# Flightplan optimization



- Requirements
- Horizontal optimization
- Vertical optimization
- Fuel policy

# Requirements

- Several optimization criteria possible
- Consideration of restrictions
- Response time less than 1 minute

# Optimization criteria

- **Implemented optimization criteria:**
  - MFT ( Minimum Fuel Track )
  - MTT ( Minimum Time Track )
  - MCT ( Minimum Cost Track, Fuel- and ATC- Costs )
  - MDT ( Minimum Distance Track )

# Consideration of restrictions

- **Consideration of restrictions, e.g.:**
  - NOTAMs
  - Traffic Rights
  - Weekend routings
  - Company restriction
  - Special rules ( NAT- tracks, NAR, RVSM, ...)
  - Restrictions dependent on aircraft equipment (RNAV, FMS ...)
  - Restrictions entered manually by user.

# Response time

- **Response times less than 1 minute:**
  - Choice of appropriate hardware
  - Very fast access to the optimization data
  - Separation of horizontal and vertical optimization.

# Horizontal optimization

Dijekstra algorithm


Worklist

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# Horizontal optimization

Dijekstra algorithm


1.) Selection of segments for current from- waypoint

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# Horizontal optimization

Dijekstra algorithm


1.) Selection of segments for current from- waypoint

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# Horizontal optimization

Dijekstra algorithm


1.) Selection of segments for current from- waypoint

2.) Calculation of costs for selected segments

Worklist

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# Horizontal optimization

Dijekstra algorithm


1.) Selection of segments for current from- waypoint

2.) Calculation of costs for selected segments

3.) Entering calculated datasets into worklist

Worklist

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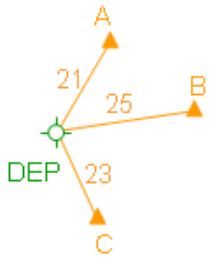
# Horizontal optimization

Dijekstra algorithm




DEST

1.) Selection of segments for current from- waypoint

2.) Calculation of costs for selected segments

3.) Entering calculated datasets into worklist

Worklist

| TO_WPT | FROM_WPT | Cost |
|---|---|---|
| A | DEP | 21 |
| B | DEP | 25 |
| C | DEP | 23 |
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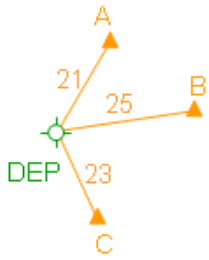
# Horizontal optimization

Dijekstra algorithm

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| TO_WPT | FROM_WPT | Cost |
|---|---|---|
| A | DEP | 21 |
| B | DEP | 25 |
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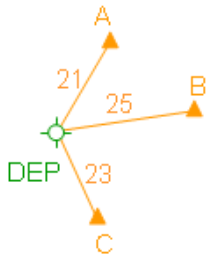


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Worklist

| TO_WPT | FROM_WPT | Cost |
|---|---|---|
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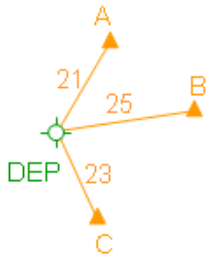
| B | DEP | 25 |
| C | DEP | 23 |

# Horizontal optimization

Dijekstra algorithm




DEST

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3.) Entering calculated datasets into worklist

4.) Selection of best dataset from worklist

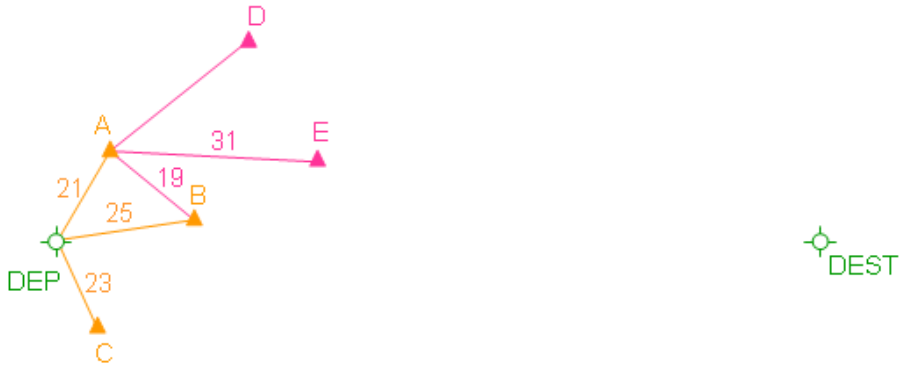
5.) To- waypoint of best dataset becomes from- waypoint

Worklist

| TO_WPT | FROM_WPT | Cost |
|---|---|---|
| A | DEP | 21 |
| B | DEP | 25 |
| C | DEP | 23 |

# Horizontal optimization

## Dijekstra algorithm

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| TO_WPT | FROM_WPT | Cost |
|---|---|---|
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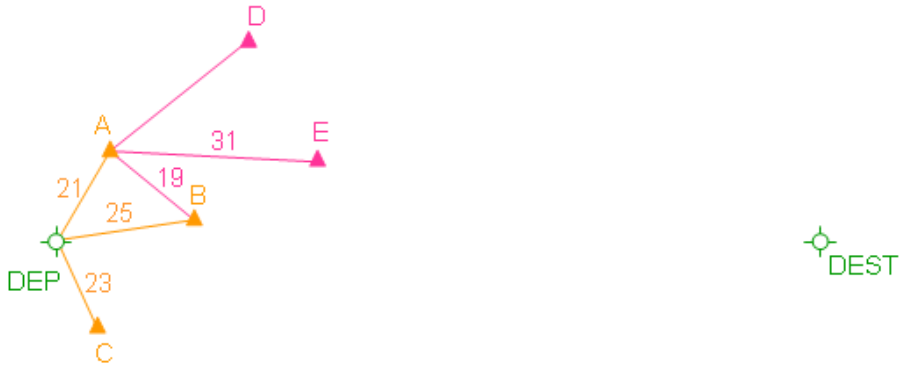
| B | DEP | 25 |
| C | DEP | 23 |

# Horizontal optimization

## Dijekstra algorithm

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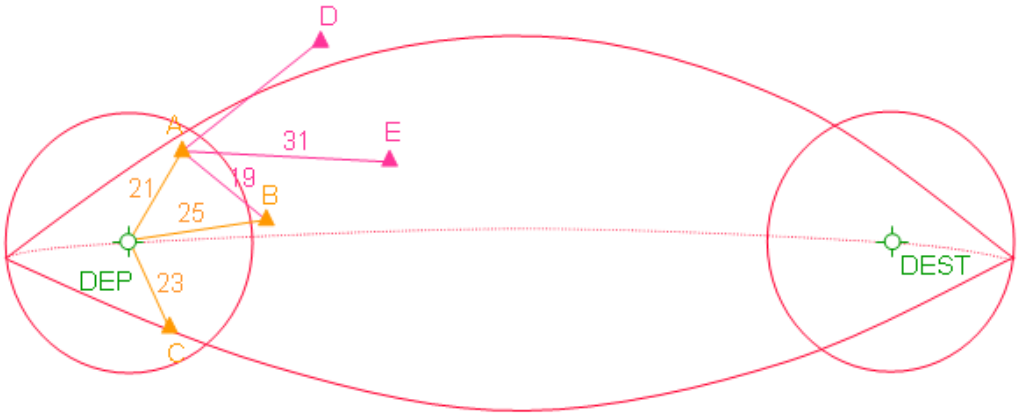
## Worklist

| TO_WPT | FROM_WPT | Cost |
|---|---|---|
| A | DEP | 21 |
| B | DEP | 25 |
| C | DEP | 23 |
| E | A | 52 |
| B | A | 40 |

# Horizontal optimization

## Dijekstra algorithm

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|---|---|---|
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| E | A | 52 |
| B | A | 40 |

# Horizontal optimization

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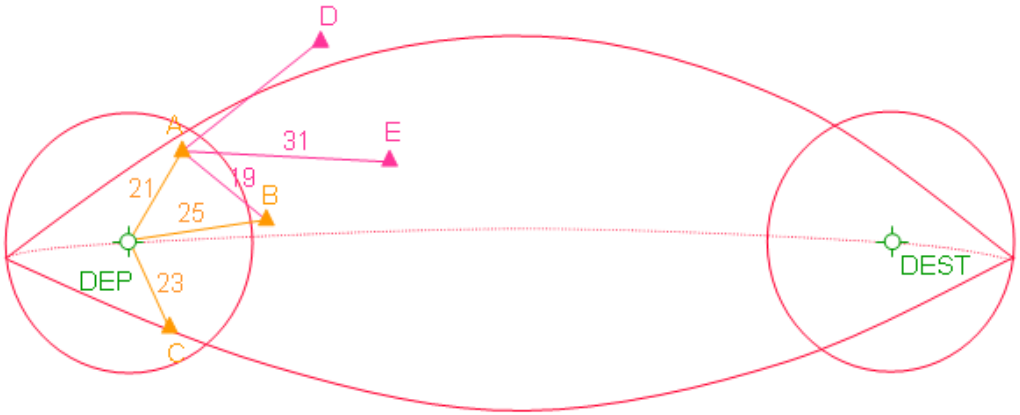


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|---|---|---|
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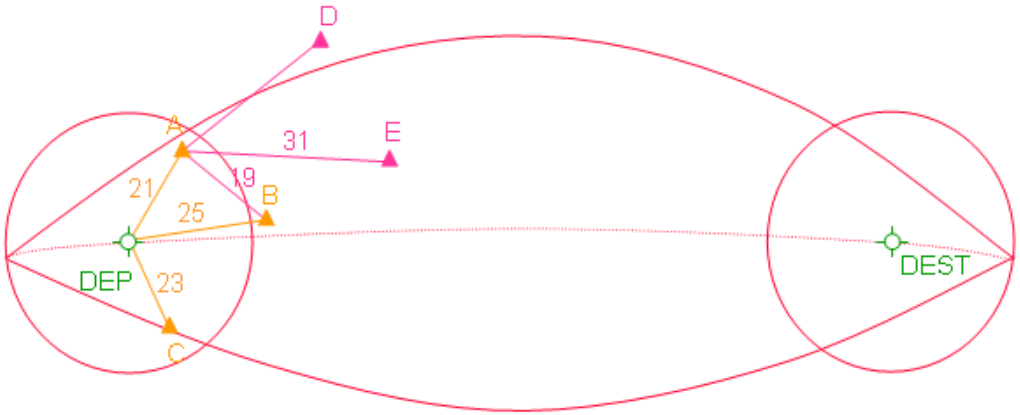
| B | DEP | 25 |
| C | DEP | 23 |
| E | A | 52 |
| X | X | X |

# Horizontal optimization

## Dijekstra algorithm

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| E | A | 52 |
| X | X | X |

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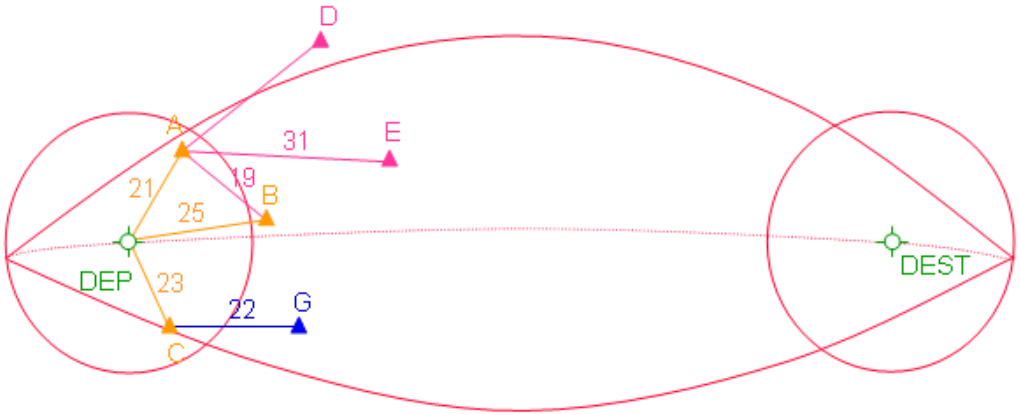


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# Horizontal optimization

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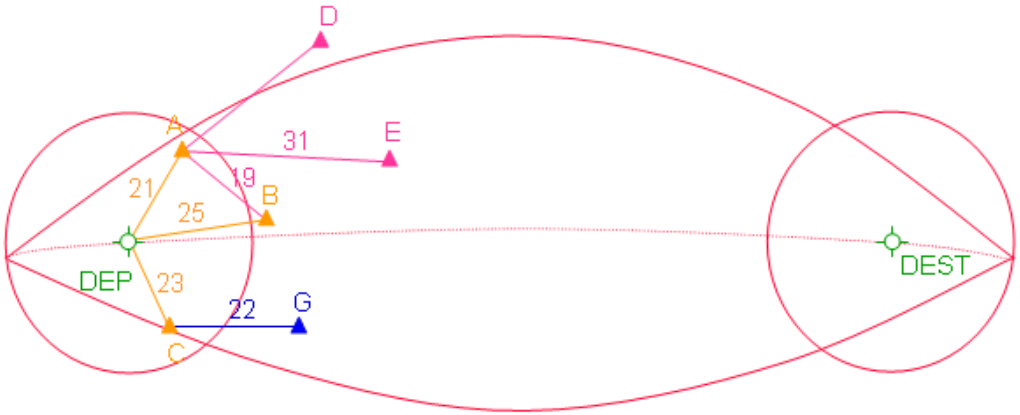


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|---|---|---|
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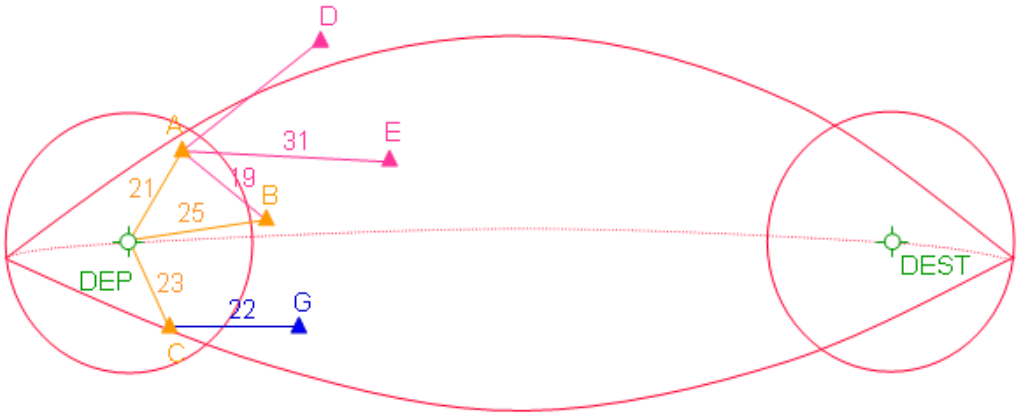
| B | DEP | 25 |
| C | DEP | 23 |
| E | A | 52 |
| X | X | X |
| G | C | 45 |

# Horizontal optimization

## Dijekstra algorithm

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| C | DEP | 23 |
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| X | X | X |
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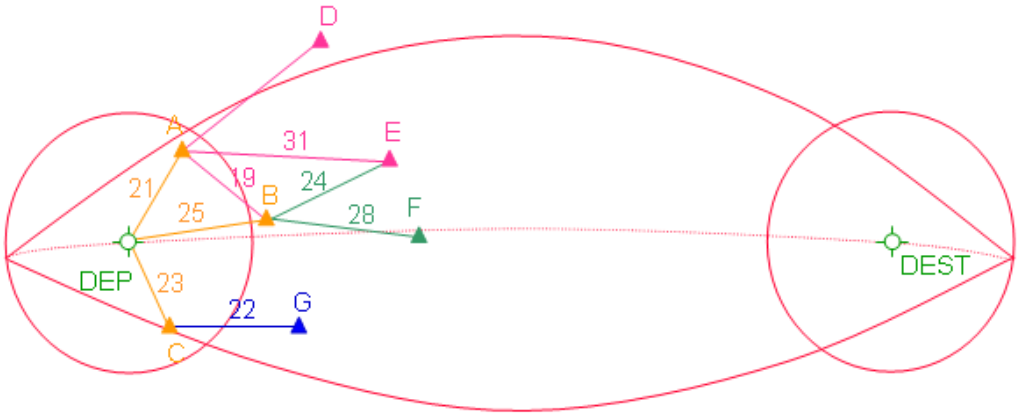


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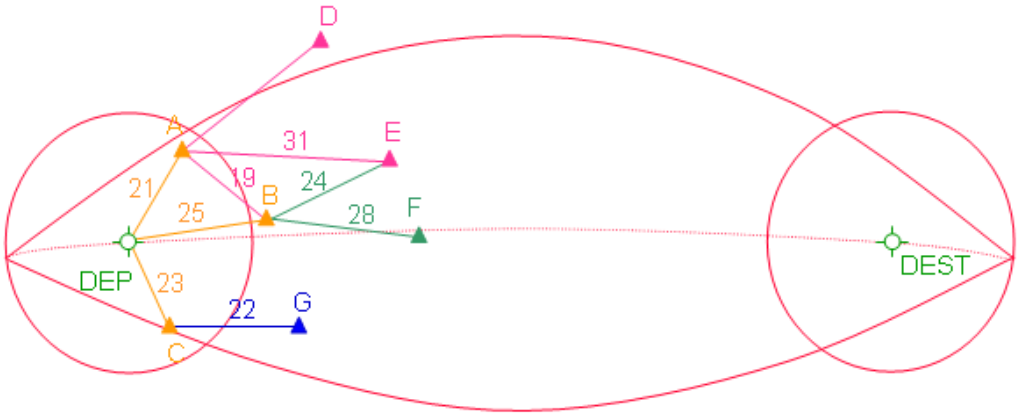
# Horizontal optimization

