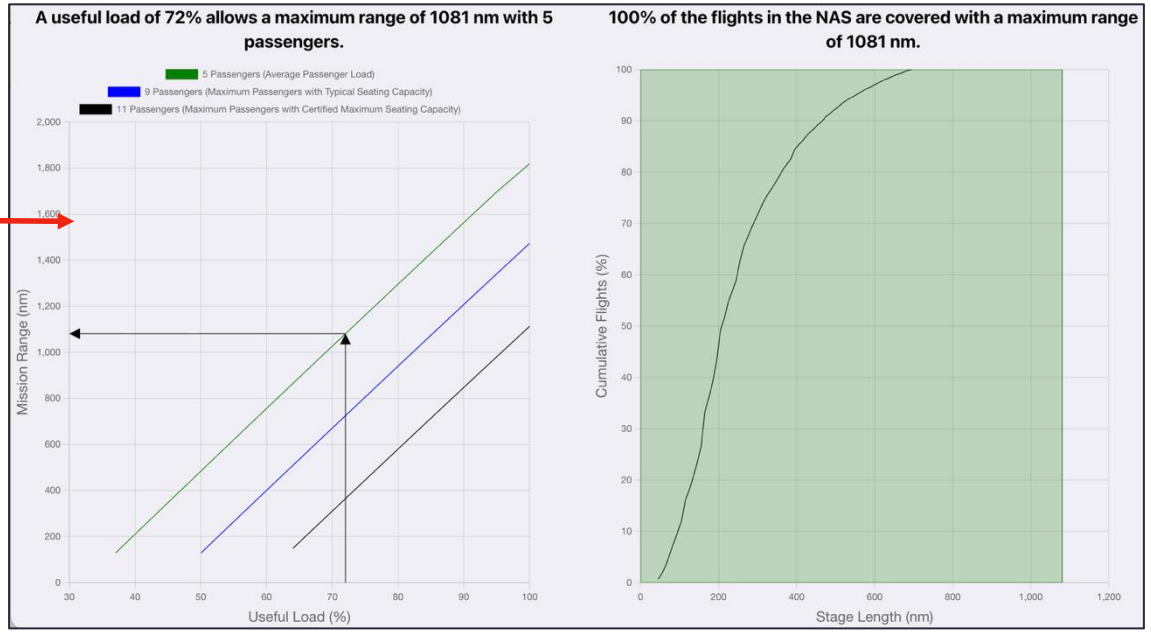
- The B350 can operate at 42% of its maximum useful load
- The maximum takeoff weight is 12,930 lbs. and carry five passengers and travel 265 nautical miles
- 265 nm covers 66.7% of the flights conducted with the B350 in the NAS.

VIRGINIA TECH

Interpretation of Results for B350 Operating with Moderate Useful Load Limitations at 70 Degrees Fahrenheit

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135/91K	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
B350 - Beechcraft King Air 350ER	1%	100 % FLIGHTS IN NAS 1081 nm / 5 pax	38 % FLIGHTS IN NAS 183 nm / 5 pax	72 % 14779 lbs	39 % 12773 lbs	✓	✓			✓	✓

Click the orange area to explore the cumulative diagram of flights possible with five passengers plus two pilots and fly 1,081 nautical miles (with NBAA reserves)

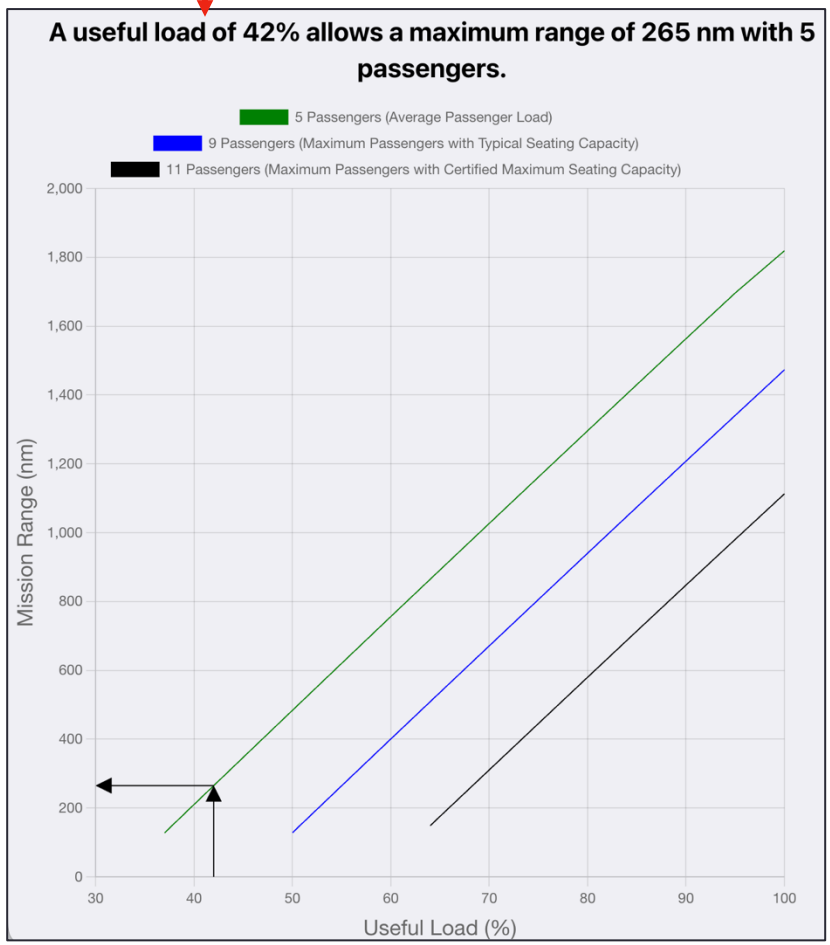


- The B350 can operate at 72% of its maximum useful load
- The aircraft can takeoff at 14,779 lbs. and carry five passengers and travel 1,081 nautical miles
- 1,081 nm covers 100% of the flights conducted with the B350 in the NAS.

Useful Load and Mission Range for B350 (89 Deg. Fahrenheit)

Pressure Altitude: 2960 ft | Air Temperature: 89 F | Wind Speed: 0 kts | Runway Length: 5300 ft | Gradient: 0.6 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135/91K	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
B350 - Beechcraft King Air 350ER	1%	66 % FLIGHTS IN NAS 265 nm / 5 pax	✗	42 % 12930 lbs	12 % 11100 lbs	✓	✓			✓	✓

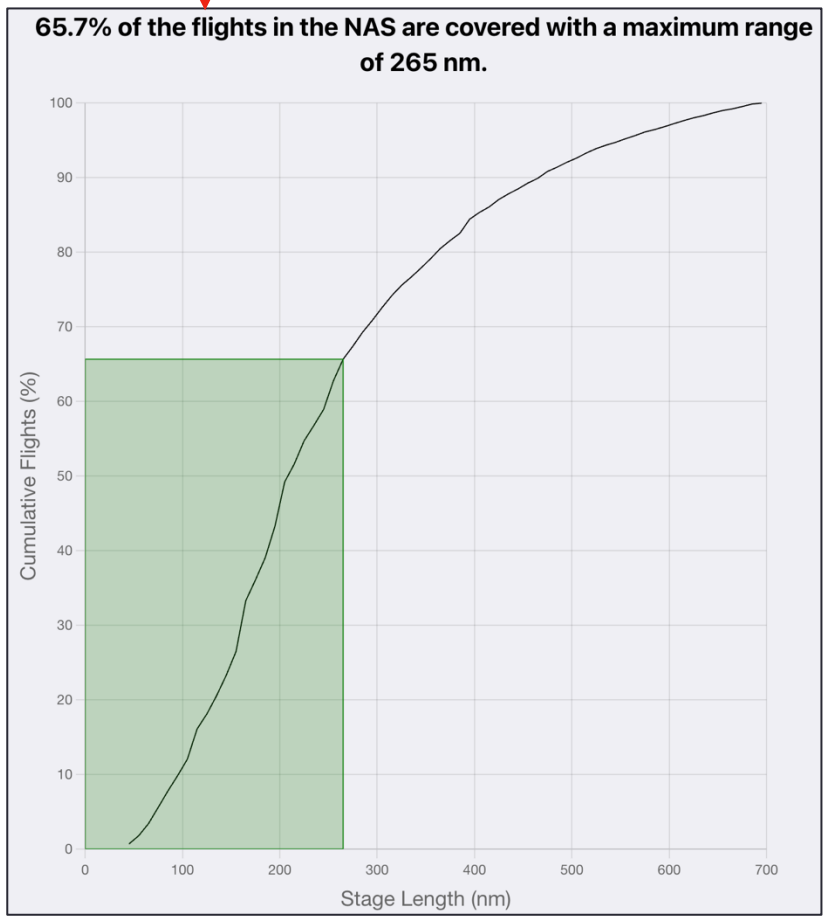


- The B350 can operate at 42% of its maximum useful load from the 5,300-foot runway (dry pavement)
- The aircraft can takeoff at 12,930 lbs. and carry five passengers and two pilots and travel 265 nautical miles
- The mission range with 42% limits the operational use of the aircraft
- The aircraft cannot operate with a passenger load of nine plus two pilots from the airport