## Dijekstra algorithm

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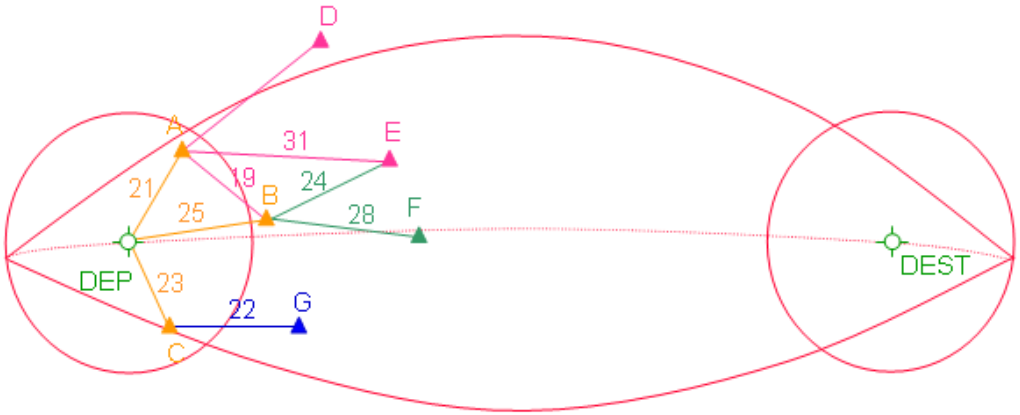
| TO_WPT | FROM_WPT | Cost |
|---|---|---|
| A | DEP | 21 |
| B | DEP | 25 |
| C | DEP | 23 |
| E | A | 52 |
| X | X | X |
| G | C | 45 |
| E | B | 49 |
| F | B | 53 |

# Horizontal optimization

## Dijekstra algorithm

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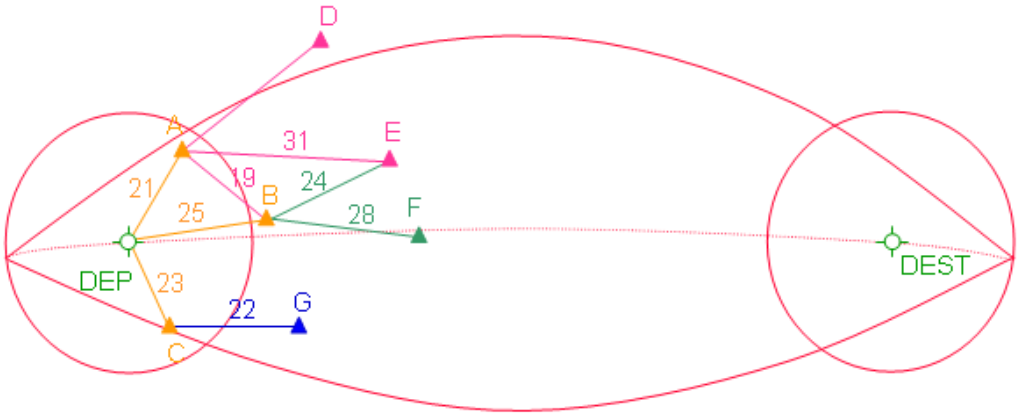
## Worklist

| TO_WPT | FROM_WPT | Cost |
|---|---|---|
| A | DEP | 21 |
| B | DEP | 25 |
| C | DEP | 23 |
| ~~X~~ | ~~X~~ | ~~X~~ |
| ~~X~~ | ~~X~~ | ~~X~~ |
| G | C | 45 |
| E | B | 49 |
| F | B | 53 |

# Horizontal optimization

## Dijekstra algorithm

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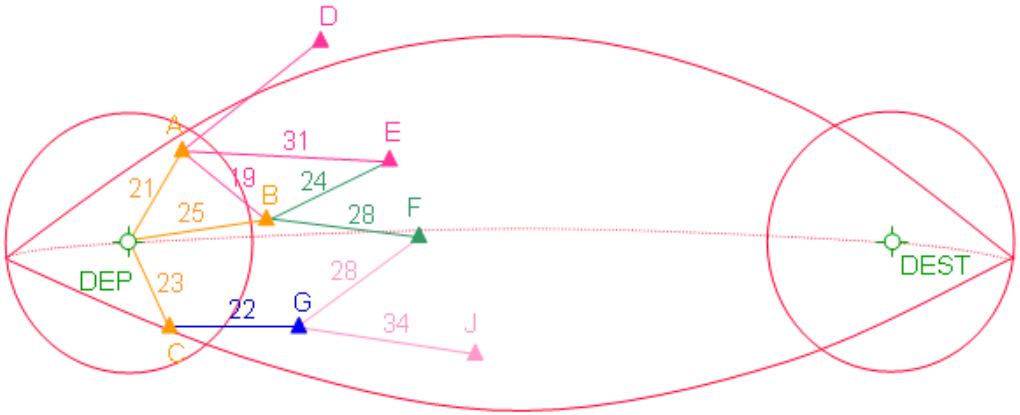
## Worklist

| TO_WPT | FROM_WPT | Cost |
|---|---|---|
| A | DEP | 21 |
| B | DEP | 25 |
| C | DEP | 23 |
| ~~X~~ | ~~X~~ | ~~X~~ |
| ~~X~~ | ~~X~~ | ~~X~~ |
| G | C | 45 |
| E | B | 49 |
| F | B | 53 |

# Horizontal optimization

## Dijekstra algorithm

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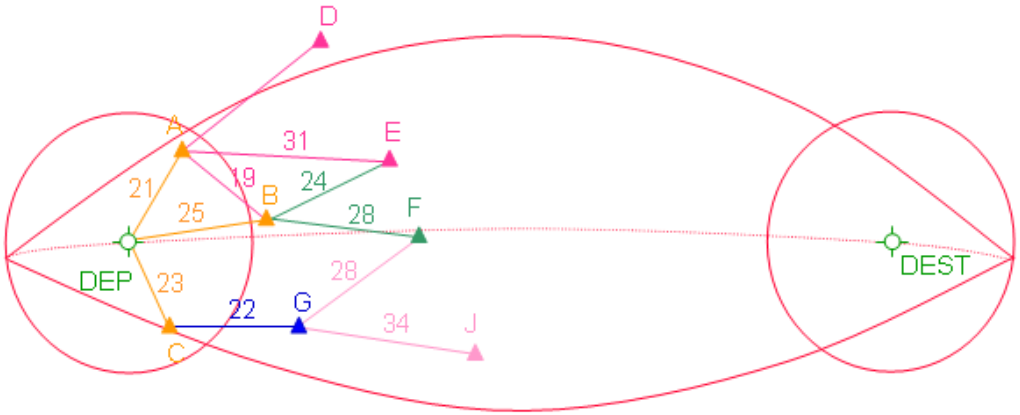
| TO_WPT | FROM_WPT | Cost |
|---|---|---|
| A | DEP | 21 |
| B | DEP | 25 |
| C | DEP | 23 |
| ~~X~~ | ~~X~~ | ~~X~~ |
| ~~X~~ | ~~X~~ | ~~X~~ |
| G | C | 45 |
| E | B | 49 |
| F | B | 53 |

# Horizontal optimization

## Dijekstra algorithm

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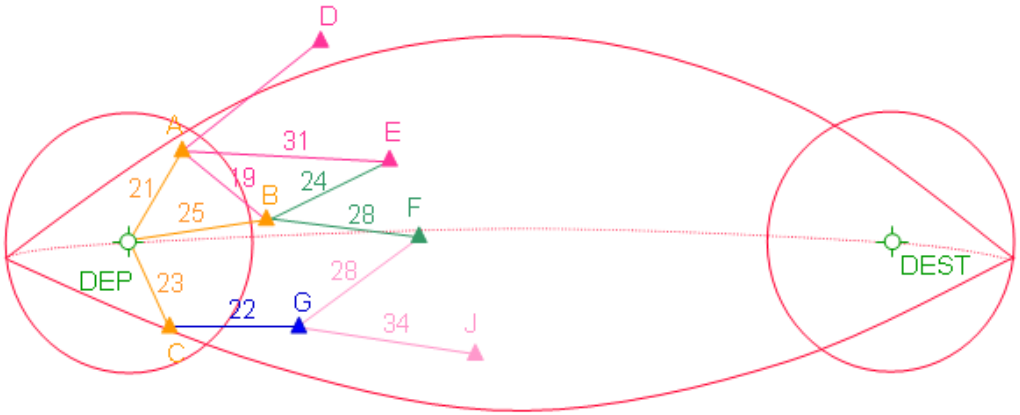
## Worklist

| TO_WPT | FROM_WPT | Cost |
|---|---|---|
| A | DEP | 21 |
| B | DEP | 25 |
| C | DEP | 23 |
| X | X | X |
| X | X | X |
| G | C | 45 |
| E | B | 49 |
| F | B | 53 |
| F | G | 73 |
| J | G | 79 |

# Horizontal optimization

## Dijekstra algorithm

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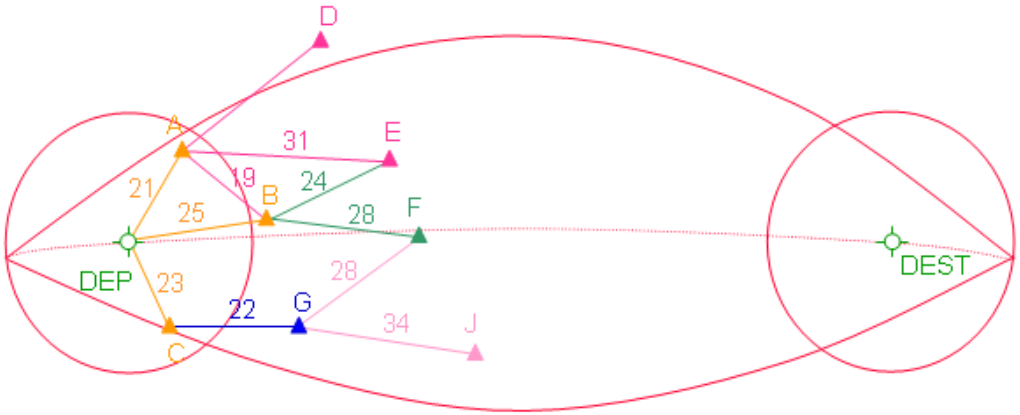
## Worklist

| TO_WPT | FROM_WPT | Cost |
|---|---|---|
| A | DEP | 21 |
| B | DEP | 25 |
| C | DEP | 23 |
| X | X | X |
| X | X | X |
| G | C | 45 |
| E | B | 49 |
| F | B | 53 |
| X | X | X |
| J | G | 79 |

# Horizontal optimization

## Dijekstra algorithm

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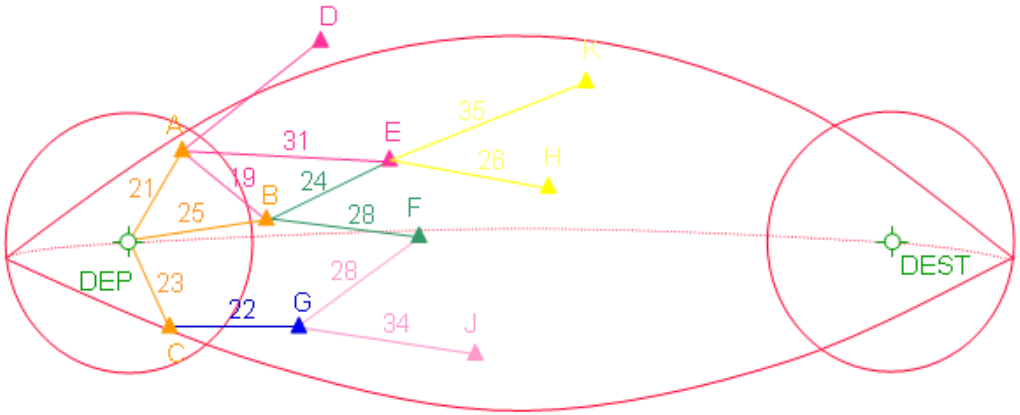
| TO_WPT | FROM_WPT | Cost |
|---|---|---|
| A | DEP | 21 |
| B | DEP | 25 |
| C | DEP | 23 |
| X | X | X |
| X | X | X |
| G | C | 45 |
| E | B | 49 |
| F | B | 53 |
| X | X | X |
| J | G | 79 |

# Horizontal optimization

## Dijekstra algorithm

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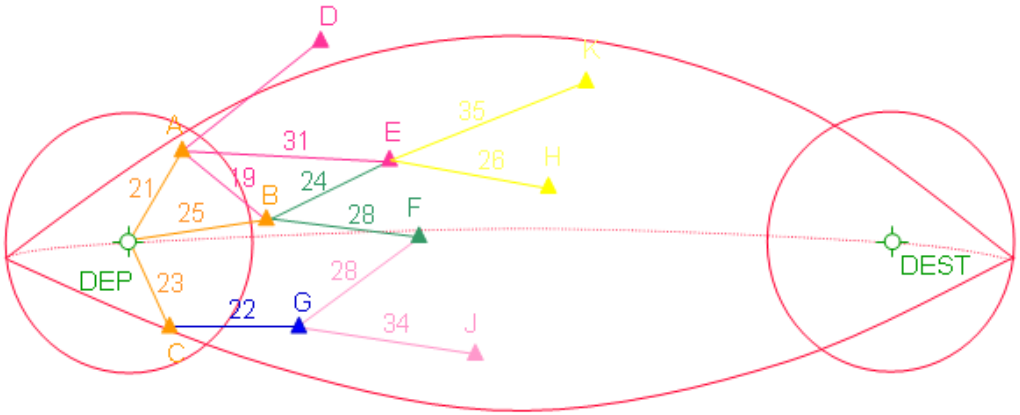
| TO_WPT | FROM_WPT | Cost |
|---|---|---|
| A | DEP | 21 |
| B | DEP | 25 |
| C | DEP | 23 |
| X | X | X |
| X | X | X |
| G | C | 45 |
| E | B | 49 |
| F | B | 53 |
| X | X | X |
| J | G | 79 |
| K | E | 84 |
| H | E | 75 |

# Horizontal optimization

## Dijekstra algorithm

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|---|---|---|
| A | DEP | 21 |
| B | DEP | 25 |
| C | DEP | 23 |
| X | X | X |
| X | X | X |
| G | C | 45 |
| E | B | 49 |
| F | B | 53 |
| X | X | X |
| J | G | 79 |
| K | E | 84 |
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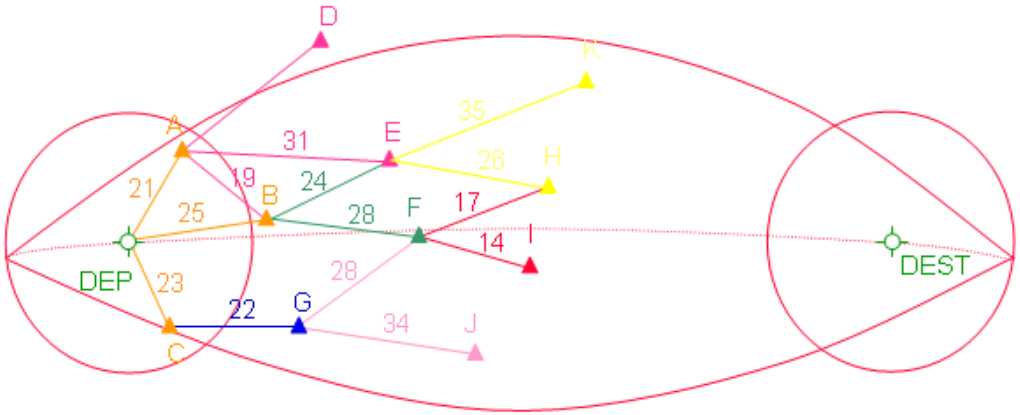
# Horizontal optimization

## Dijekstra algorithm

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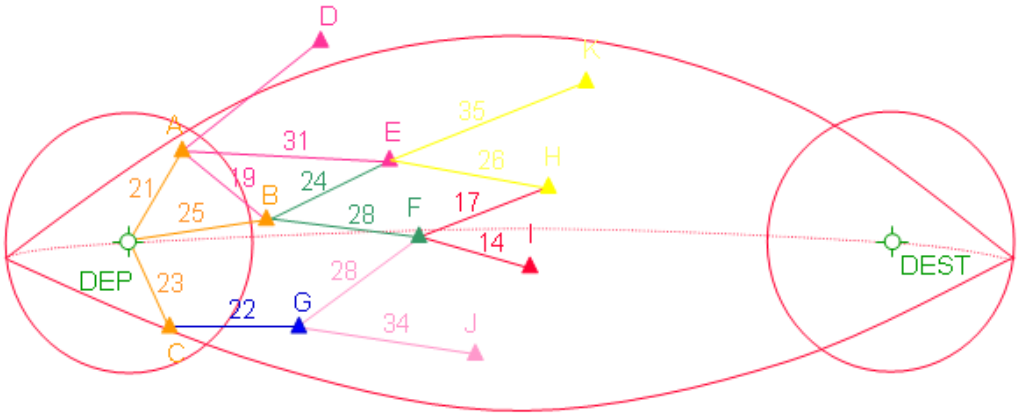
5.) To- waypoint of best dataset becomes from- waypoint

## Worklist

| TO_WPT | FROM_WPT | Cost |
|---|---|---|
| A | DEP | 21 |
| B | DEP | 25 |
| C | DEP | 23 |
| X | X | X |
| X | X | X |
| G | C | 45 |
| E | B | 49 |
| F | B | 53 |
| X | X | X |
| J | G | 79 |
| K | E | 84 |
| H | E | 75 |

# Horizontal optimization

## Dijekstra algorithm

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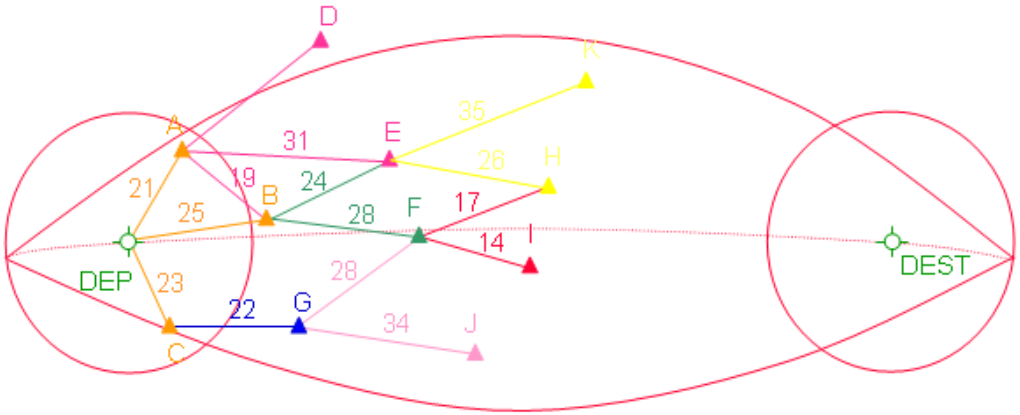
# Horizontal optimization

## Dijekstra algorithm

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| J | G | 79 |
| K | E | 84 |
| H | E | 75 |
| H | F | 70 |
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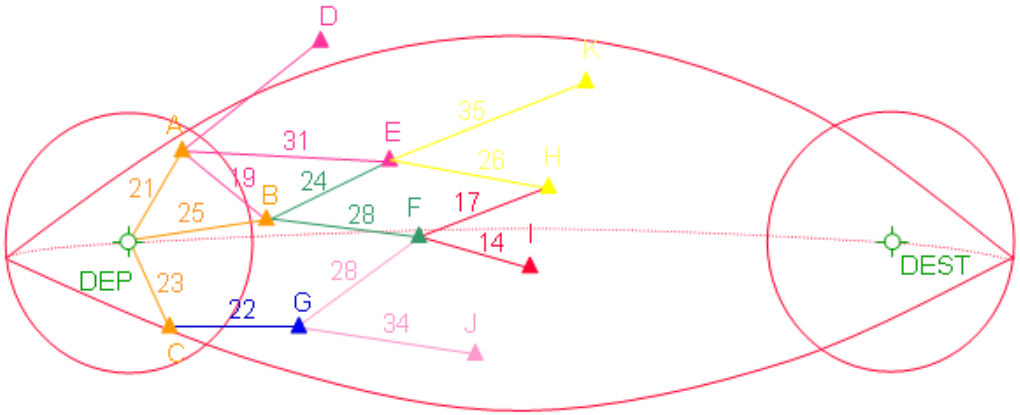
## Dijekstra algorithm

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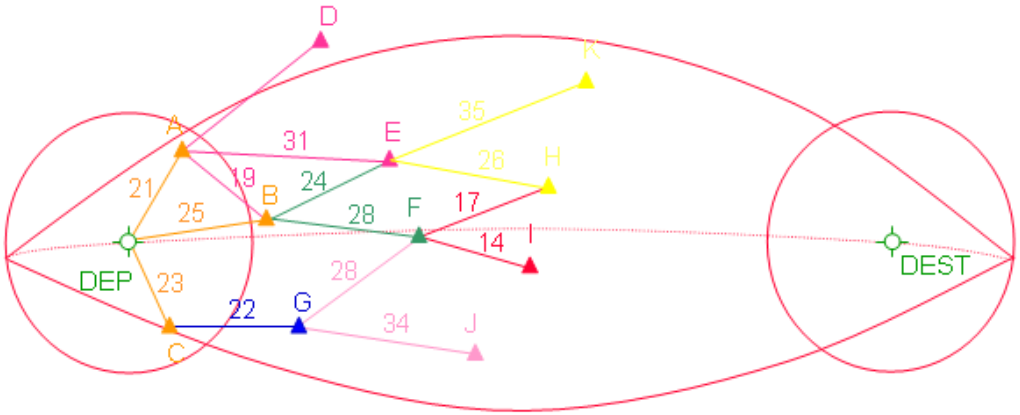
## Dijekstra algorithm

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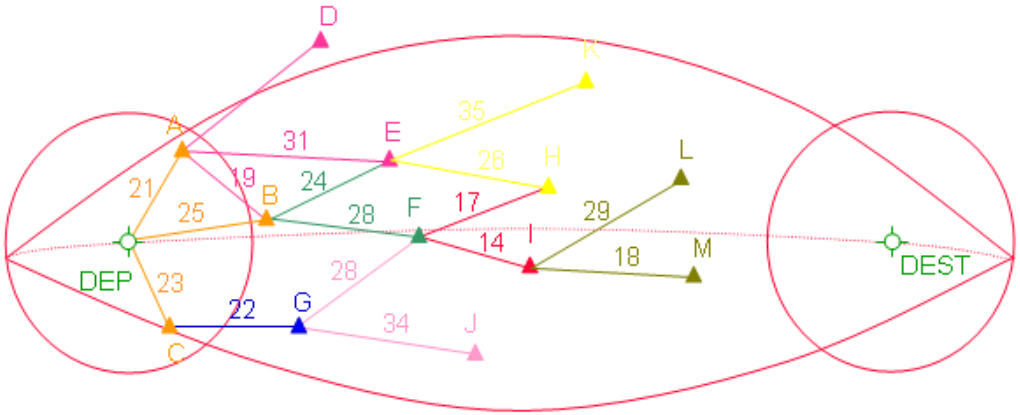
# Horizontal optimization

## Dijekstra algorithm

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|---|---|---|
| A | DEP | 21 |
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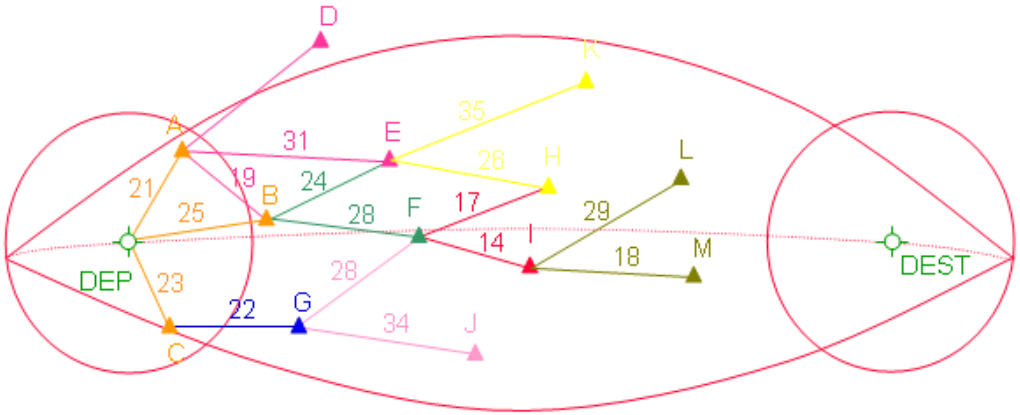


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| X | X | X |
| H | F | 70 |
| I | F | 67 |
| L | I | 96 |
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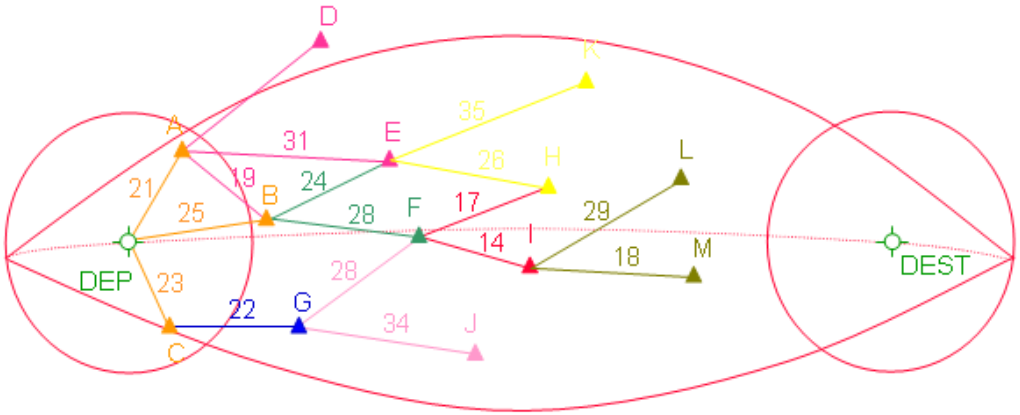
# Horizontal optimization

## Dijekstra algorithm

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# Horizontal optimization

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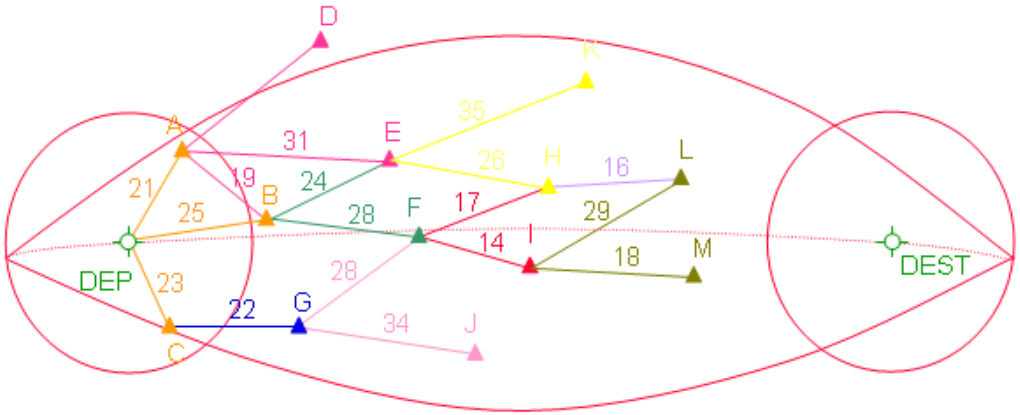


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# Horizontal optimization

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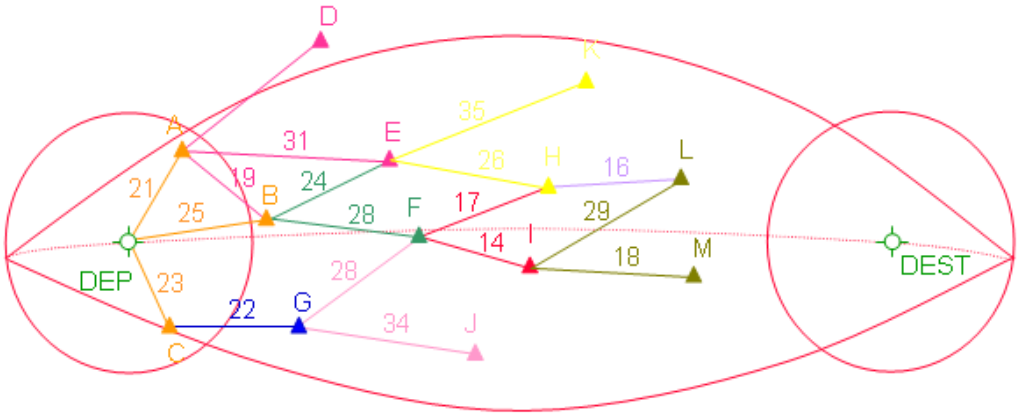


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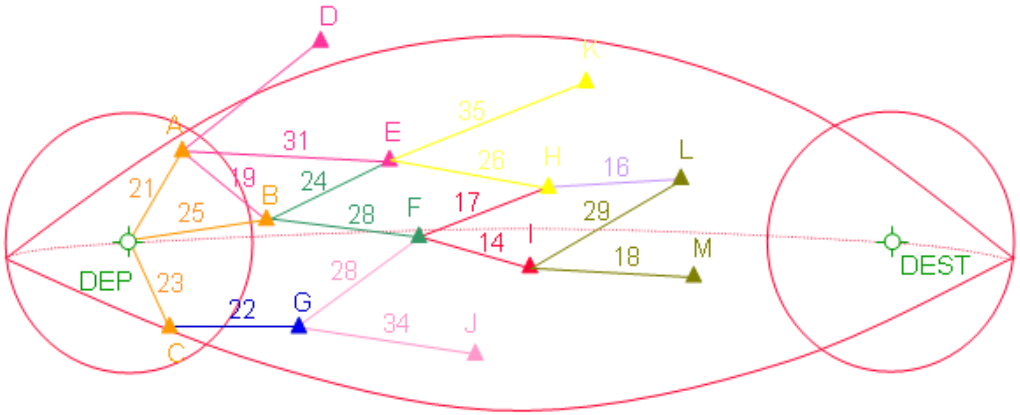
# Horizontal optimization

## Dijekstra algorithm

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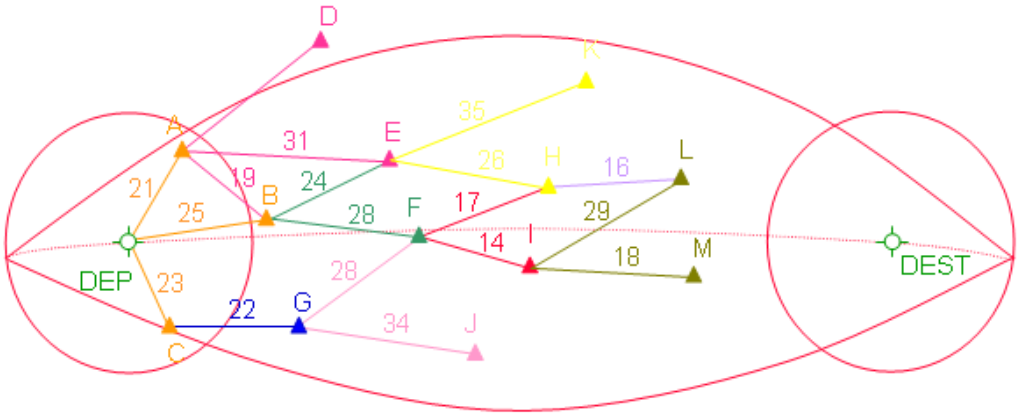
# Horizontal optimization

## Dijekstra algorithm

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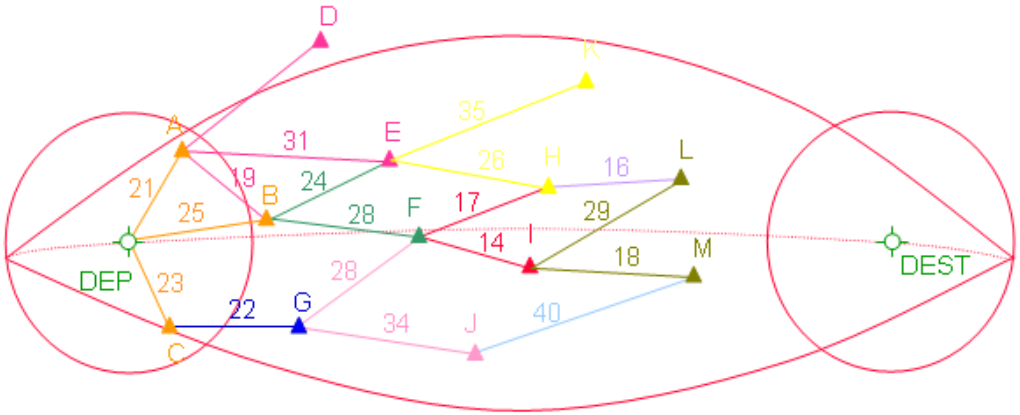
# Horizontal optimization

## Dijekstra algorithm

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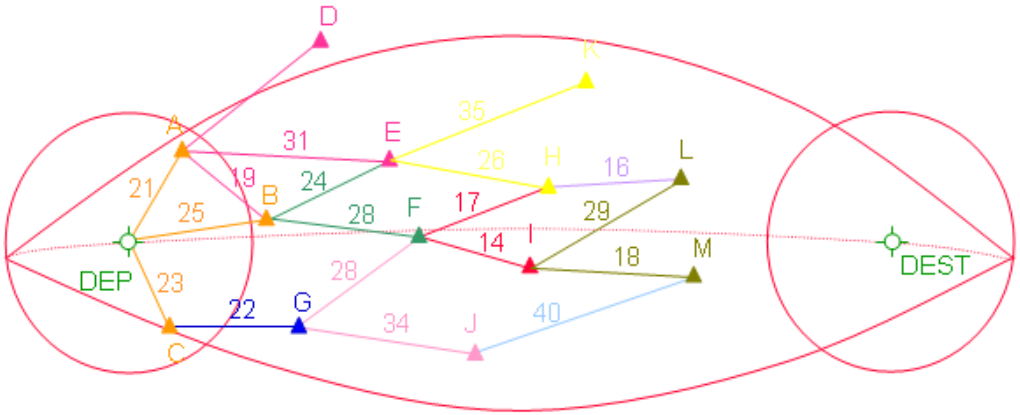
# Horizontal optimization