Mission Range and Trip Distances Flown by B350 (89 Deg. Fahrenheit)

Pressure Altitude: 2960 ft | Air Temperature: 89 F | Wind Speed: 0 kts | Runway Length: 5300 ft | Gradient: 0.6 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135/91K	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
B350 - Beechcraft King Air 350ER	1%	66 % FLIGHTS IN NAS 265 nm / 5 pax	✗	42 % 12930 lbs	12 % 11100 lbs	✓	✓			✓	✓



- A King Air B350ER can operate at 42% of its maximum useful load from the 5,300-foot runway (dry pavement)
- The aircraft can takeoff at 12,930 lbs. and carry five passengers and two pilots and travel 265 nautical miles
- With a mission range of 265 nautical miles, the B350 can complete 66.7% of the historical missions flown in the NAS

Useful Load Results for the Hawker 800XP at 89 Deg. Fahrenheit

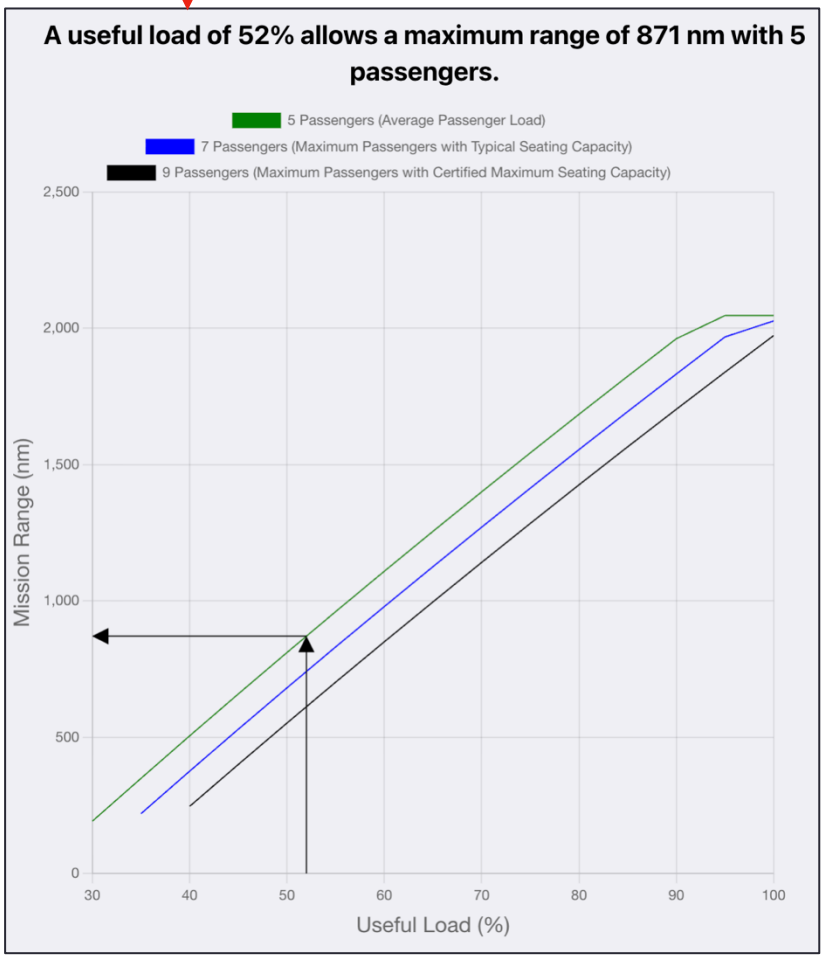
Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135/91K	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
H25B - Hawker 800XP	1%	81 % FLIGHTS IN NAS 871 nm / 5 pax	55 % FLIGHTS IN NAS 474 nm / 5 pax	52 % 22318 lbs	39 % 20750 lbs	✓	✓	✓	✗	✗	✗

Click on the green area to explore the cumulative diagram of flights possible with five passengers plus two pilots and fly 871 nautical miles (with NBAA reserves)

- The Hawker 800XP can operate at 52% of its maximum useful load from the 5,300-foot runway (dry pavement)
- The aircraft can takeoff at 22,318 lbs. and carry five passengers and two pilots and travel 871 nautical miles
- 871 nm covers 86.4% of the flights in the NAS flown with Hawker 800XP

Useful Load and Mission Range for the Hawker 800XP

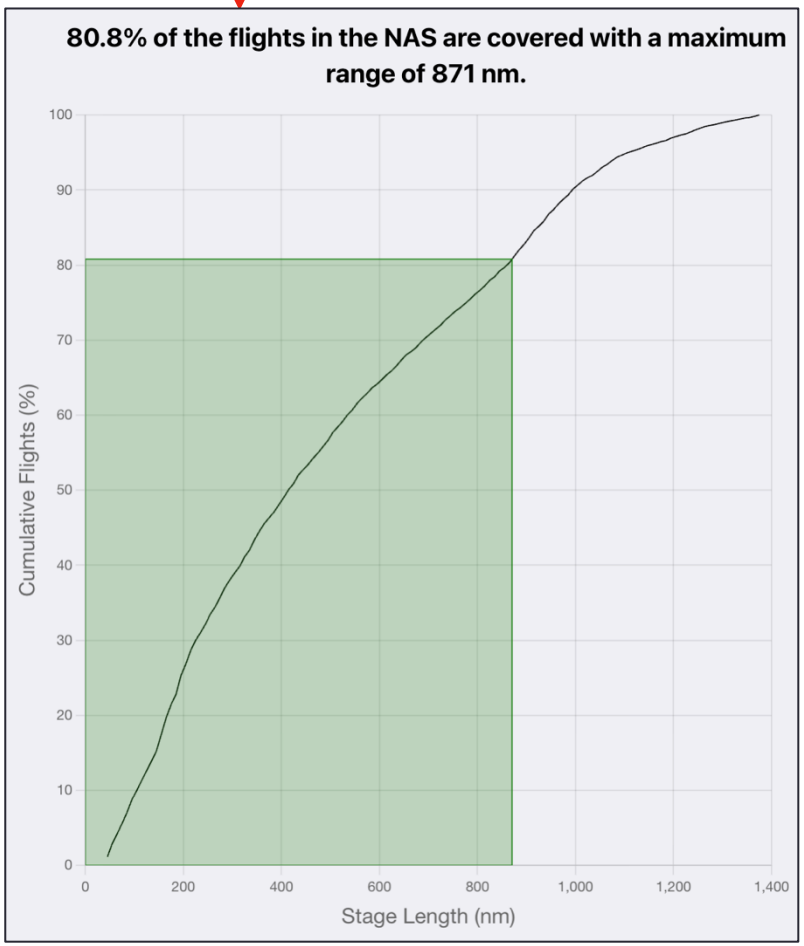
Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135/91K	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
H25B - Hawker 800XP	1%	81 % FLIGHTS IN NAS 871 nm / 5 pax	55 % FLIGHTS IN NAS 474 nm / 5 pax	52 % 22318 lbs	39 % 20750 lbs	✓	✓	✓	✗	✗	✗



- The Hawker 800XP can operate at 52% of its maximum useful load from the 5,300-foot runway (dry pavement)
- The aircraft can takeoff at 22,318 lbs. and carry five passengers plus two pilots and travel 871 nautical miles
- 871 nm covers 86.4% of the flights in the NAS flown with Hawker 800XP

Mission Range and Trip Distances Flown for the Hawker 800XP

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135/91K	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
H25B - Hawker 800XP	1%	81 % FLIGHTS IN NAS 871 nm / 5 pax	55 % FLIGHTS IN NAS 474 nm / 5 pax	52 % 22318 lbs	39 % 20750 lbs	✓	✓	✓	✗	✗	✗



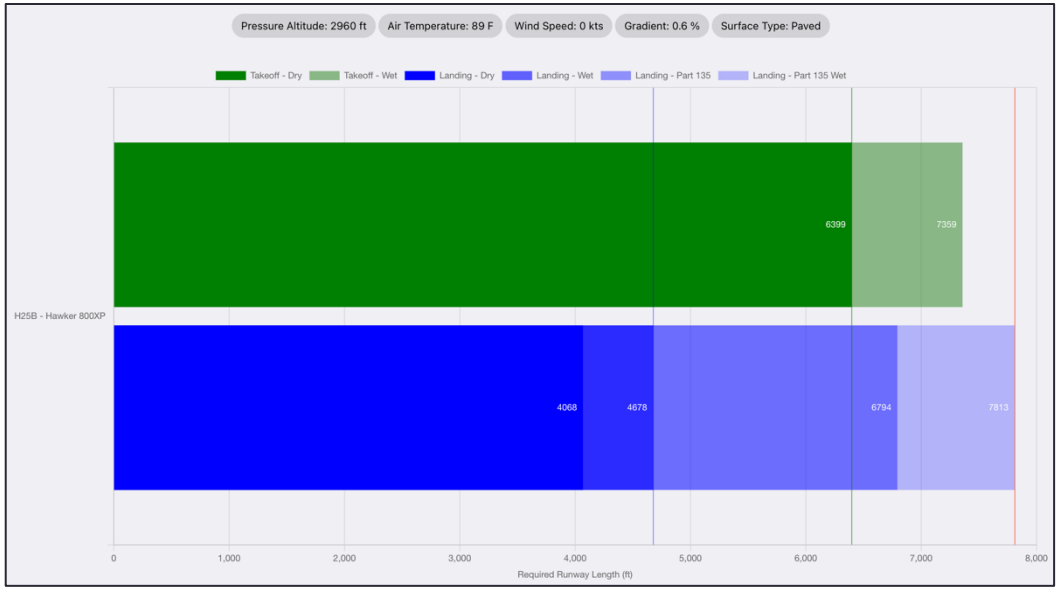
- The Hawker 800XP can operate at 52% of its maximum useful load from the 5,300-foot runway (dry pavement)
- The aircraft can takeoff at 22,318 lbs. and carry five passengers plus two pilots and travel 871 nautical miles
- 871 nm covers 86.4% of the flights in the NAS flown with Hawker 800XP
- The cumulative flights versus stage length plot is obtained from thousands of flights via FAA TFMSC data.