## Dijekstra algorithm

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# Horizontal optimization

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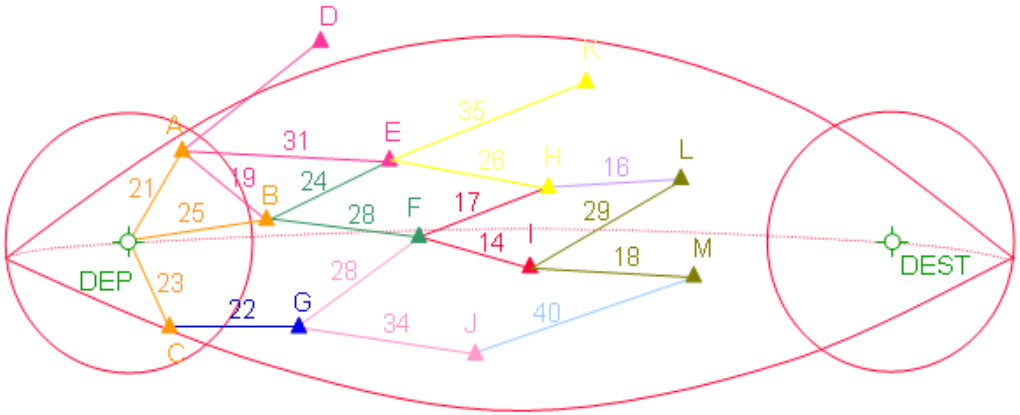


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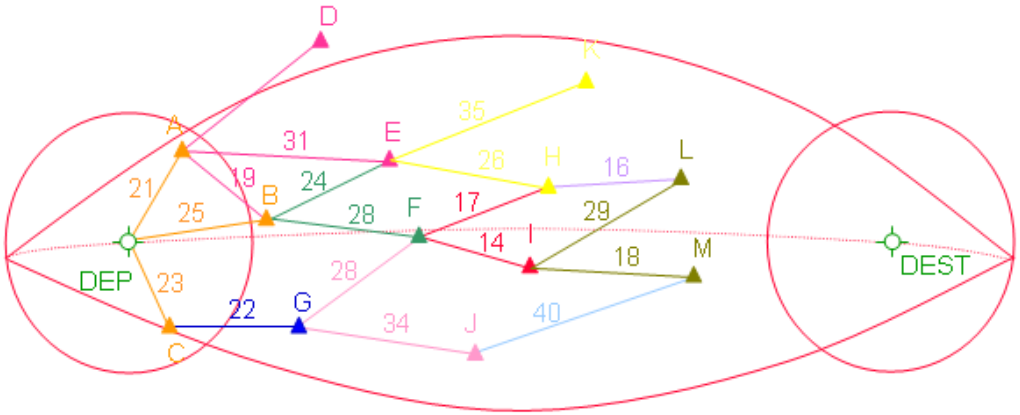


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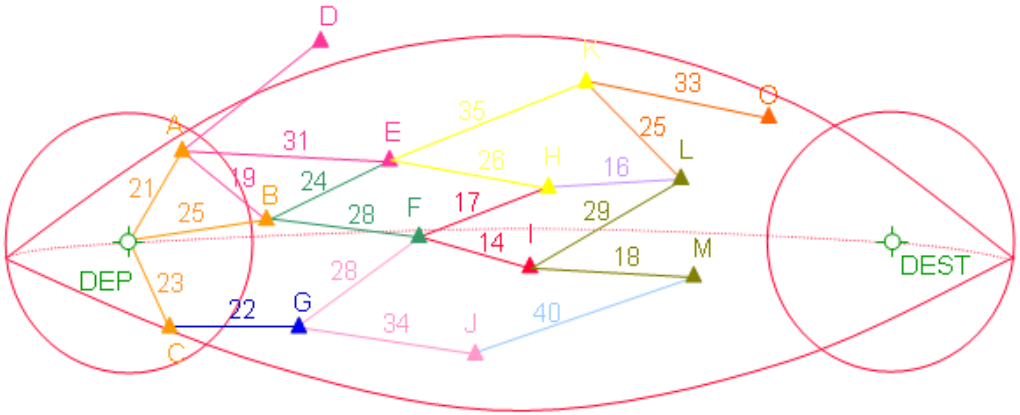


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# Horizontal optimization

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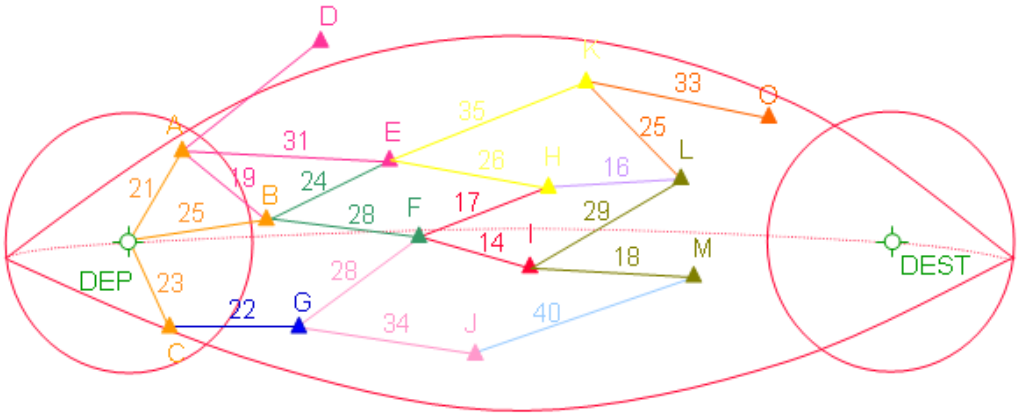


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# Horizontal optimization

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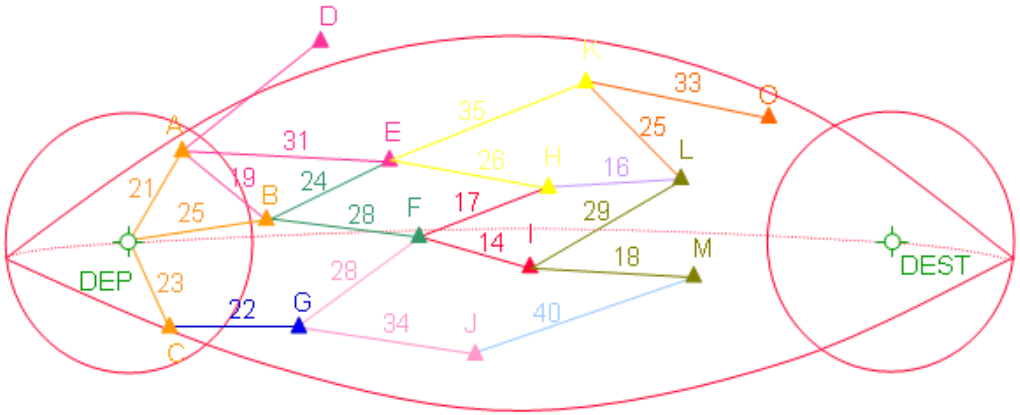


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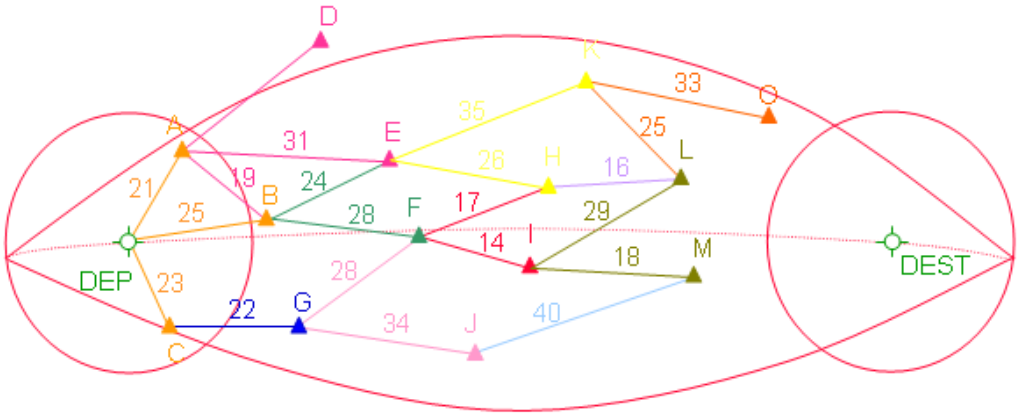


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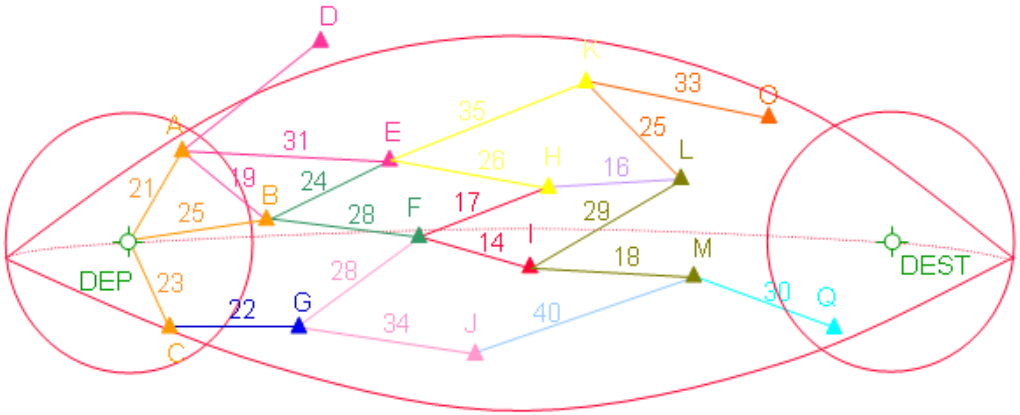
# Horizontal optimization

## Dijekstra algorithm

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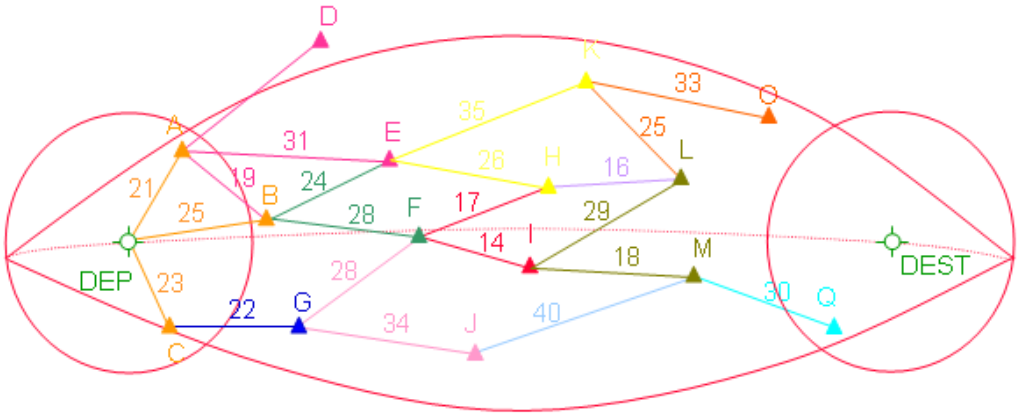


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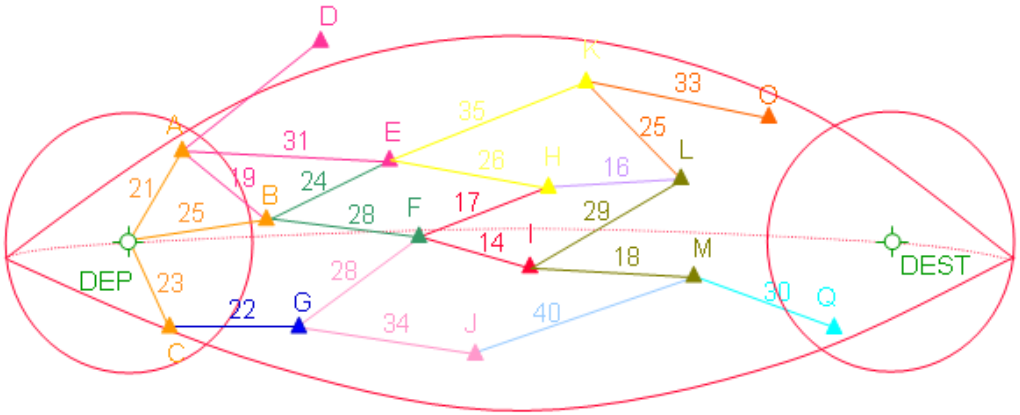


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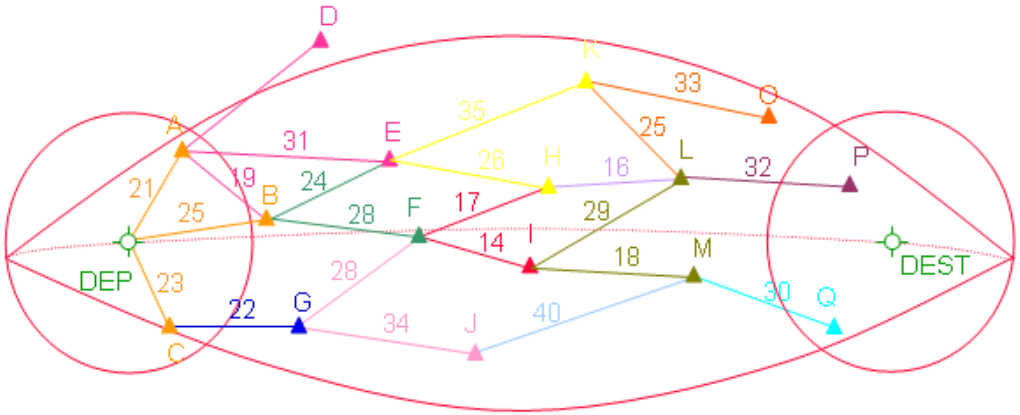


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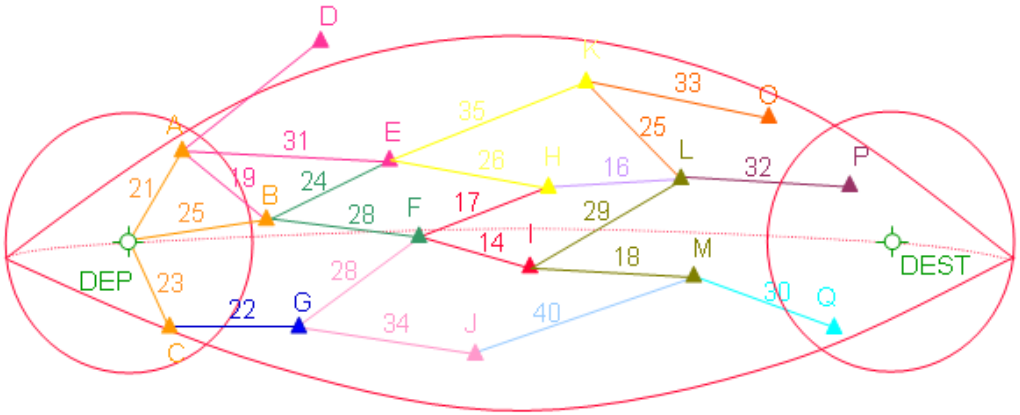


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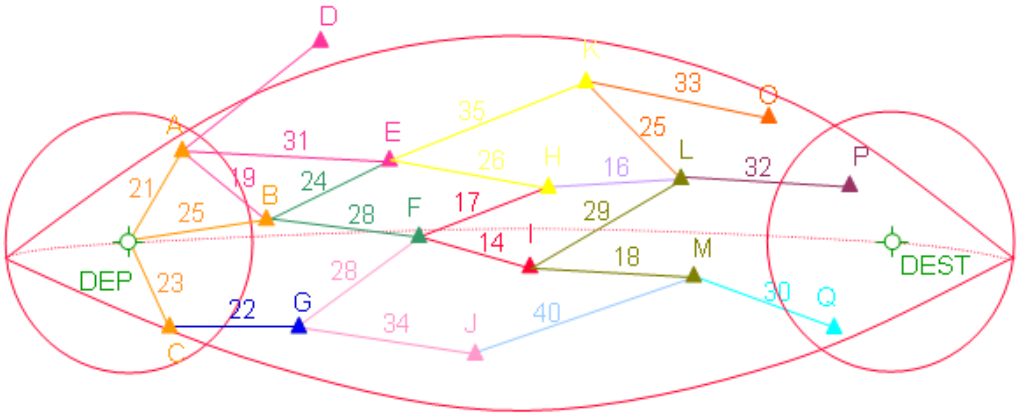


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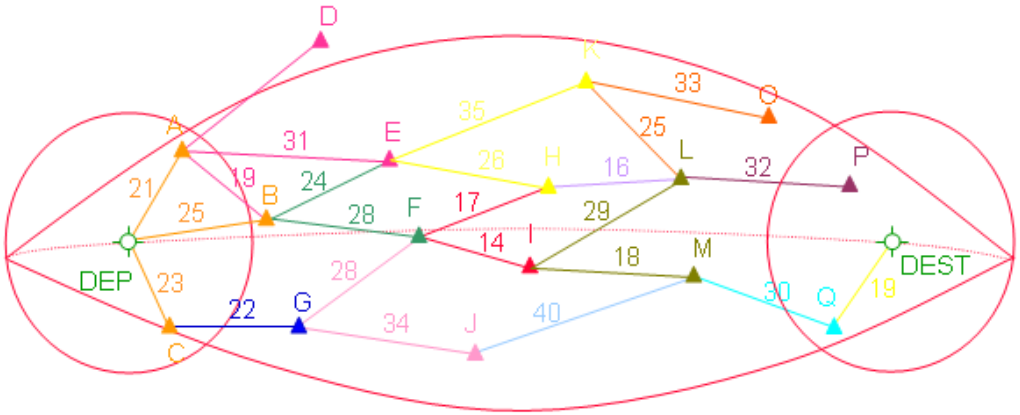


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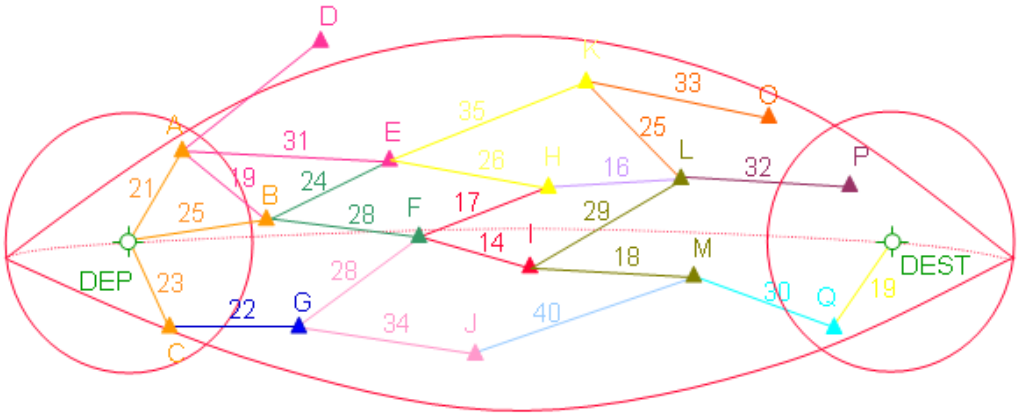


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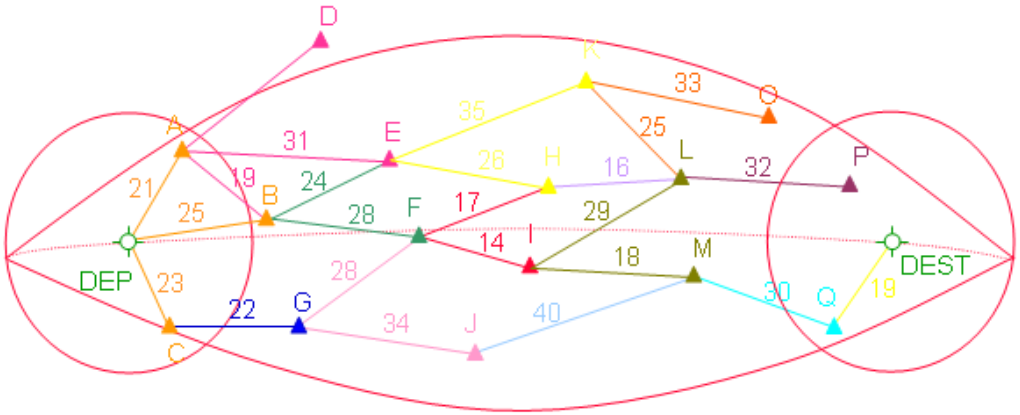


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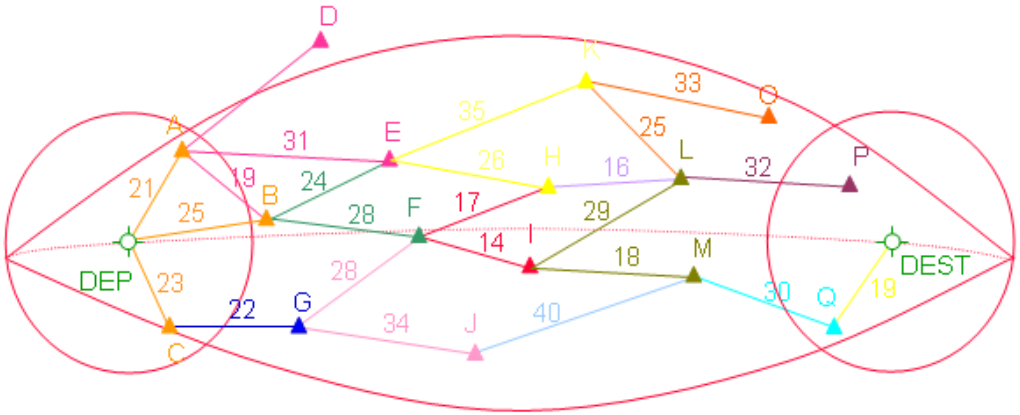


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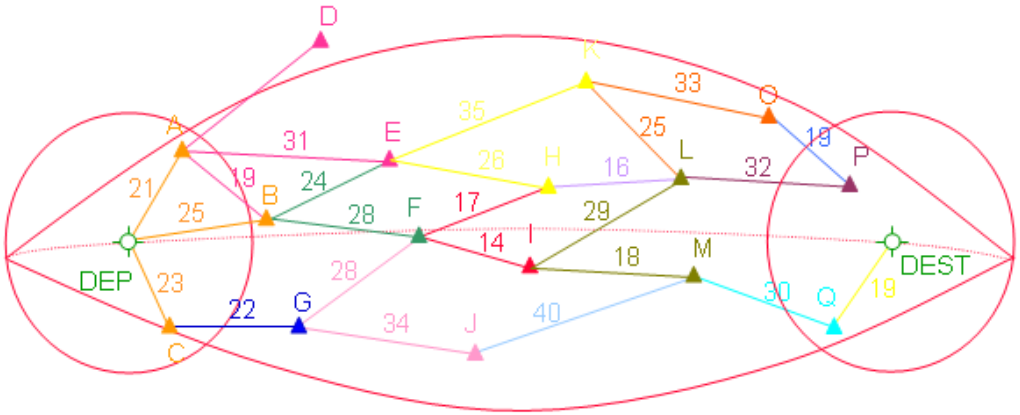


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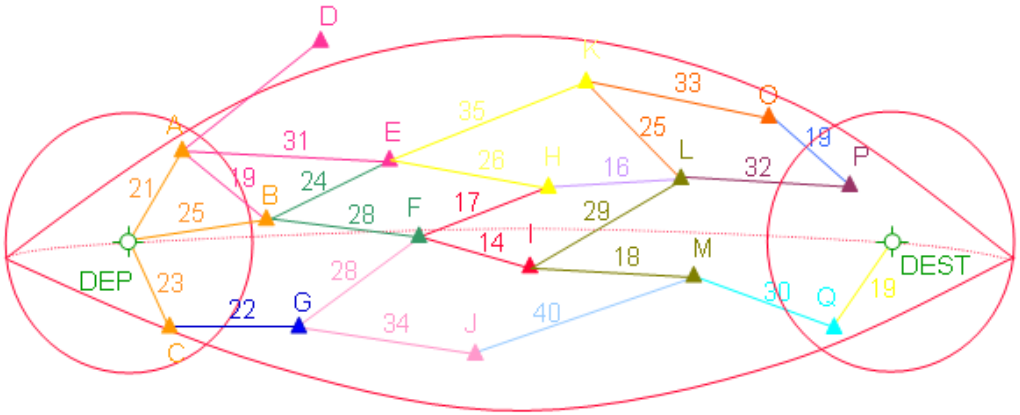


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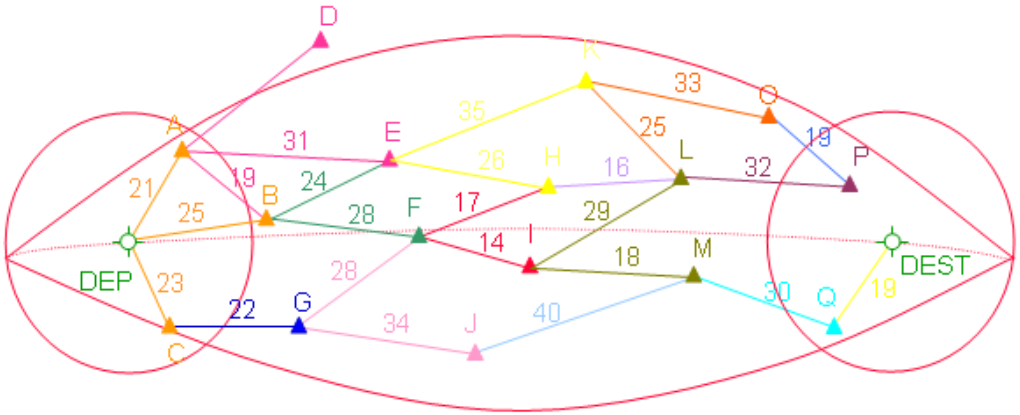


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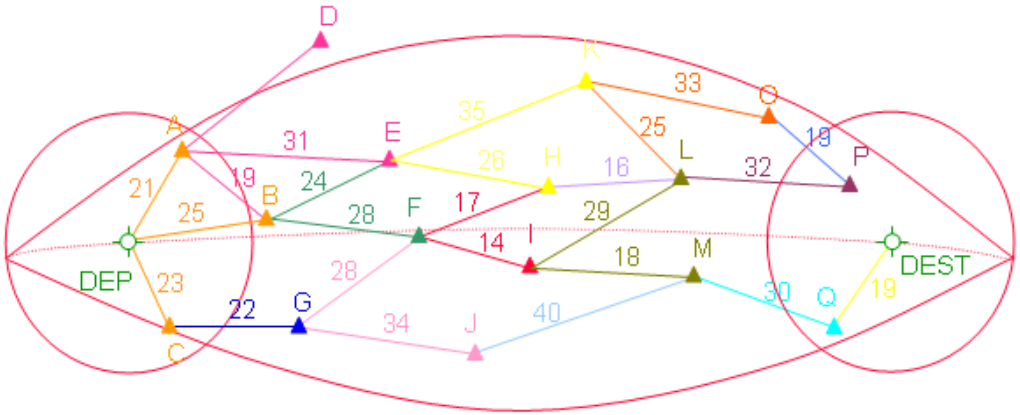


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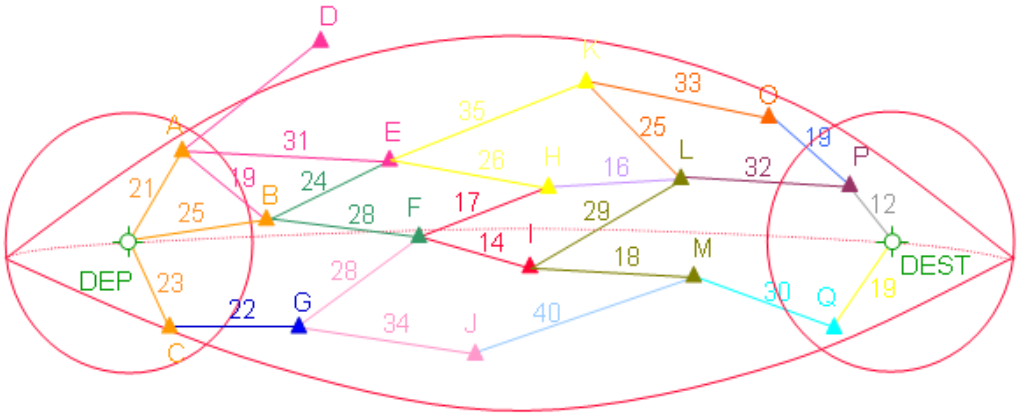


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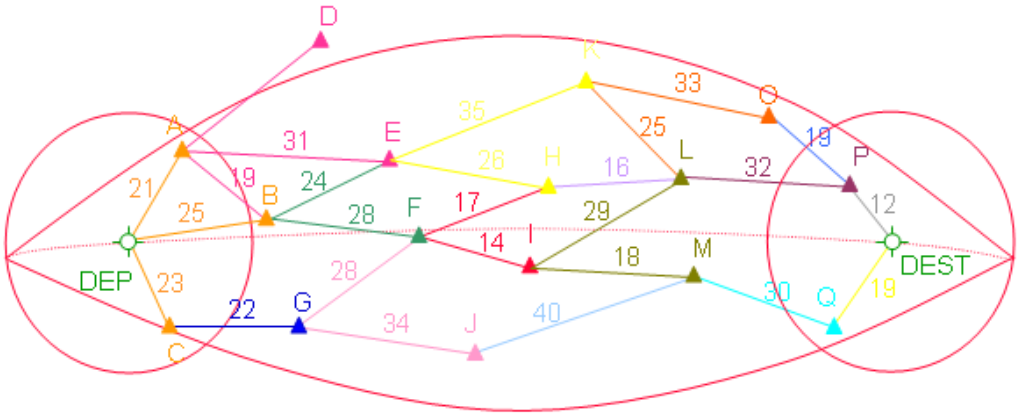


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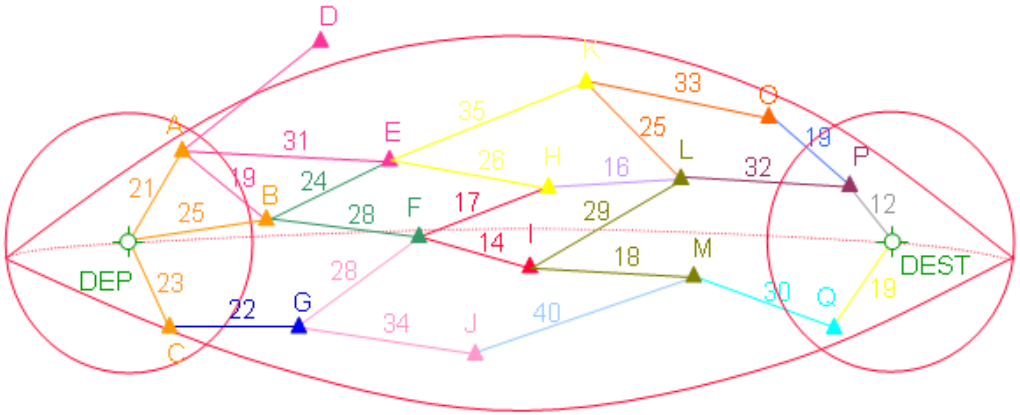


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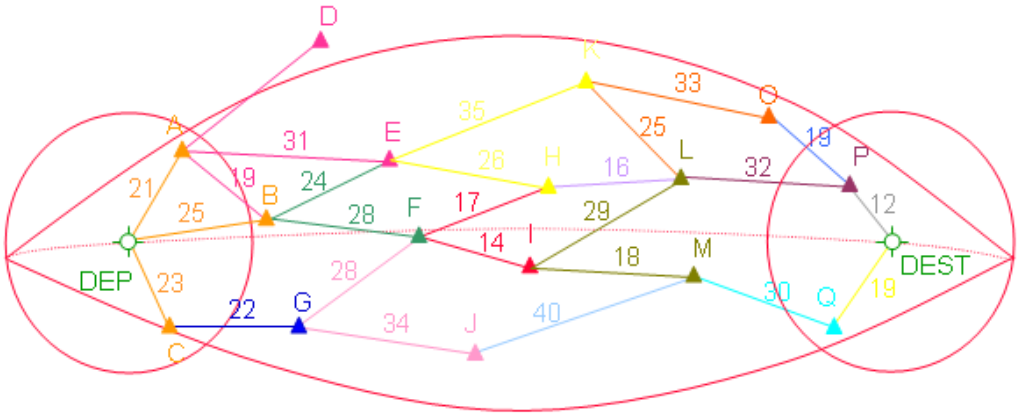


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# Calculation phases departure - destination