Interpretation of 14 CFR Part 135 Landing Results for the Hawker 800XP

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135/91K	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
H25B - Hawker 800XP	1%	81 % FLIGHTS IN NAS 871 nm / 5 pax	55 % FLIGHTS IN NAS 474 nm / 5 pax	52 % 22318 lbs	39 % 20750 lbs	✓	✓	✓	✗	✗	✗

Hawker 800XP cannot operate under Part 135 criteria

Runway Design Case for Hawker 800XP



- The Hawker 800XP can take off and land on the 5,300-foot runway using Part 91 (no correction) in dry and wet pavement conditions
- The Hawker 800XP can only operate under **Part 135 EOD criteria** in dry runway conditions
- The aircraft **cannot land under 14 CFR Part 135 rules**
- For 14 CFR Part 135 rules under dry runway conditions, the runway requirement is 6,794 feet long (verify by running a **Runway Design** case).

Useful Load Capabilities for Selected Aircraft that Operate with Substantial Useful Load Limitations

- The effect of temperature in runway operational performance is illustrated below for one large turboprop (B350) and two mid-size jets (H25B and CL35)
- When operated at the average annual temperature, the useful load capabilities for all three aircraft seem acceptable
- Operating at hot temperature conditions, the B350 looses 75% of its mission range carrying five passengers and two pilots

FAA/ICAO Name	Aircraft Full Name	Useful Load (%) / Max. Range (nm) at Design Temperature 89 Degrees Fahrenheit	Useful Load (%) / Max. Range (nm) at Mean Annual Temperature 70 Degrees Fahrenheit
B350	Beechcraft King Air 350ER	42% 265 nm	72% 1,081 nm
CL35	Bombardier Challenger 350	51% 1,195 nm	69 1,908 nm
H25B	Hawker 800XP	52% 871 nm	67% 1,313 nm

Runway Evaluation Case Analysis Summary

- The 5,300-foot runway seems acceptable for most of the aircraft in the fleet mix particularly at the annual average daytime temperature
- Performance degrades as expected during hot day conditions, but remains generally useful for most aircraft types
- For an assessment of a runway extension, use SARLAT's Runway Design mode
- Large turboprops like the B350 (King Air B350ER) operate with significant limitations from the 5,300 feet runway (e.g., takeoff at 42% of its maximum useful load on a dry runway on the hot day, vs 72% during a more typical day)
- Surprisingly, some very light jets like the Honda Jet 420 operate with moderate useful load limitations if the 5,300-foot runway is wet (i.e., 50% useful load but only able to fly 185 nm with three passengers and a single pilot)

Case Study # 3
Reduction in Runway Length due to Compliance with Obstacle Standards

Shorten Runway Case Study

- The airport has obstacles penetrating the airport design approach surface, and no near-term ability to mitigate the obstacles
- Therefore, a displaced threshold is needed for operational safety, resulting in a reduced Landing Distance Available (LDA)
- Original runway length is 3,400 feet
- LDA to mitigate approach obstacles is 3,050 feet
- Use the Runway Evaluation mode iteratively to understand the impact to aircraft operations with a shorter runway
- A similar analysis is performed to understand possible payload impacts if the runway is temporarily shortened during construction.

Existing Airport Fleet Mix and Design Conditions

Aircraft Name	FAA / ICAO Code	Annual Operations	Part 135
Piston	**Piston**		
Cessna 152	C152	320	No
Cessna 172 Skyhawk	C172	460	No
Cessna 182 Skylane	C182	640	No
Piper Archer	P28B	450	No
Piper Cherokee 161	P28A	950	No
Cirrus SR22	SR22	435	No
Cirrus SR20	SR20	270	No
Diamond DA40 Star	DA40	180	No
Piper Comanche	PA24	110	No
Beechcraft Baron 58	BE58	230	No
Turboprop	**Turboprop**		
Pilatus PC12	PC12	145	No
Cessna 208	C208	205	No

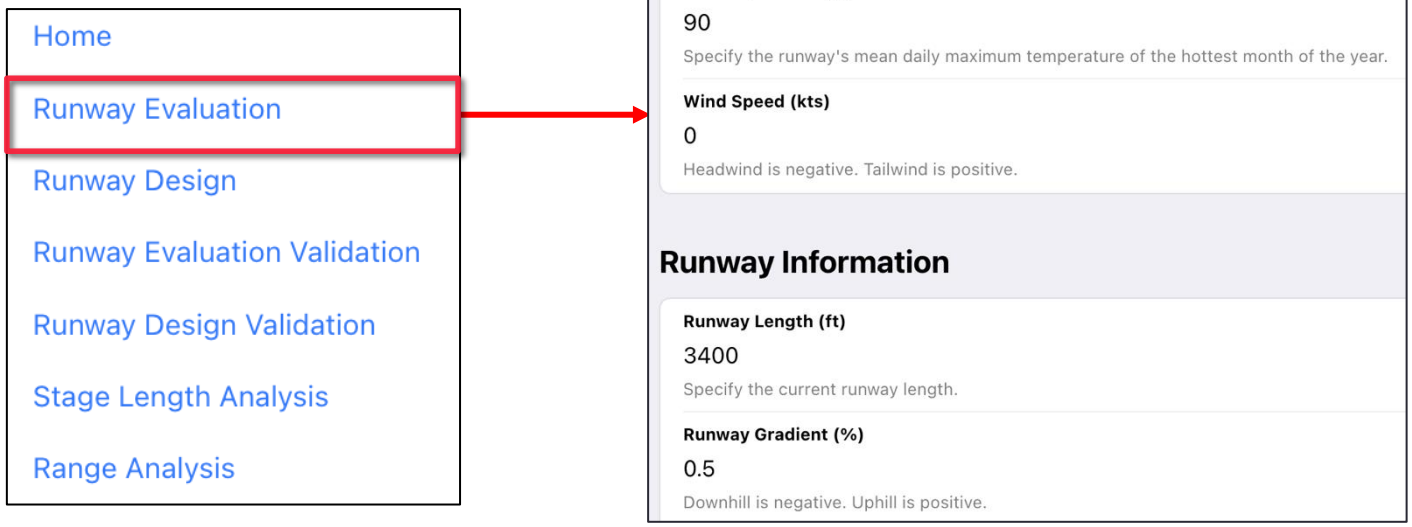
Existing Airport Conditions

Parameter	Value
Existing Runway length (ft)	3,400
Proposed Shorter Runway length (ft)	3,050
Pressure Altitude (Field Elevation) (ft)	1,820
Design Temperature (F)	90
Mean Annual Temperature (F)	70
Wind Speed (knots)	0
Runway Gradient (%)	0.5
Surface Type	Paved

Runway Evaluation Case Study

- Go to the **Runway Evaluation Analysis** in SARLAT to determine if the existing aircraft can reliably operate from an existing runway
- Define the airport fleet mix and airport environmental conditions in the SARLAT interface

Original runway length (3,400 feet)



Evaluation Results for Piston Aircraft (**3,400-foot Runway**)

Runway Takeoff and Landing Restrictions

Pressure Altitude: 1820 ft | Air Temperature: 90 F | Wind Speed: 0 kts | Runway Length: 3400 ft | Gradient: 0.5 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Piston											
BE58 - Beechcraft 58 Baron	4%			100 % 5400 lbs	100 % 5400 lbs	✓	✓				
C152 - Cessna 152	6%			100 % 1670 lbs	100 % 1670 lbs	✓	✓				
C172 - Cessna 172 Skyhawk	9%			100 % 2300 lbs	100 % 2300 lbs	✓	✓				
C182 - Cessna 182 Skylane	12%			100 % 2950 lbs	100 % 2950 lbs	✓	✓				
SR20 - Cirrus SR 20	5%			86 % 3007 lbs	70 % 2838 lbs	✓	✓				
SR22 - Cirrus SR 22	8%			100 % 3600 lbs	100 % 3600 lbs	✓	✓				
DA40 - Diamond 40 Star	3%			100 % 2646 lbs	100 % 2646 lbs	✓	✓				
PA24 - Piper 24 Comanche	2%			97 % 2512 lbs	79 % 2319 lbs	✓	✓				
P28A - Piper 28 161 Cherokee	18%			100 % 2325 lbs	100 % 2325 lbs	✓	✓				
P28B - Piper 28B Dakota	9%			100 % 3000 lbs	100 % 3000 lbs	✓	✓				