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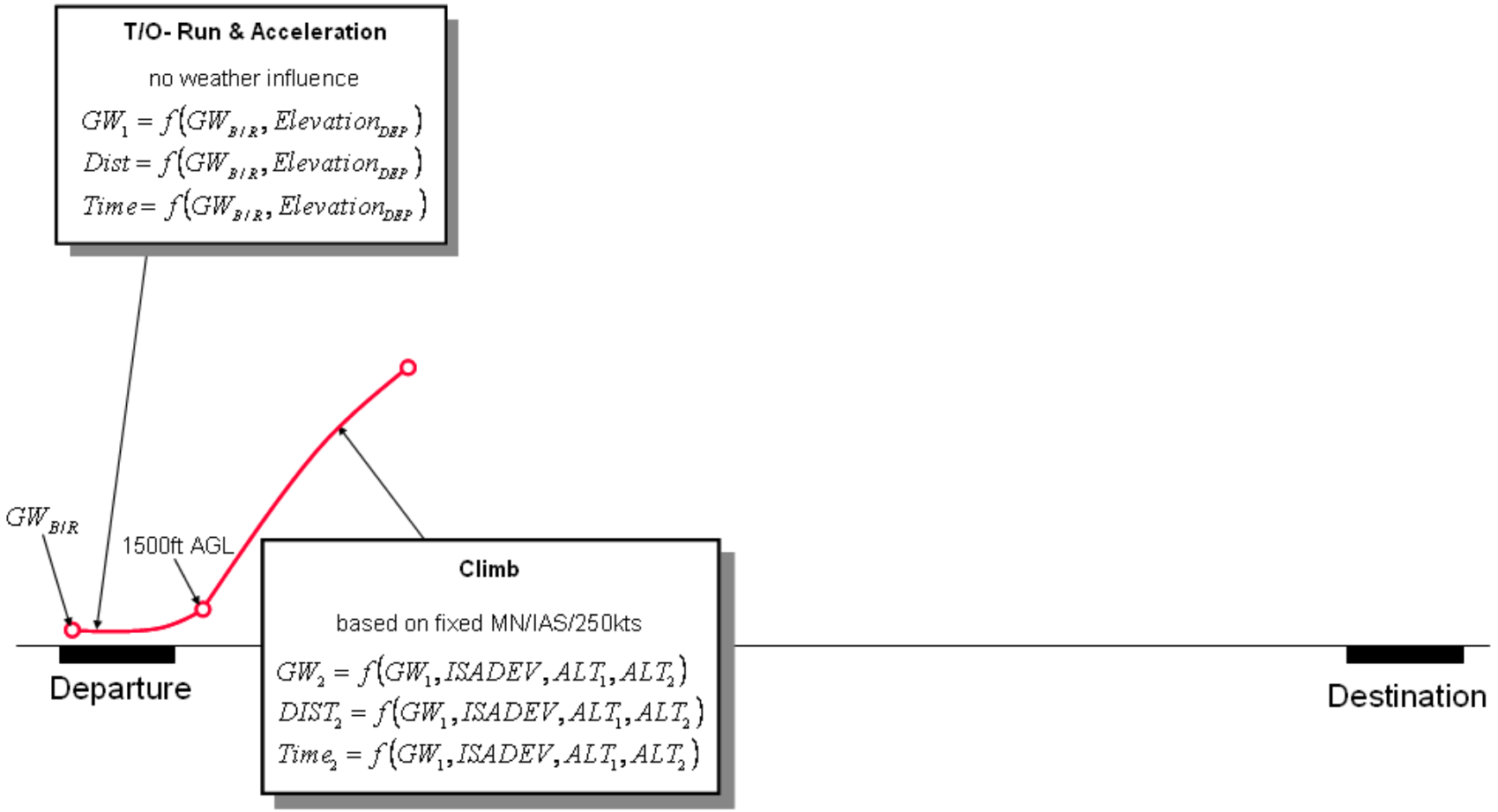
**T/O- Run & Acceleration**

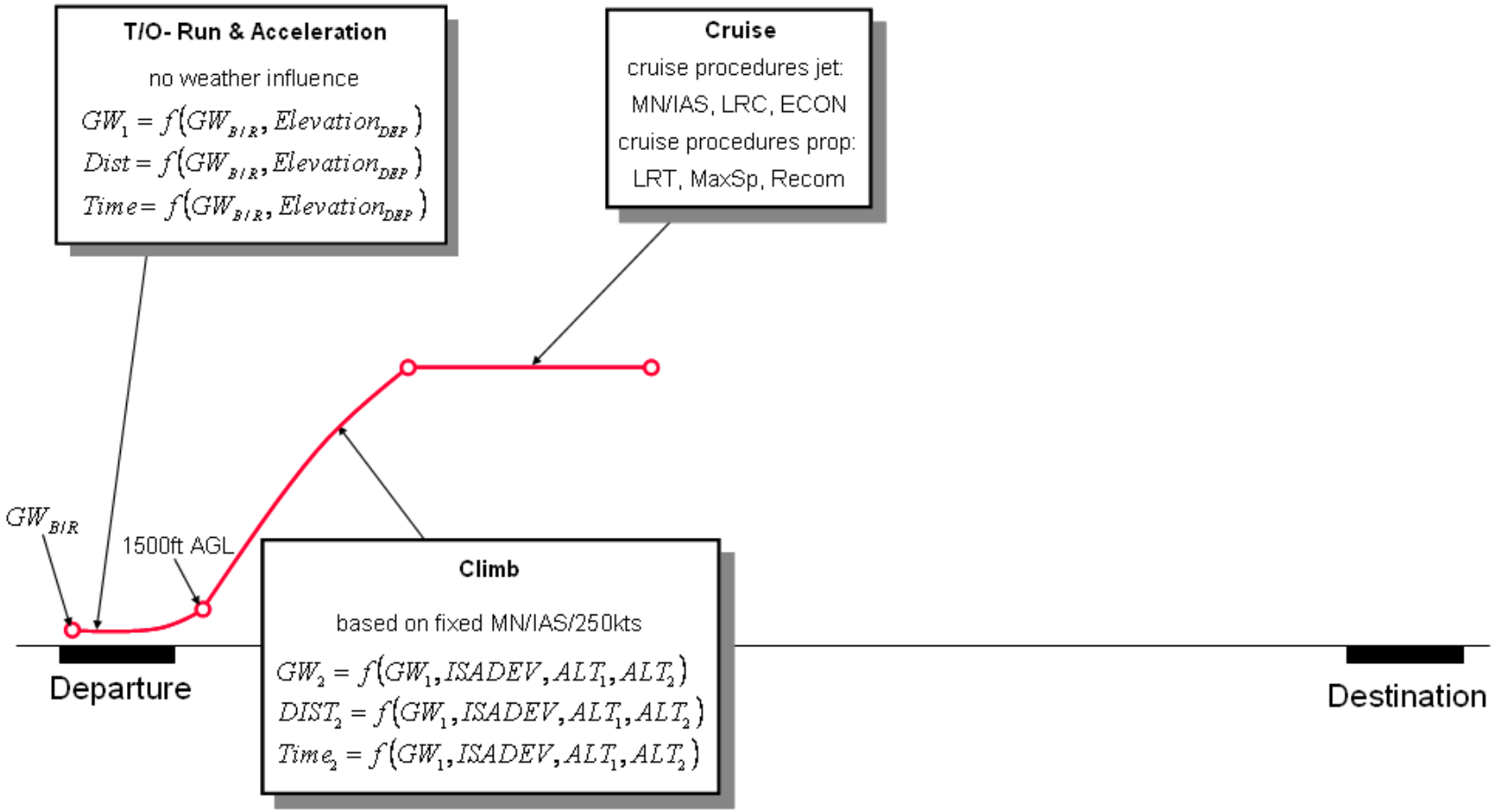
no weather influence

$$GW_1 = f(GW_{BIR}, Elevation_{DEP})$$
$$Dist = f(GW_{BIR}, Elevation_{DEP})$$
$$Time = f(GW_{BIR}, Elevation_{DEP})$$

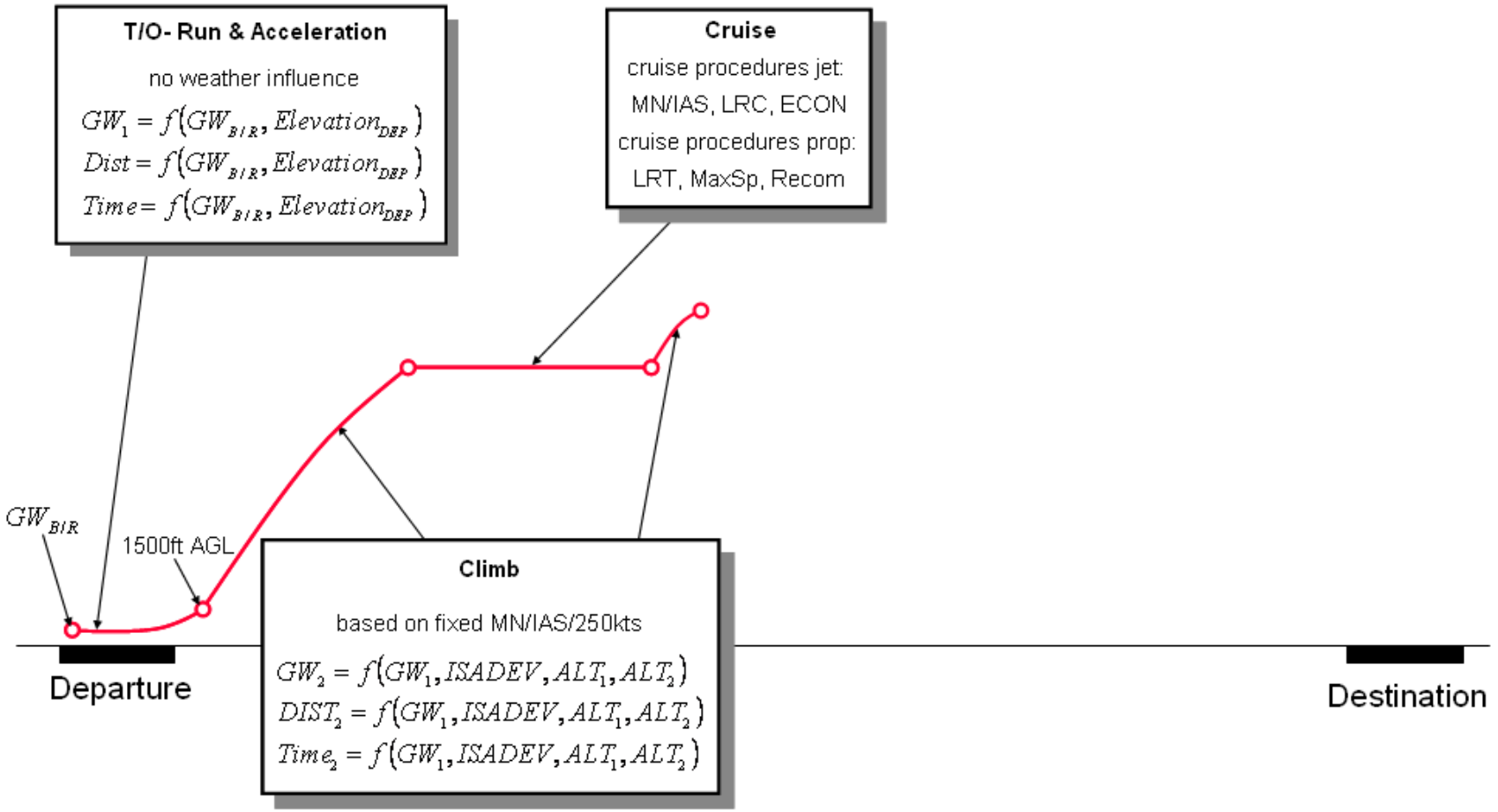
# Calculation phases departure - destination



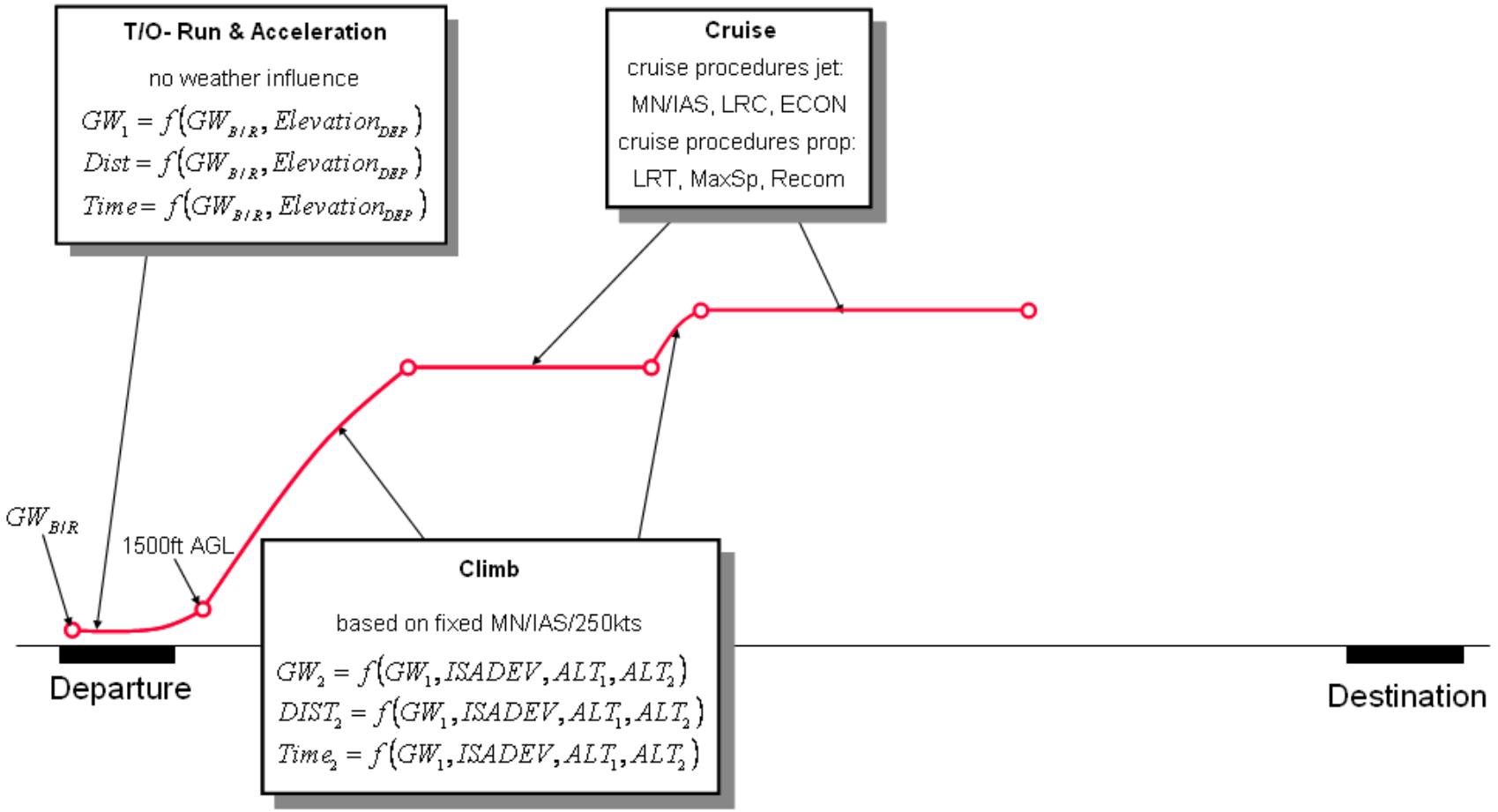
# Calculation phases departure - destination



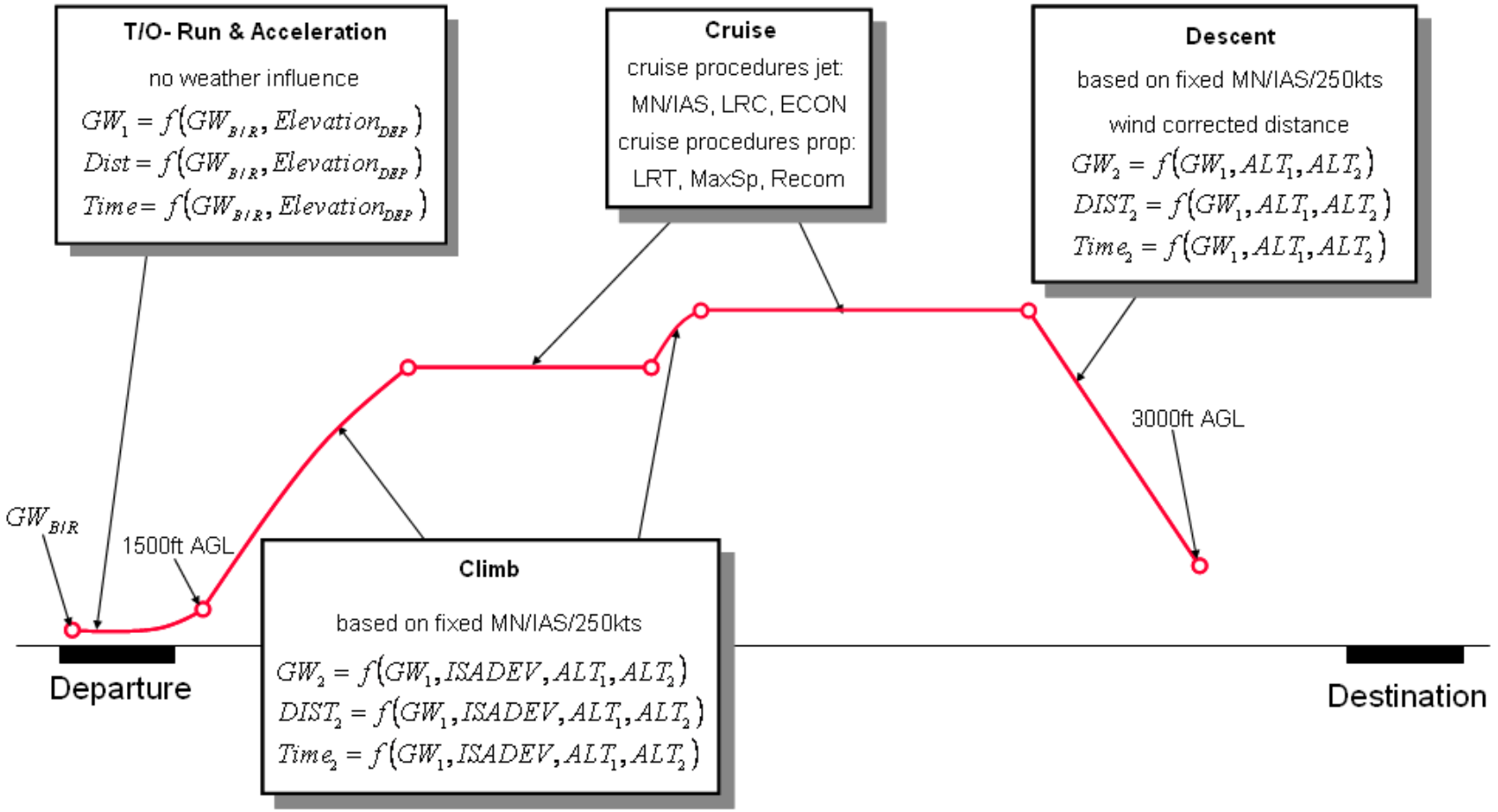
# Calculation phases departure - destination