Observations:

1) Most piston aircraft can operate at 100% useful load under dry pavement conditions from the 3,400-foot runway
2) Some aircraft like the Cirrus SR20 operate with modest restrictions

Evaluation Results for Turboprop Aircraft (3,400-foot Runway)

Runway Takeoff and Landing Restrictions

Pressure Altitude: 1820 ft | Air Temperature: 90 F | Wind Speed: 0 kts | Runway Length: 3400 ft | Gradient: 0.5 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Turboprop											
BE9L - Beechcraft King Air C90	8%			100 % 10485 lbs	83 % 9922 lbs	✓	✓			✗	✗
C208 - Cessna 208 Caravan	4%			100 % 8000 lbs	100 % 8000 lbs	✓	✓			✓	✓
PC12 - Pilatus PC 12 NG	3%			93 % 10152 lbs	81 % 9621 lbs	✓	✓			✗	✗
P46T - Piper 46 Malibu Meridian	4%			100 % 5092 lbs	84 % 4862 lbs	✓	✓			✓	✗
TBM7 - Socata TBM 700	4%			100 % 6579 lbs	100 % 6579 lbs	✓	✓			✗	✗

Observations:

1) The Cessna Caravan (C208) can operate under Part 135 rules
2) All turboprop aircraft can operate under 91 rules (under the “No Correction” Columns)
3) The Pilatus PC12 has a small limitations on takeoff for dry and wet runway conditions. For example, departing a dry runway, the PC12 can carry 93% of the maximum useful load.

Evaluation Results for Piston Aircraft (**3,050-foot Runway**)

Runway Takeoff and Landing Restrictions

Pressure Altitude: 1820 ft | Air Temperature: 90 F | Wind Speed: 0 kts | Runway Length: 3050 ft | Gradient: 0.5 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Piston											
BE58 - Beechcraft 58 Baron	4%			Not applicable since the Takeoff Distance Available (TODA) remains unchanged		✓	✗				
C152 - Cessna 152	6%					✓	✓				
C172 - Cessna 172 Skyhawk	9%					✓	✓				
C182 - Cessna 182 Skylane	12%					✓	✓				
SR20 - Cirrus SR 20	5%					✓	✗				
SR22 - Cirrus SR 22	8%					✓	✗				
DA40 - Diamond 40 Star	3%					✓	✓				
PA24 - Piper 24 Comanche	2%					✓	✓				
P28A - Piper 28 161 Cherokee	18%					✓	✓				
P28B - Piper 28B Dakota	9%					✓	✓				

Observations:

1) Disregard the Takeoff calculation since TODA is not changing
2) Three piston aircraft cannot land on the shorter runway when the pavement is wet.

Evaluation Results for Turboprop Aircraft (**3,050-foot Runway**)

Runway Takeoff and Landing Restrictions

Pressure Altitude: 1820 ft | Air Temperature: 90 F | Wind Speed: 0 kts | Runway Length: 3050 ft | Gradient: 0.5 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Turboprop				Not applicable since TODA remains unchanged							
BE9L - Beechcraft King Air C90	8%					✓	✗			✗	✗
C208 - Cessna 208 Caravan	4%					✓	✓			✓	✓
PC12 - Pilatus PC 12 NG	3%					✓	✓			✗	✗
P46T - Piper 46 Malibu Meridian	4%					✓	✓			✗	✗
TBM7 - Socata TBM 700	4%					✓	✓			✗	✗

Observations:

1) The Cessna Caravan (C208) is the only turboprop aircraft that can operate under Part 135 rules
2) Four turboprop aircraft can operate with 100% useful load
3) The Beechcraft King Air C90 (BE9L) cannot land at the shorter runway in wet pavement conditions under Part 91

Shortened Runway Length Evaluation

- The proposed 3,050-foot runway introduces substantial operational limitations to (**with 90 deg. F. temperature**)
  - The Cessna Caravan (C208) is the only turboprop aircraft that can operate under Part 135 rules
  - The Beechcraft King Air C90 (BE9L) cannot land at the shorter runway in wet pavement conditions
  - Three piston aircraft cannot land on the shorter runway if the pavement is wet
- A scenario with a departure obstacle in Departure Surface #7 that warrants a reduced TODA would undertake a similar analysis to evaluate for payload limitations on takeoff during both daily annual average and hot day conditions.
  - A similar analysis can be conducted for a planned short term construction project the reduces TORA/TODA in order to quantitively evaluate the operational impact to payload using average temperatures for the construction period, rather than hot day or average annual temperatures.

Case Study # 4
Existing Airport Runway Evaluation then Runway Extension Analysis

Existing Airport: Runway Extension

- Existing General Aviation airport in a rural area with a single 4,600-foot runway.
- Airport manager needs to understand current aircraft performance with the existing runway, and if runway extension is warranted with upcoming runway reconstruction project.
- Three business jets are based at the airport: a C25C, C68A, and a C56X
- The existing aircraft fleet mix was developed using ADS-B and FAA Traffic Management Systems counts
- Operators of relevant aircraft types use Part 135/91K regulations, so Part 135/91K operations are selected for those aircraft types in the analysis
- The airport is located at an elevation of 2,130 feet Mean Sea Level (MSL)
- Evaluate both the hot day temperature (mean daily maximum temperature of the hottest month of the year, which is 85 degrees Fahrenheit in August) as well as the annual average daily daytime temperature (67 F) in order to understand how performance varies seasonally since not all operations occur during hot conditions
- Wind conditions were assumed to be calm for the analysis
- The existing runway has a gradient of 0.2%.

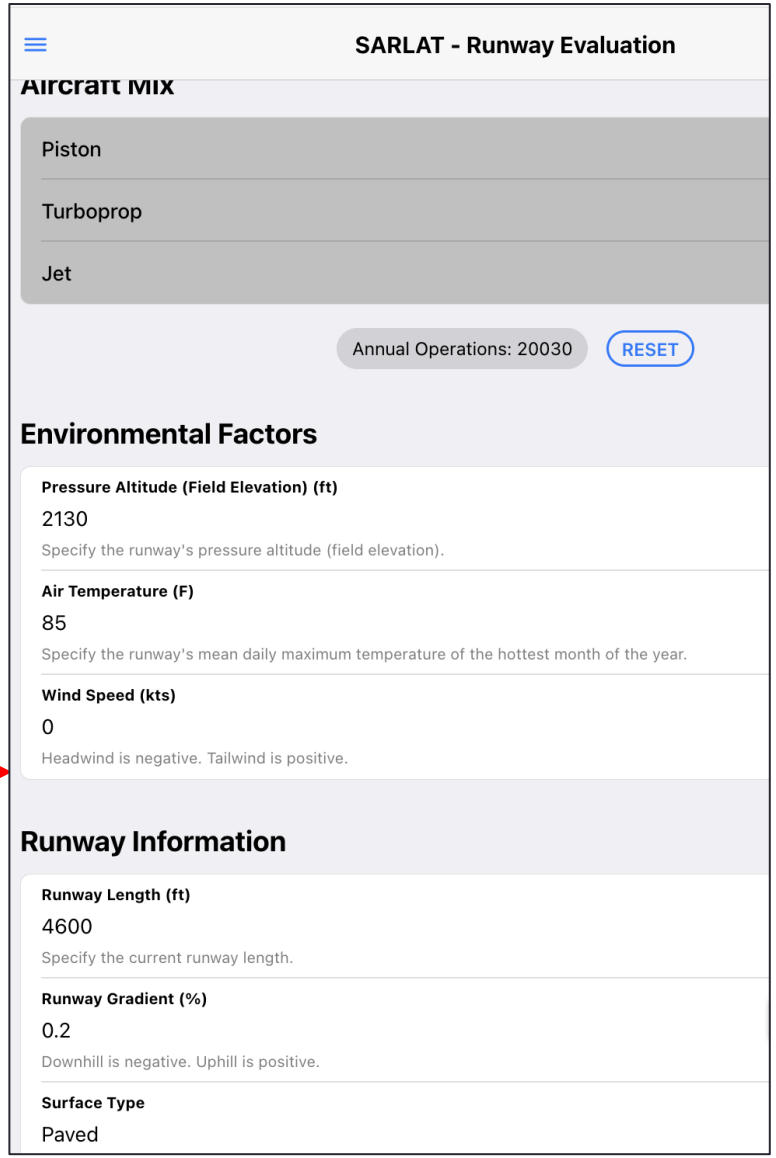
Existing Airport Fleet Mix and Design Conditions

FAA/ICAO Name	Aircraft Full Name	Annual Operations	Part 135/91K Operations
Piston	**Piston**		
BE58	Beechcraft 58 Baron	1260	No
C152	Cessna 152	7900	No
C172	Cessna 172 Skyhawk	7340	No
Turboprop	**Turboprop**		
B350	Beechcraft King Air 350ER	410	Yes
PC12	Pilatus PC 12 NG	520	Yes
TBM7	Socata TBM 700	210	No
Jet	**Jet**		
CL35	Bombardier Challenger 350	210	Yes
C56X	Cessna Citation 560XL	530	No
C80A	Cessna Citation Latitude	490	No
C25C	Cessna Citation CJ4	320	No
SF50	Cirrus Vision SF50	255	No
E55P	Embraer Phenom 300	495	Yes

Aircraft operating under Part 135 standards are highlighted in yellow.