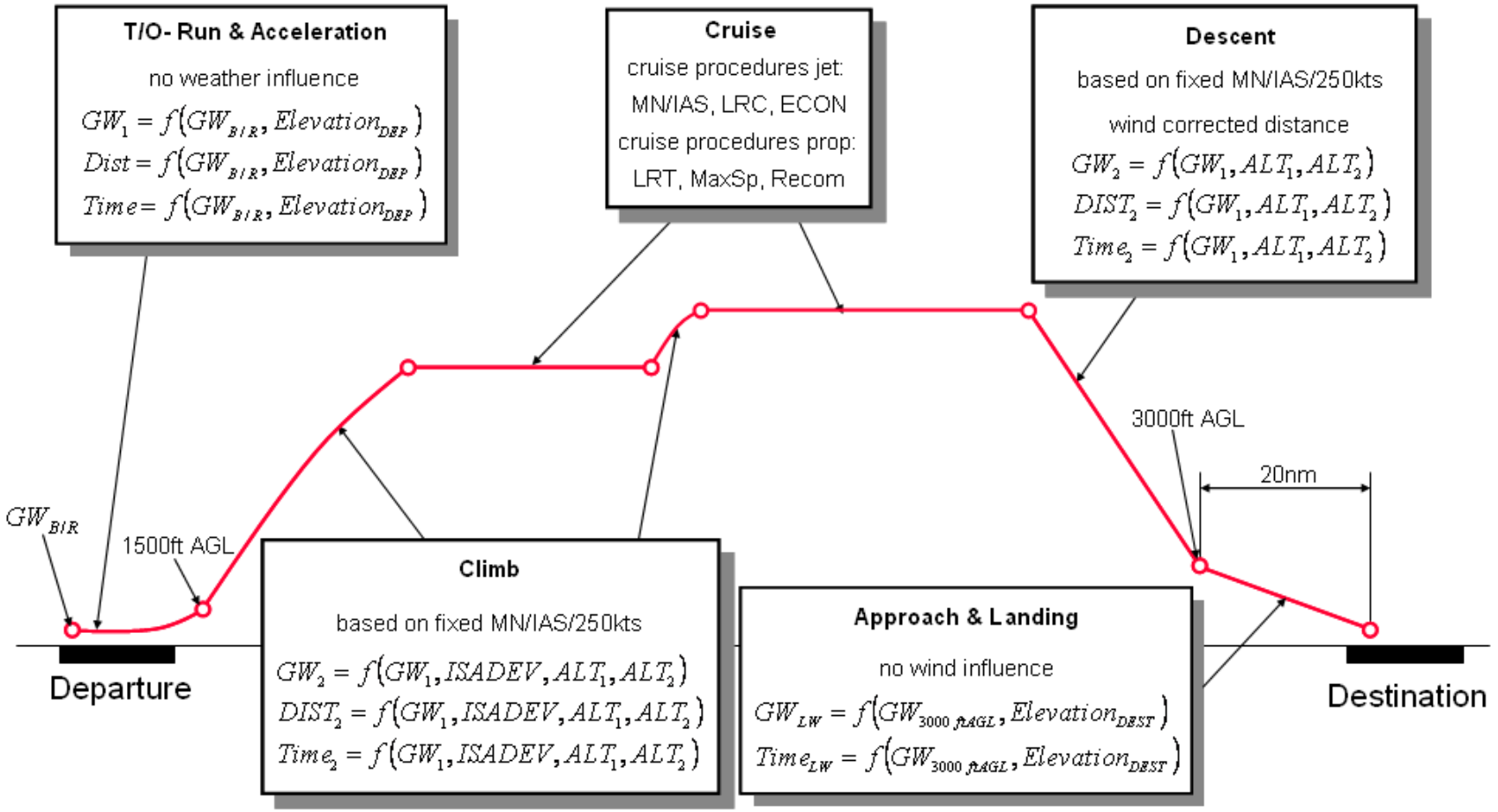
# Calculation phases departure - destination



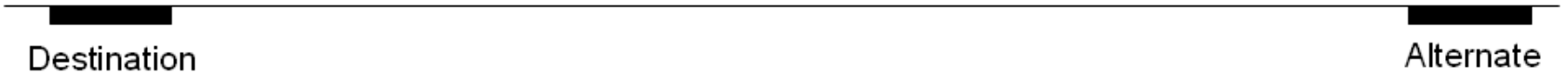
# Calculation phases departure - destination



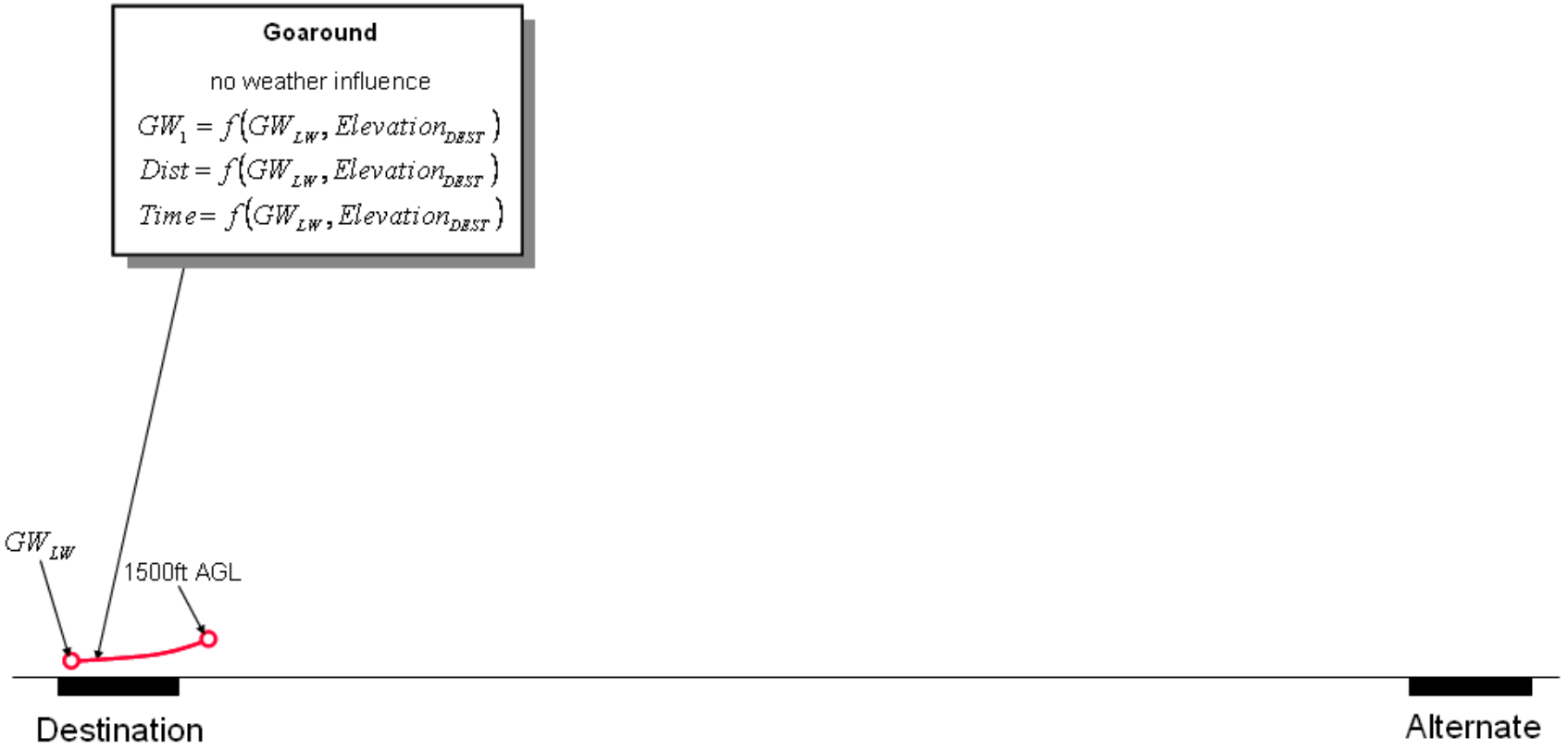
# Calculation phases departure - destination



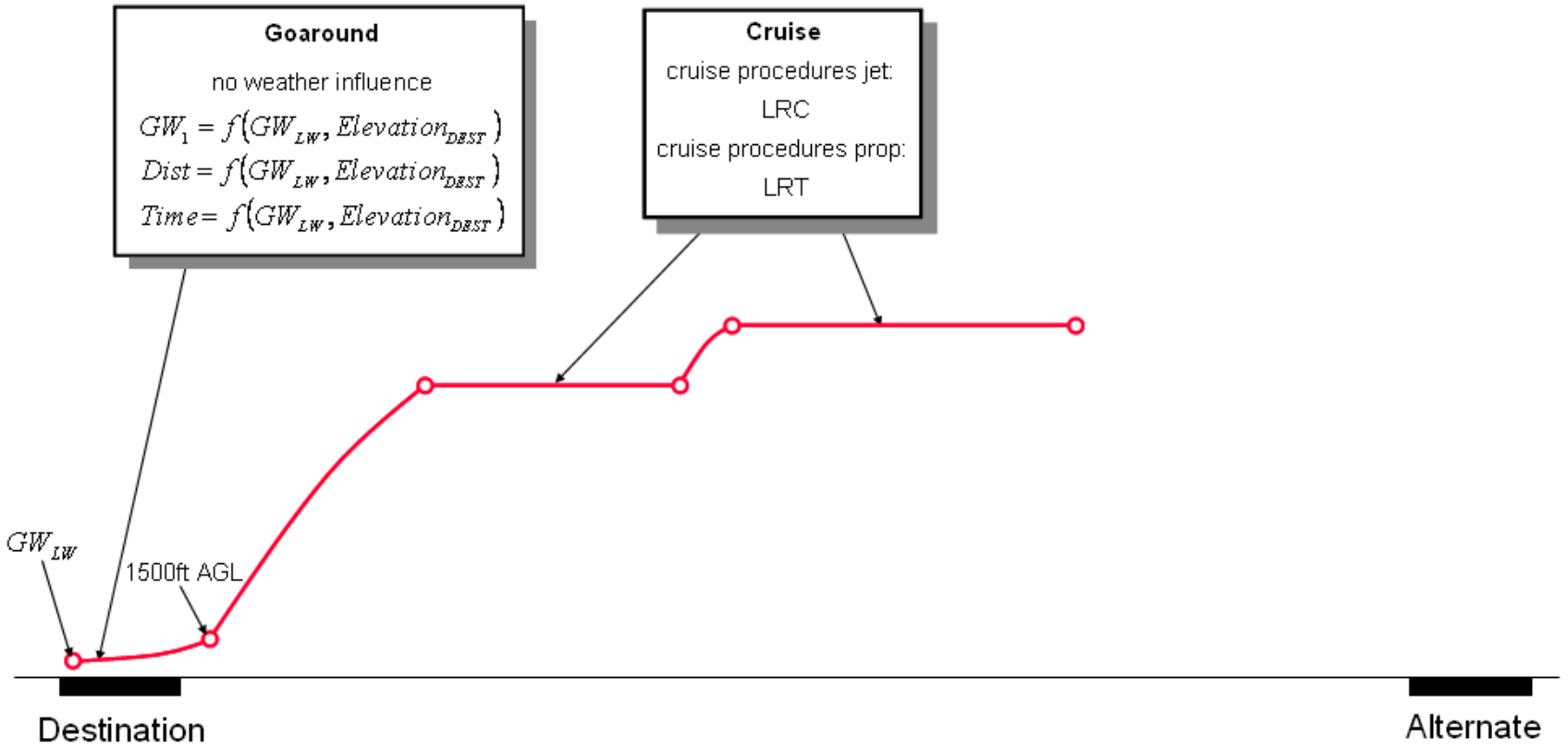
# Calculation phases destination - alternate



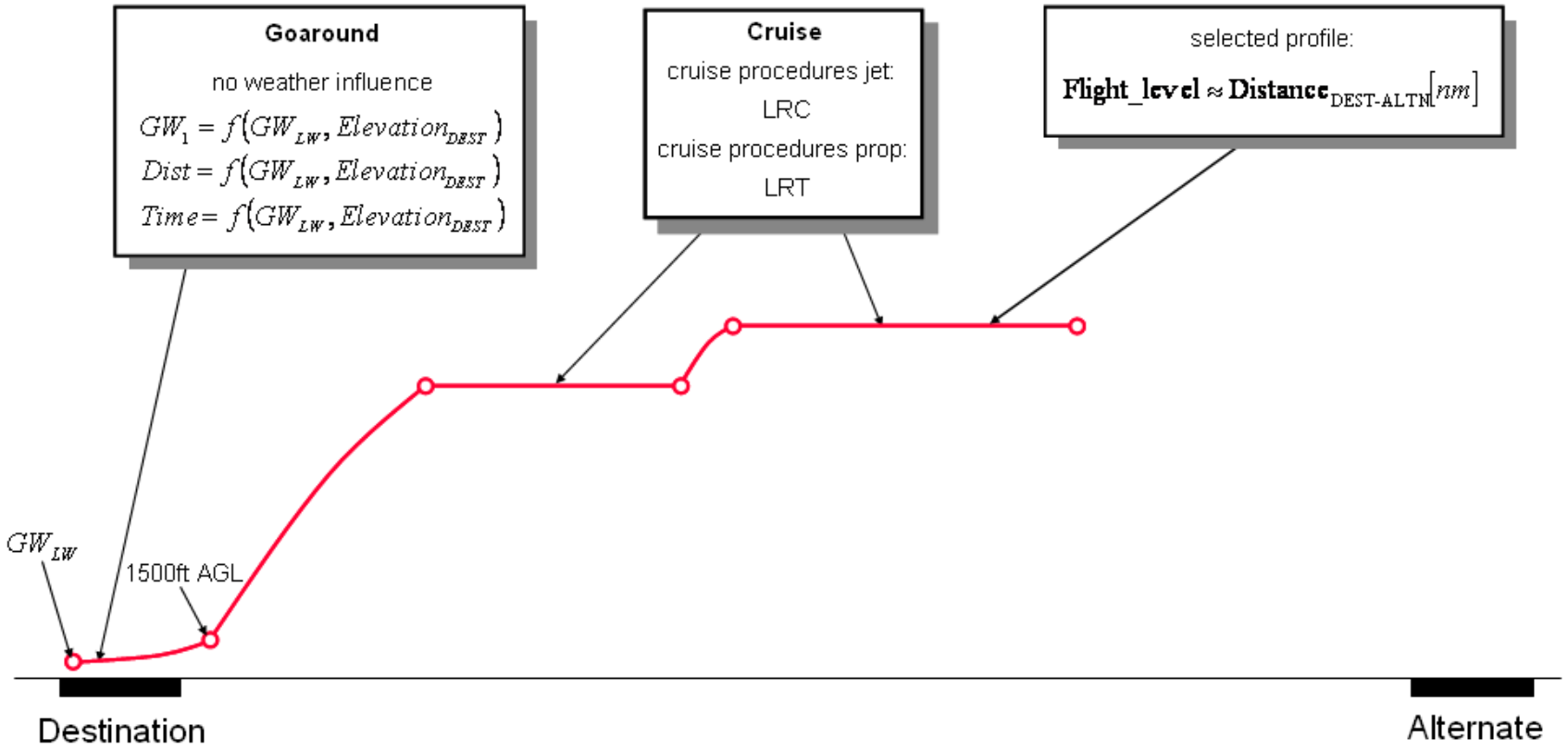
# Calculation phases destination - alternate