Part 1: Runway Evaluation

- Go to the **Runway Evaluation Analysis** in SARLAT to determine if the existing aircraft can reliably operate from an existing runway
- Airport manager hears concerns about payload performance on hot days, but validation is needed
- Define the airport fleet mix and airport environmental conditions in the SARLAT interface



Part 1: Fleet Mix

- Go to the **Runway Evaluation Analysis** in SARLAT and define the fleet mix in the Existing Airport Fleet Mix table

Aircraft Mix

Piston

Aircraft Name	Annual Operations
BE36 - Beech Bonanza 36	0
BE55 - Beechcraft 55 Baron	0
BE58 - Beechcraft 58 Baron	1260
C150 - Cessna 150	0
C152 - Cessna 152	7900
C172 - Cessna 172 Skyhawk	7340

Piston Aircraft Fleet Mix

SARLAT - Runway Evaluation

Aircraft Name	Annual Operations
AT5T - AirTractor 502	0
AT8T - AirTractor 802	0
BE30 - Beechcraft 300 Super King Air	0
B350 - Beechcraft King Air 350ER	410
BE20 - Beechcraft King Air B200GT	0
BE9L - Beechcraft King Air C90	0
C208 - Cessna 208 Caravan	0
C408 - Cessna 408	0
PC12 - Pilatus PC 12 NG	520
P46T - Piper 46 Malibu Meridian	0
AC90 - Rockwell Commander 690B	0
TBM7 - Socata TBM 700	210

Turboprop Aircraft Fleet Mix

Part 1: Fleet Mix

- Go to the **Runway Evaluation Analysis** in SARLAT and define the fleet mix in the Existing Airport Fleet Mix table

SARLAT - Runway Evaluation

Jet Aircraft Fleet Mix (partial view)

Jet

Aircraft Name	Annual Operations
CL35 - Bombardier Challenger 350	210
CL60 - Bombardier Challenger 605	0
GLEX - Bombardier Global 6000	0
LJ35 - Bombardier LearJet 35	0
LJ45 - Bombardier Learjet 45	0
LJ60 - Bombardier Learjet 60	0
C56X - Cessna 560 XL	530
C68A - Cessna Citation Latitude	490

Part 1: Output Table
Takeoff and Landing Limitations for **Piston Aircraft**

- All piston aircraft can reliably operate from the 4,600-foot runway at 100% useful load
- The design temperature in this analysis is 85 degrees Fahrenheit. The mean annual temperature analysis is presented in later slides.

RunwayExtension_Case

Runway Takeoff and Landing Restrictions

Pressure Altitude: 2130 ft | Air Temperature: 85 F | Wind Speed: 0 kts | Runway Length: 4600 ft | Gradient: 0.2 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Piston											
BE58 - Beechcraft 58 Baron	6%			100 % 5400 lbs	100 % 5400 lbs	✓	✓				
C152 - Cessna 152	39%			100 % 1670 lbs	100 % 1670 lbs	✓	✓				
C172 - Cessna 172 Skyhawk	37%			100 % 2300 lbs	100 % 2300 lbs	✓	✓				
PA24 - Piper 24 Comanche	1%			100 % 2550 lbs	100 % 2550 lbs	✓	✓				

Phase 1 : Output Table
Takeoff and Landing Limitations for Turboprop Aircraft

- The PC12 and the TBM7 can operate at 100% useful load at the airport with a 4,600-foot dry runway
- The B350 can operate from the 4,600-foot runway at 39% useful load on a **dry runway** (limited by runway length)
- The B350 can fly five passengers and two pilots 183 nm limited by runway length

RunwayExtension_Case

Runway Takeoff and Landing Restrictions

Pressure Altitude: 2130 ft | Air Temperature: 85 F | Wind Speed: 0 kts | Runway Length: 4600 ft | Gradient: 0.2 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Turboprop											
B350 - Beechcraft King Air 350ER	1%	38 % FLIGHTS IN NAS 183 nm / 5 pax	✗	39 % 12761 lbs	6 % 10775 lbs	✓	✓			✓	✗
PC12 - Pilatus PC 12 NG	3%			100 % 10450 lbs	100 % 10450 lbs	✓	✓			✓	✓
TBM7 - Socata TBM 700	1%			100 % 6579 lbs	100 % 6579 lbs	✓	✓			✓	✓

Explanations about Differences in Turboprop Aircraft Performance

- The performance of single-engine turboprop aircraft like the the PC12 and the TBM7, show substantial differences compared to that of large twin-engine turboprops like the B350 (King Air 350ER) for several reasons:

- The PC12 and TBM7 maximum takeoff weights are less than 12,500 lbs. and the takeoff distance reported in SARLAT is the **Distance to Clear a 50-foot obstacle**

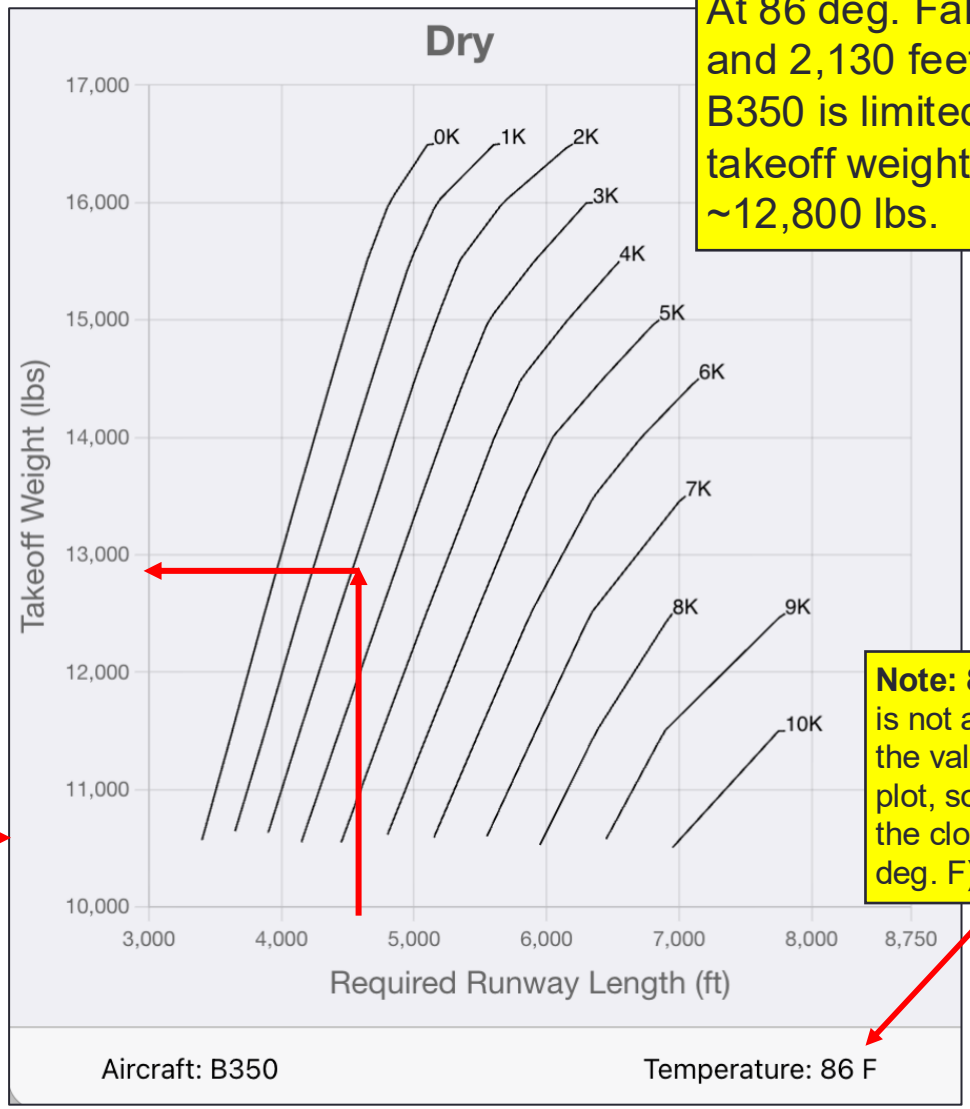
- For large twin-engine turboprops with maximum takeoff weights at or above 12,500 lbs., SARLAT reports the **Takeoff Field Length (TOFL)** which is controlled by the Accelerate-Stop Distance

- The use of **Takeoff Field Length (TOFL)** coupled with higher takeoff speeds for the B350 (King Air B350ER), yields substantially higher takeoff distances reported in SARLAT

- You can understand the performance characteristics of each aircraft in SARLAT using the **Runway Evaluation Validation** and **Runway Design Validation** plots as we illustrate next.

Exploring the Aircraft Performance of the B350 for Validation

- Go to the **Runway Evaluation Validation mode in** SARLAT to understand the performance of the B350
- Select the aircraft B350 and temperature in the lower panel



At 86 deg. Fahrenheit and 2,130 feet, the B350 is limited to a takeoff weight of ~12,800 lbs.

Note: 85 deg. F. is not available in the validation plot, so we use the closest (86 deg. F)

VIRGINIA TECH

Part 1: Output Table for Jet Aircraft Takeoff and Landing Limitations at **85 Degrees Fahrenheit**

- The CL35 can operate at **50% useful load** at the airport with a 4,600-foot dry runway and fly 1,155 nm with five passengers and two pilots. 1,155 nm allow the completion of 90% of the flights in the NAS.

- The Cirrus SF50 and the CL35 cannot operate from the airport under wet runway conditions (blank spaces in the table)

- The ✕ symbol implies the operation is not feasible

Analysis at 85 degrees Fahrenheit

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Jet											
CL35 - Bombardier Challenger 350	1%	90 % FLIGHTS IN NAS 1155 nm / 5 pax		50 % 32621 lbs		✓	✓	✓	✓	✓	✕
C56X - Cessna 560 XL	3%	100 % FLIGHTS IN NAS 1525 nm / 4 pax	99 % FLIGHTS IN NAS 1042 nm / 4 pax	96 % 19899 lbs	76 % 18444 lbs	✓	✓	✓	✓	✕	✕
C68A - Cessna Citation Latitude	2%	100 % FLIGHTS IN NAS 1844 nm / 5 pax	99 % FLIGHTS IN NAS 1225 nm / 5 pax	90 % 29637 lbs	69 % 26983 lbs	✓	✓	✓	✓	✓	✓
C25C - Cessna CitationJet 4	2%	100 % FLIGHTS IN NAS 1447 nm / 4 pax	100 % FLIGHTS IN NAS 1404 nm / 4 pax	100 % 16950 lbs	95 % 16591 lbs	✓	✓	✓	✓	✓	✕
SF50 - Cirrus Vision SF50	1%	68 % FLIGHTS IN NAS 417 nm / 3 pax		77 % 5455 lbs		✓	✓	✓	✓	✕	✕
E55P - Phenom 300	2%	100 % FLIGHTS IN NAS 1521 nm / 4 pax	100 % FLIGHTS IN NAS 1395 nm / 4 pax	100 % 18374 lbs	84 % 17299 lbs	✓	✓	✓	✓	✓	✕

Part 1: Output Table for Turboprop Aircraft Takeoff and Landing Limitations at **67 Degrees Fahrenheit**

- The B350 can operate from the 4,600-foot runway at **67% useful load** on a dry runway and able to fly 946 nm with five passengers and two pilots
- The PC12 and the TBM7 can operate at 100% useful load.

RunwayExtension_Case

Runway Takeoff and Landing Restrictions

Pressure Altitude: 2130 ft | Air Temperature: 85 F | Wind Speed: 0 kts | Runway Length: 4600 ft | Gradient: 0.2 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Turboprop											
B350 - Beechcraft King Air 350ER	1%	100 % FLIGHTS IN NAS 946 nm / 5 pax	✗	67 % 14453 lbs	31 % 12300 lbs	✓	✓			✓	✗
PC12 - Pilatus PC 12 NG	3%			100 % 10450 lbs	100 % 10450 lbs	✓	✓			✓	✓
TBM7 - Socata TBM 700	1%			100 % 6579 lbs	100 % 6579 lbs	✓	✓			✓	✓

Part 1: Output Table

Takeoff and Landing Limitations for Jet Aircraft at 67 Deg. Fahrenheit

- The CL35 can operate at **66% useful load** at the airport with a 4,600-foot dry runway and fly 1,790 nm with five passengers and two pilots. 1,790 nm is sufficient to complete 100% of the missions in the NAS.

- All remaining jets can operate from the airport with high useful load values operating from a dry runway

- The ✕ symbol implies the operation is not feasible

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Jet											
CL35 - Bombardier Challenger 350	1%	100 % FLIGHTS IN NAS 1790 nm / 5 pax		66 % 35227 lbs		✓	✓	✓	✓	✓	✕
C56X - Cessna 560 XL	3%	100 % FLIGHTS IN NAS 1620 nm / 4 pax	100 % FLIGHTS IN NAS 1525 nm / 4 pax	100 % 20200 lbs	96 % 19887 lbs	✓	✓	✓	✓	✕	✕
C68A - Cessna Citation Latitude	2%	100 % FLIGHTS IN NAS 2135 nm / 5 pax	100 % FLIGHTS IN NAS 1491 nm / 5 pax	100 % 30800 lbs	78 % 28098 lbs	✓	✓	✓	✓	✓	✓
C25C - Cessna CitationJet 4	2%	100 % FLIGHTS IN NAS 1447 nm / 4 pax	100 % FLIGHTS IN NAS 1447 nm / 4 pax	100 % 16950 lbs	100 % 16950 lbs	✓	✓	✓	✓	✓	✕
SF50 - Cirrus Vision SF50	1%	100 % FLIGHTS IN NAS 758 nm / 3 pax	92 % FLIGHTS IN NAS 626 nm / 3 pax	100 % 6000 lbs	91 % 5775 lbs	✓	✓	✓	✓	✕	✕
E55P - Phenom 300	2%	100 % FLIGHTS IN NAS 1521 nm / 4 pax	100 % FLIGHTS IN NAS 1521 nm / 4 pax	100 % 18387 lbs	100 % 18387 lbs	✓	✓	✓	✓	✓	✕

Part 1: Runway Performance Analysis

- The table below shows the useful load factors and the maximum range estimated in SARLAT for two operating temperatures: 1) the design temperature (mean maximum temperature of the hottest month) and 2) mean annual temperature
- Three aircraft operating with useful load penalties on takeoff are the B350 (turboprop), the CL35 (a jet), and, to a lesser extend the SF50 (a very light jet)
- The combined annual operations for all three aircraft is significant at 875; however, the runway lengths calculated need to be ranked in the Runway Design output to determine the justified design runway length

FAA/ICAO Name	Aircraft Full Name	Useful Load / Max. Range at Design Temperature 85 Degrees Fahrenheit	Useful Load / Max. Range at Mean Annual Temperature 67 Degrees Fahrenheit
B350	Beechcraft King Air 350ER	38% 183 nm	67% 946
CL35	Bombardier Challenger 350	50% 1,155 nm	66% 1,790 nm
SF50	Cirrus Vision SF50	77 417 nm	100 758 nm

Part 2: Runway Extension Analysis

- Part 2 of the problem demonstrates the use of SARLAT to find a suitable runway extension
- Use the **Runway Design** mode to find the takeoff and landing distance requirements for the airport fleet mix and known useful load or mission distance conditions
- In practice there are other constraints that may have to be examined including cost and land availability. Those constraints can be studied outside SARLAT after runway extension alternatives are produced, including calculating the significance of payload reductions using SARLAT.

Part 2: Runway Extension Desired Parameters

- For this Case Study, assume we would like to extend the runway allowing the following aircraft operations:

1. B350 (King Air B350ER) to operate with at least a 60% useful load on takeoff at the **design temperature** (85 degrees Fahrenheit). A 60% useful load factor allows missions of up to ~750 nm for the B350.
2. CL350 (Bombardier Challenger 350) to operate with at least a 60% useful load on takeoff at the design temperature (85 degrees Fahrenheit). A 60% useful load factor allows missions of up to ~1,550 nm for the CL35.
3. Allow landing operations of the B350 and CL35 under Part 135 criteria

Part 2: Runway Extension Analysis

- Use the **SARLAT Runway Design mode** to find the takeoff and landing distance requirements for the airport fleet mix and known useful load or mission distance conditions.
- Define a new Runway Design Scenario and in the definition of the fleet mix parameters, enter 60% useful load for the B350 and the CL35 aircraft (see graphic below)

Select the Part 135 toggle

Turboprop

Aircraft Name	Annual Operations	Critical Range with Average Passenger Load (nm)	Takeoff Useful Load (%)	Part 135	Landing Weight (% of MALW)
B350 - Beechcraft King Air 350ER	410	756	60	Yes	

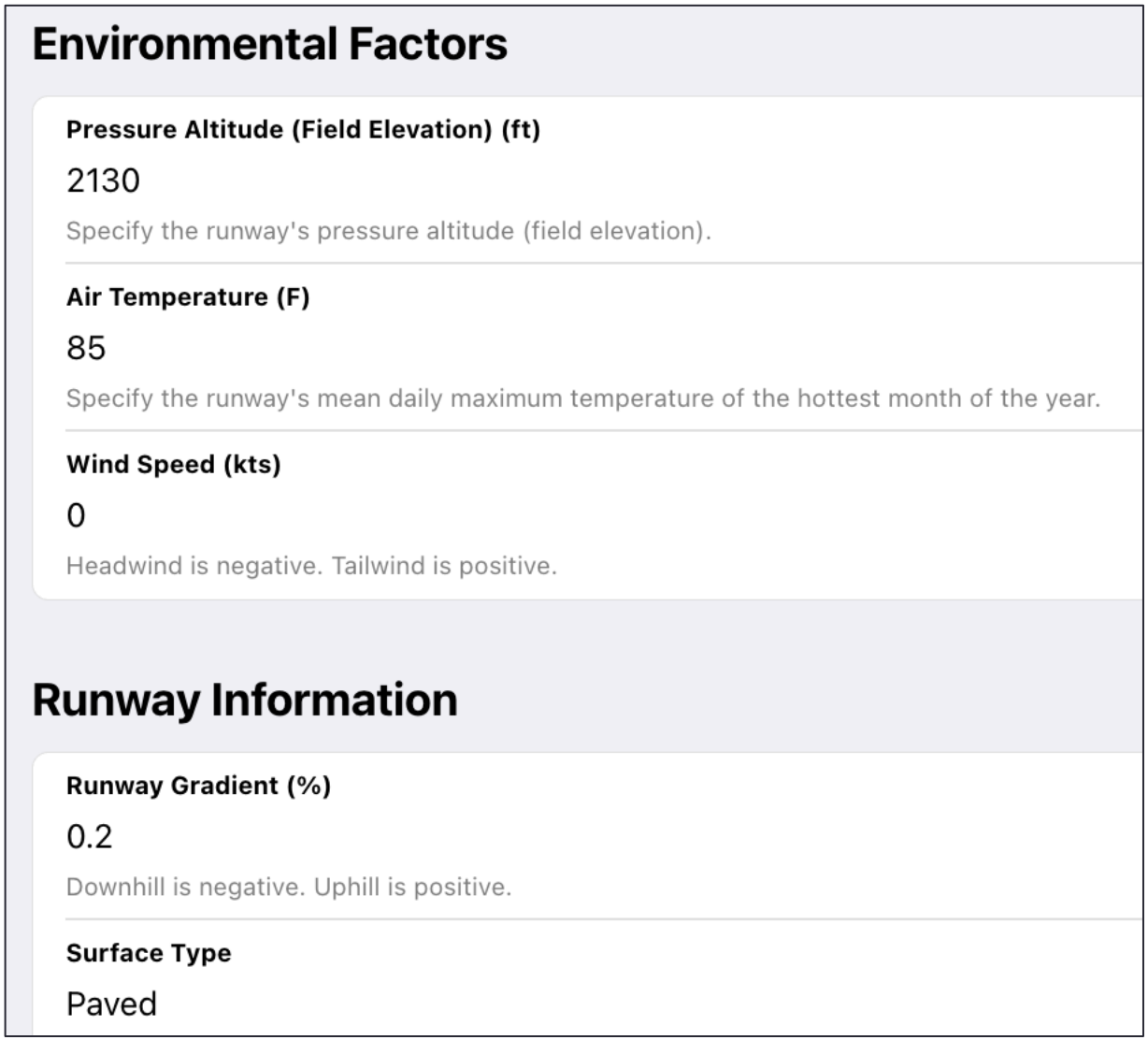
Jet

Aircraft Name	Annual Operations	Critical Range with Average Passenger Load (nm)	Takeoff Useful Load (%)	Part 135	Landing Weight (% of MALW)
CL35 - Bombardier Challenger 350	210	1553	60	Yes	82

Part 2: Input Parameters

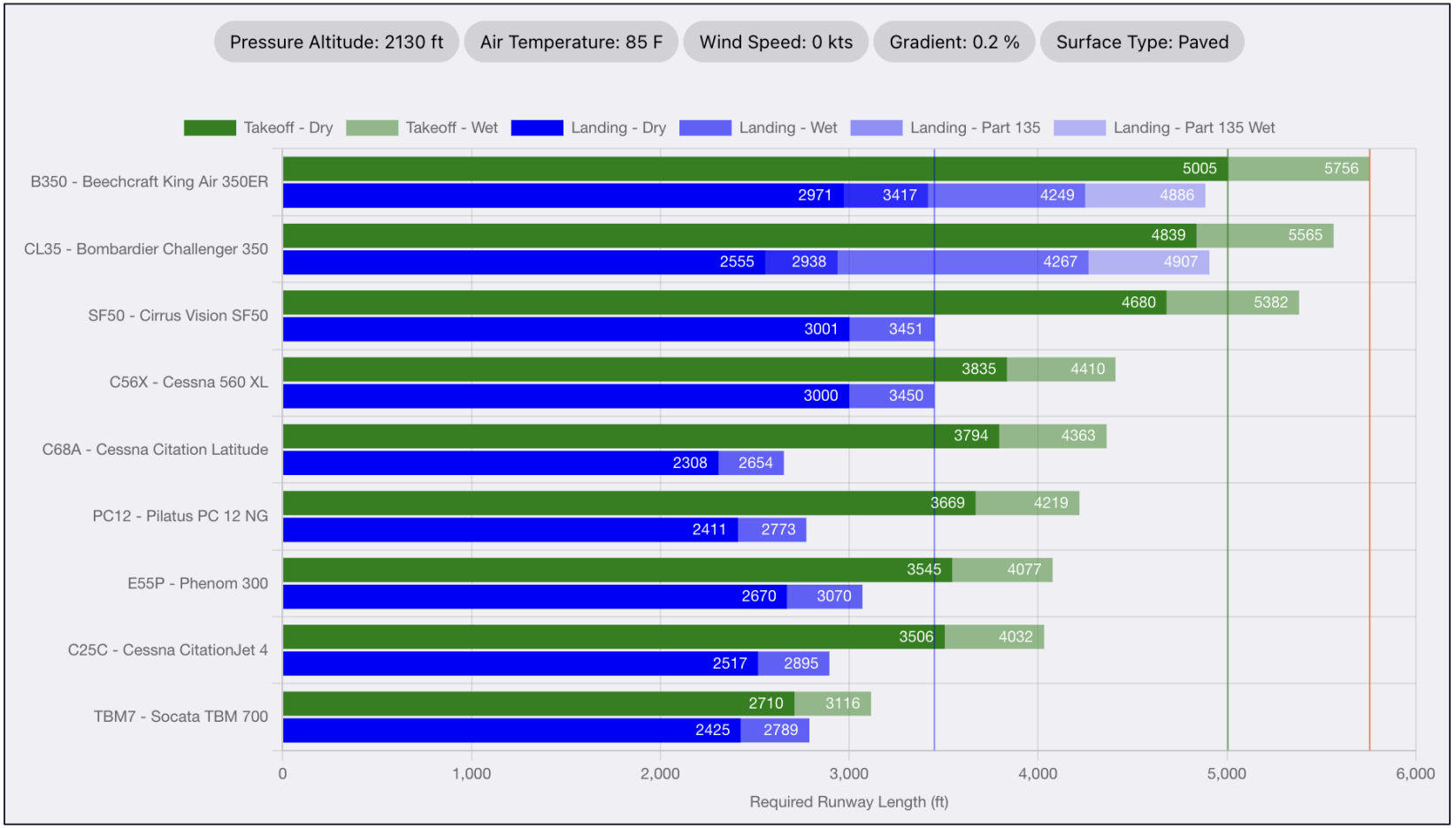
- Use the **SARLAT Runway Design** mode and define the airport environmental factors and runway information (see graphic)

- Run the scenario and obtain the takeoff and landing distance requirements



Part 2: Runway Extension Analysis

- **SARLAT** Takeoff and landing distances for runway extension analysis



In this run, we included all turboprops and jets in the original scenario.

Part 2: Runway Extension Critical Aircraft

- Observe the table for Critical Aircraft for Runway Length
- Since Part 135 operations are required in the analysis, **select the Part 135 toggle** above the table
- The analysis shows the Bombardier Challenger 350 (CL35) to be the **critical aircraft requiring 4,907 feet** to land at the airport under Part 135 criteria using the default landing weight factor
- Note that the CL35 can operate at 60% useful load on takeoff using 4,839 feet (dry)

Critical Aircraft for Runway Length

TAKEOFF DRY | TAKEOFF WET | LANDING DRY | LANDING WET | PART 135

CL35 - Bombardier Challenger 350 is the critical aircraft and requires **4907 ft** of runway to be fully accommodated in the full range of specified operating conditions.

Aircraft Name	Engine Type	Aircraft Design Group (ADG)	Aircraft Approach Category (AAC)	Taxiway Design Group (TDG)	Takeoff Useful Load (%)	Landing Useful Load (%)	Annual Operations	Cumulative Annual Operations	Takeoff Dry (ft)	Takeoff Wet (ft)	Landing Dry (ft)	Landing Wet (ft)
B350 - Beechcraft King Air 350ER	Turboprop	II	B	2A	60	74	410	410	5005	5756	**4249**	**4886**
CL35 - Bombardier Challenger 350	Jet	II	C	1B	60	82	210	620	4839	5565	**4267**	4907
SF50 - Cirrus Vision SF50	Jet	I	A	1A	80	90	255	875	4680	5382	3001	3451

Part 2: Observations of Runway Extension Analysis

- The Runway Design analysis in SARLAT shows that the critical aircraft is the Bombardier Challenger 350 (CL35) to be the **critical aircraft requiring 4,907 feet** to land at the airport under Part 135 criteria using the default landing weight factor
- The CL35 can operate at 60% useful load on **takeoff using 4,839 feet (dry)**
- To meet the 60% useful load takeoff requirements of the B350, 5,005 feet are needed

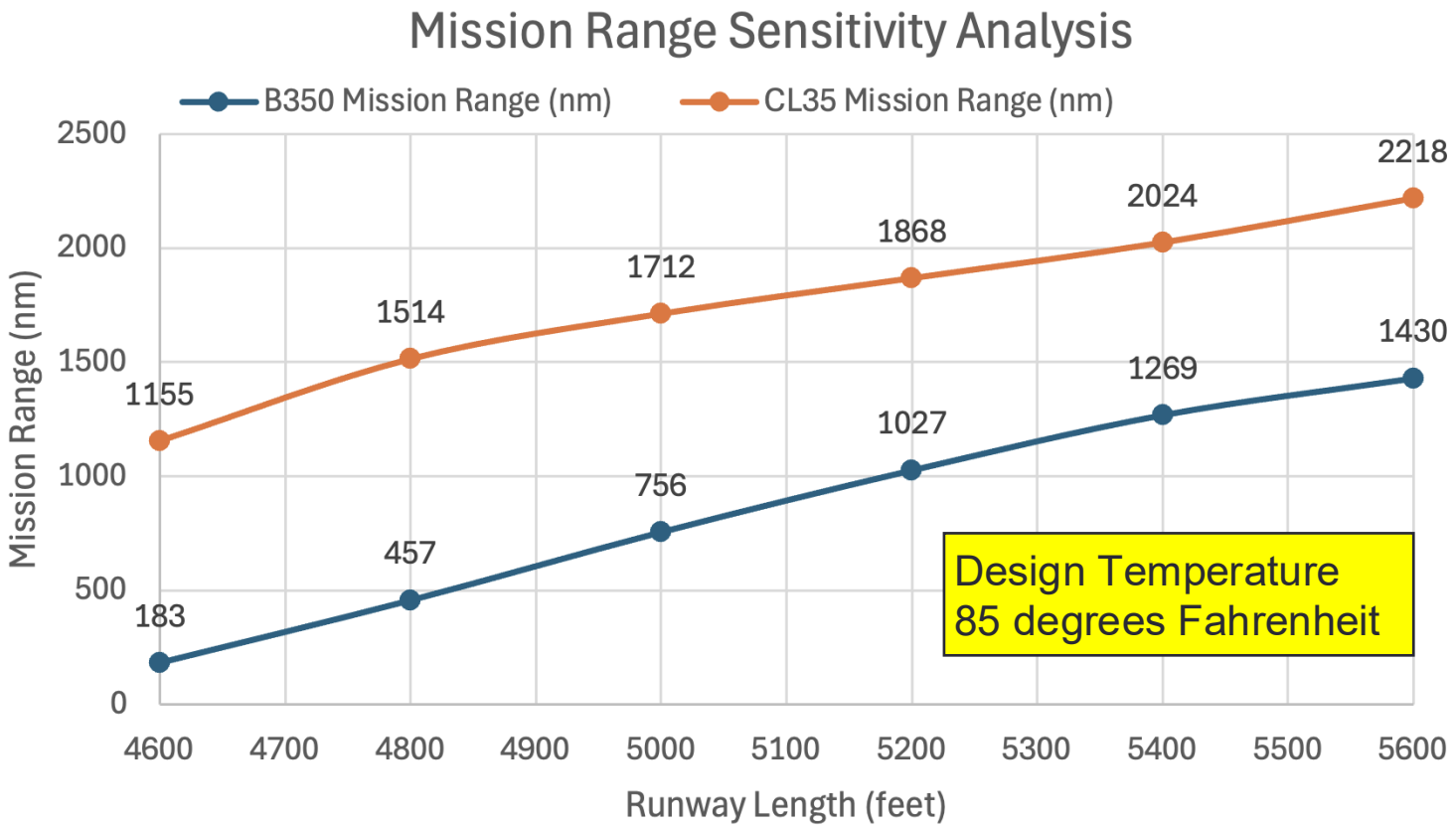
- **A practical runway extension for this airport may be to increase the runway length to 5,000 feet baseline (400-foot extension).**

- Note: many other factors will have to consider in the final determination of a runway extension program including terrain, land available, obstacles, cost, etc.

Note: For AIP projects, use **wet landing** and **dry takeoff** performance.

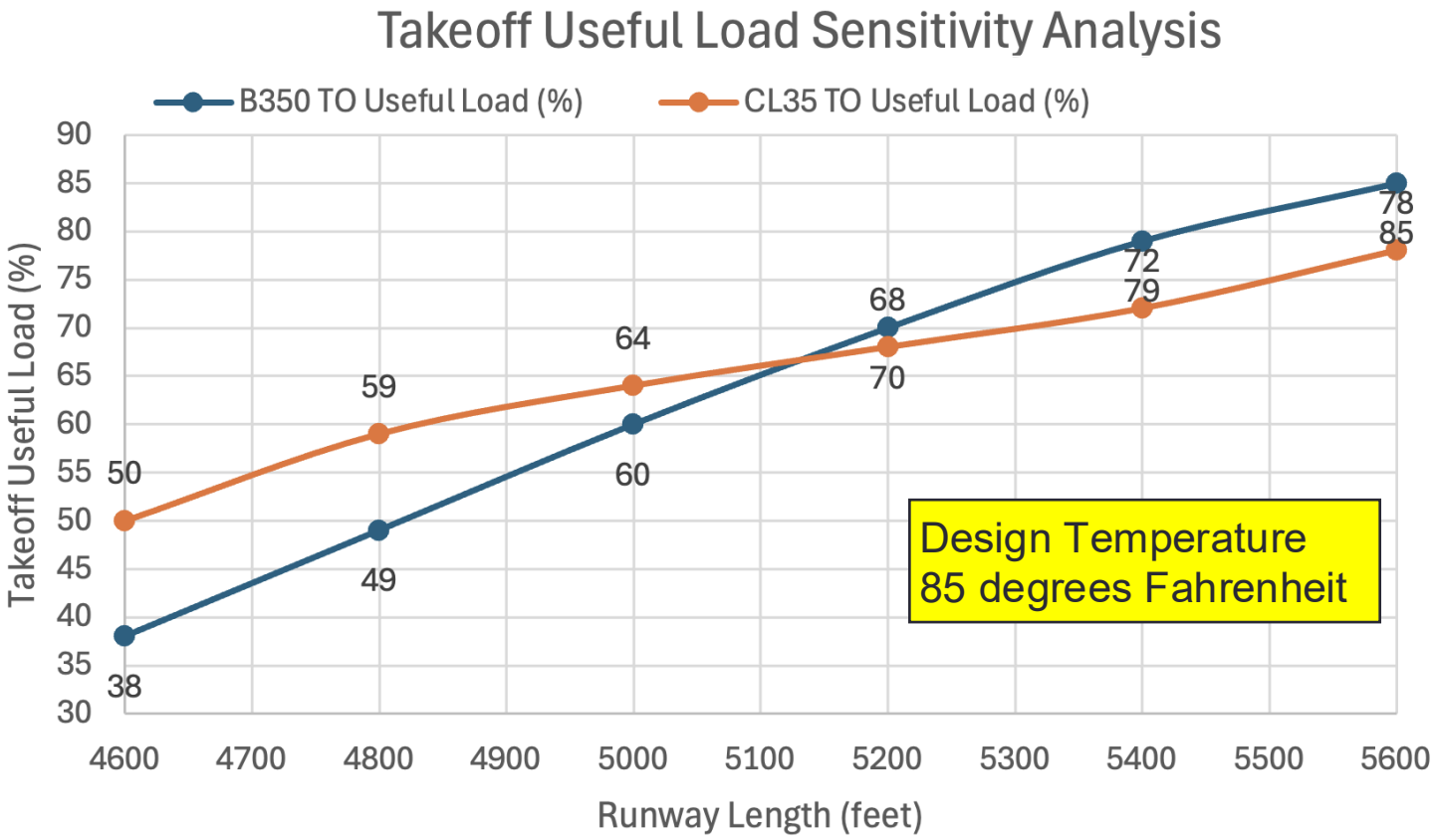
Part 2: Runway Extension Sensitivity Analysis

- Tabulate or plot the results obtained for the most critical aircraft to understand the sensitivity of mission range for each runway extension (or runway length as shown in the graphic)



Part 2: Runway Extension Sensitivity Analysis

- Tabulate or plot the results obtained for the most demand aircraft to understand the sensitivity of takeoff useful load for each runway extension (or runway length as shown in the graphic)



Part 2: Runway Extension Analysis: Conclusion

- The Runway Evaluation analysis in SARLAT can be used iteratively to show the changes in mission range and useful load obtained for the most demanding aircraft for various runway length or runway extension conditions

- The graphical sensitivity analysis presented shows that in order to improve the useful load capability for the B350 and CL35 (the two most demanding aircraft in the existing fleet mix) a runway extension may be needed

- For example, a runway extension of 400 feet (to 5,000 feet total) will allow both CL35 and B350 to operate at takeoff useful loads at or above 60%

- With a 5,000-foot runway, both CL35 and B350 will be able to satisfy 99% and 100%, respectively the cumulative percent of flights performed in the NAS for each aircraft type

Note: For AIP projects, use **wet landing** and **dry takeoff** performance.