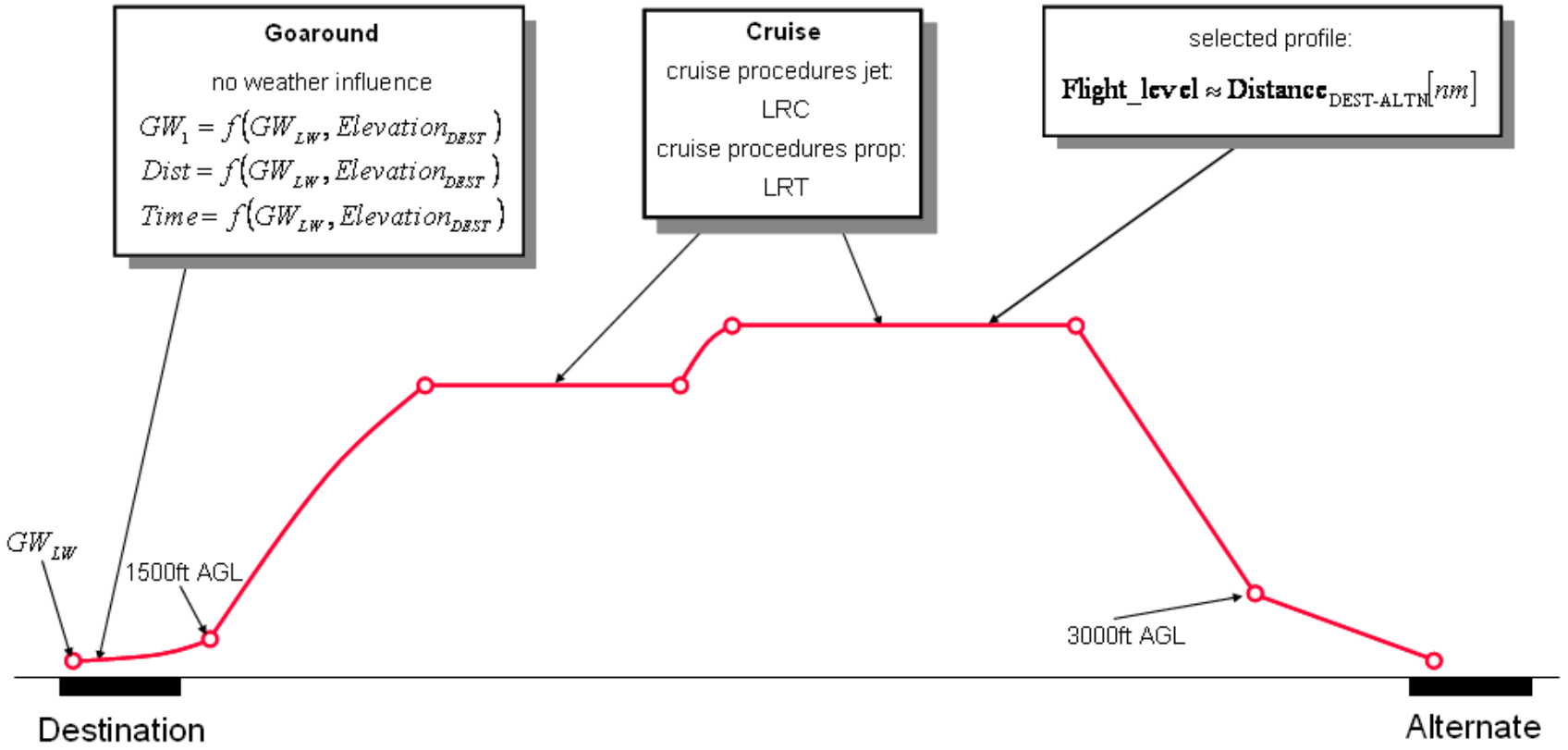
# Calculation phases destination - alternate



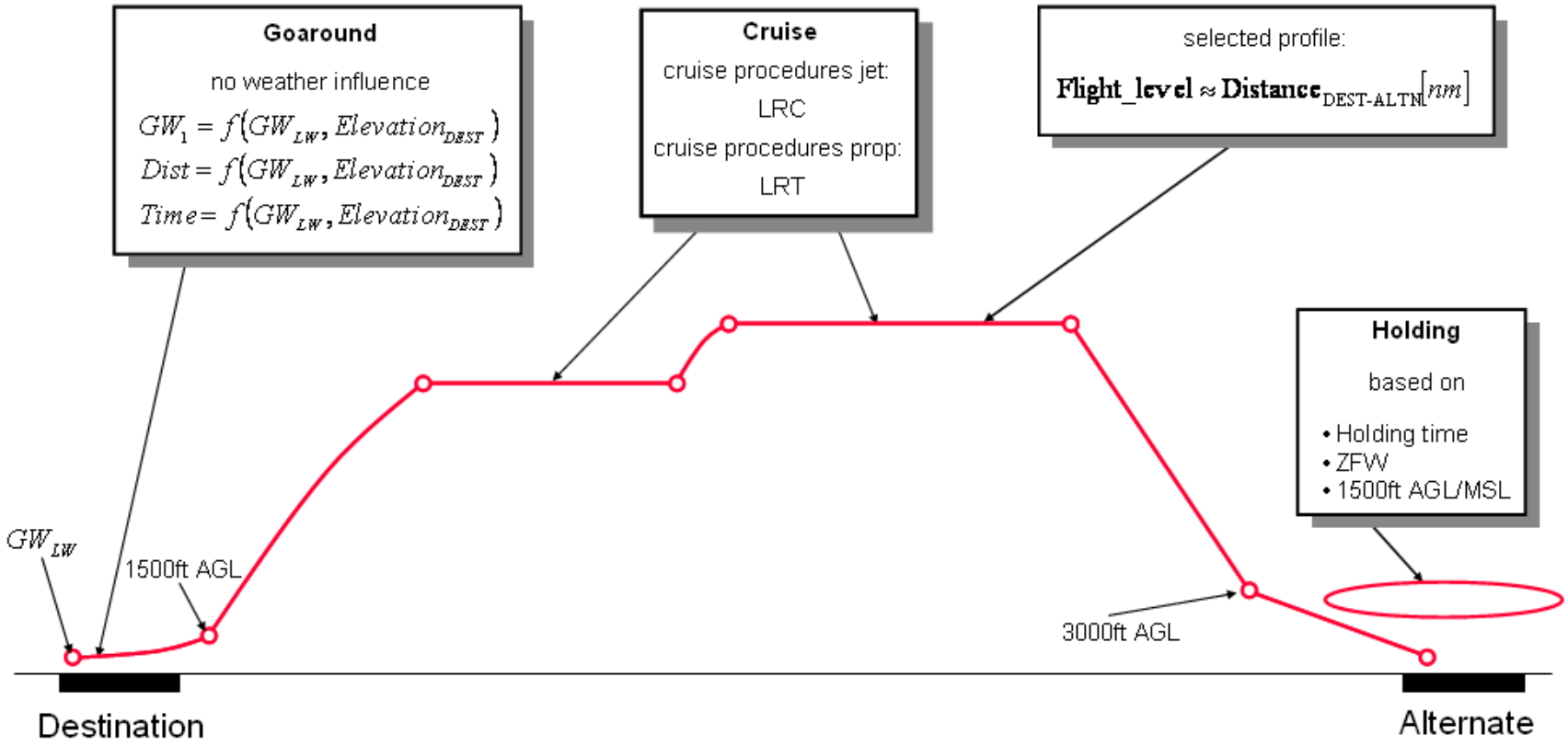
# Calculation phases destination - alternate



# Calculation phases destination - alternate

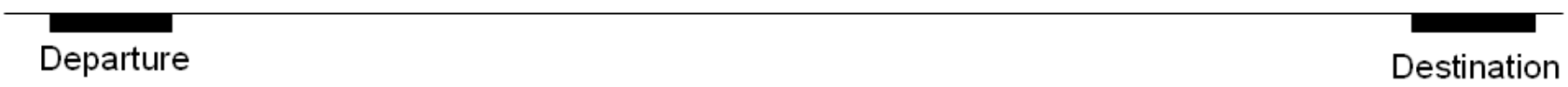


# Calculation phases destination - alternate

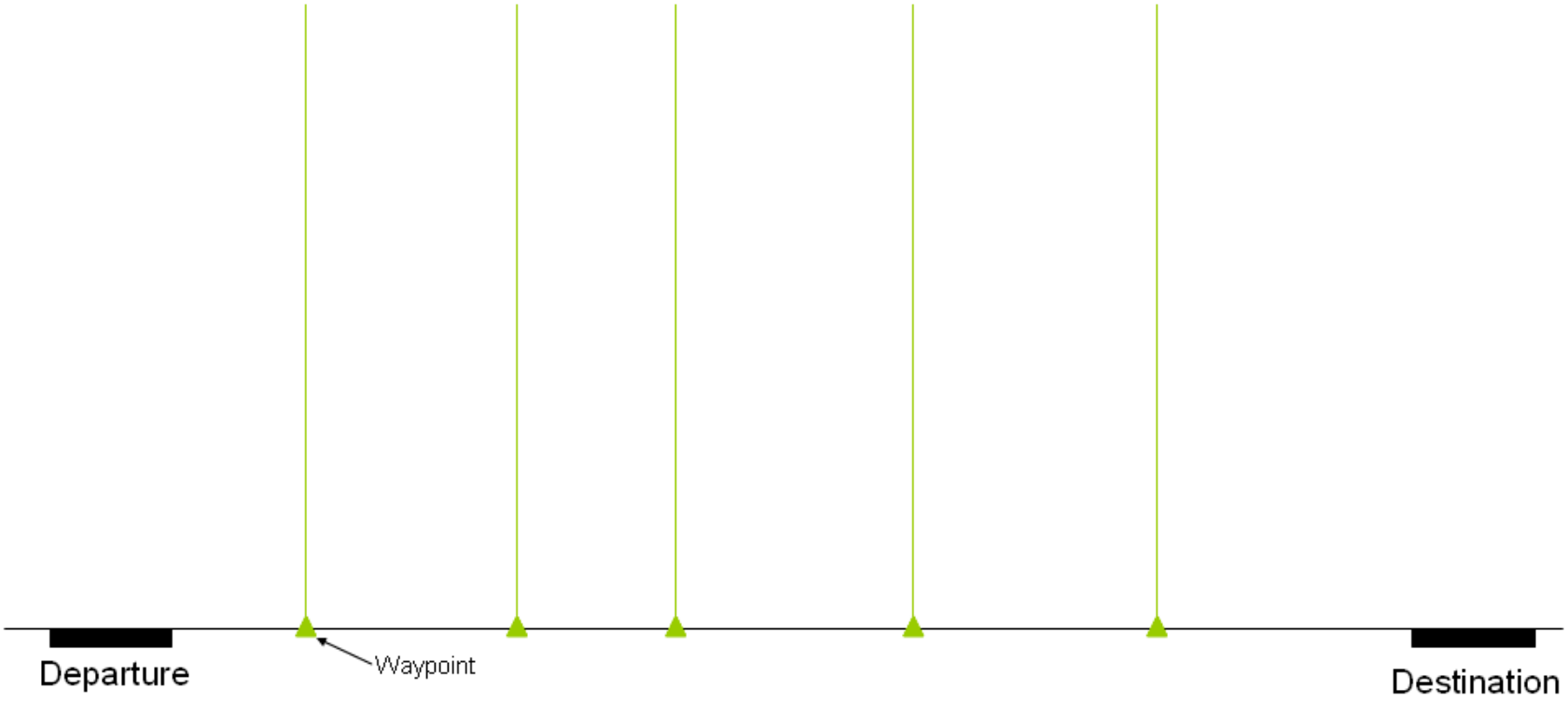


# Vertical optimization

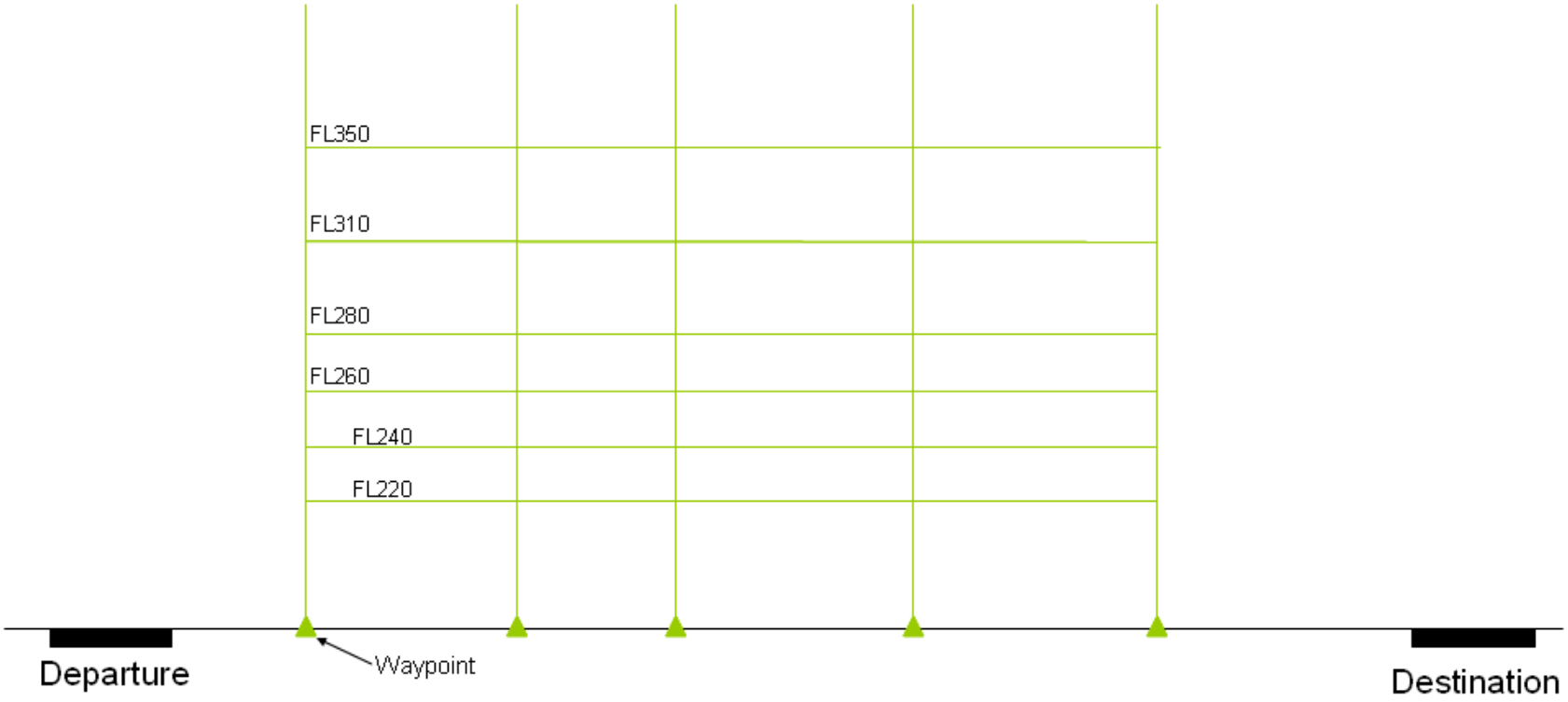
# Vertical optimization



# Vertical optimization



# Vertical optimization



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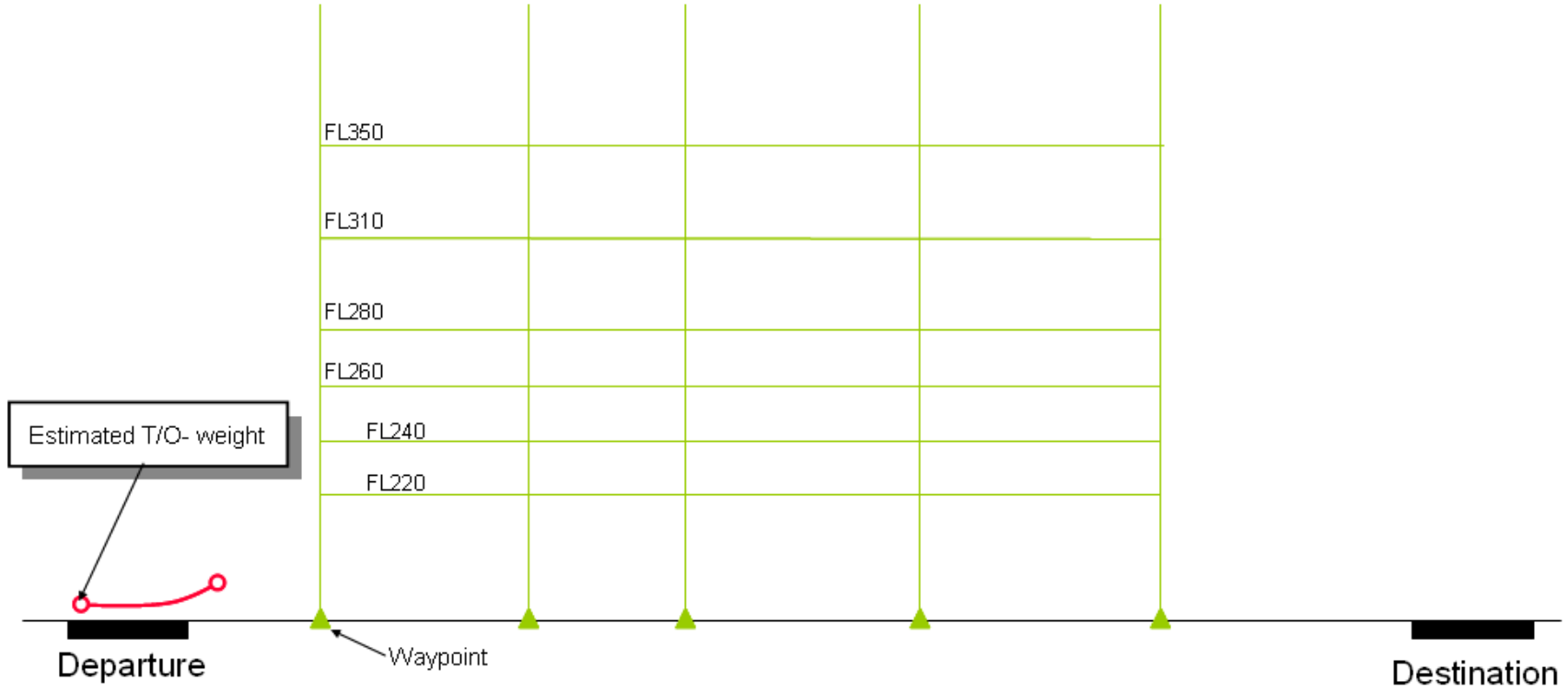

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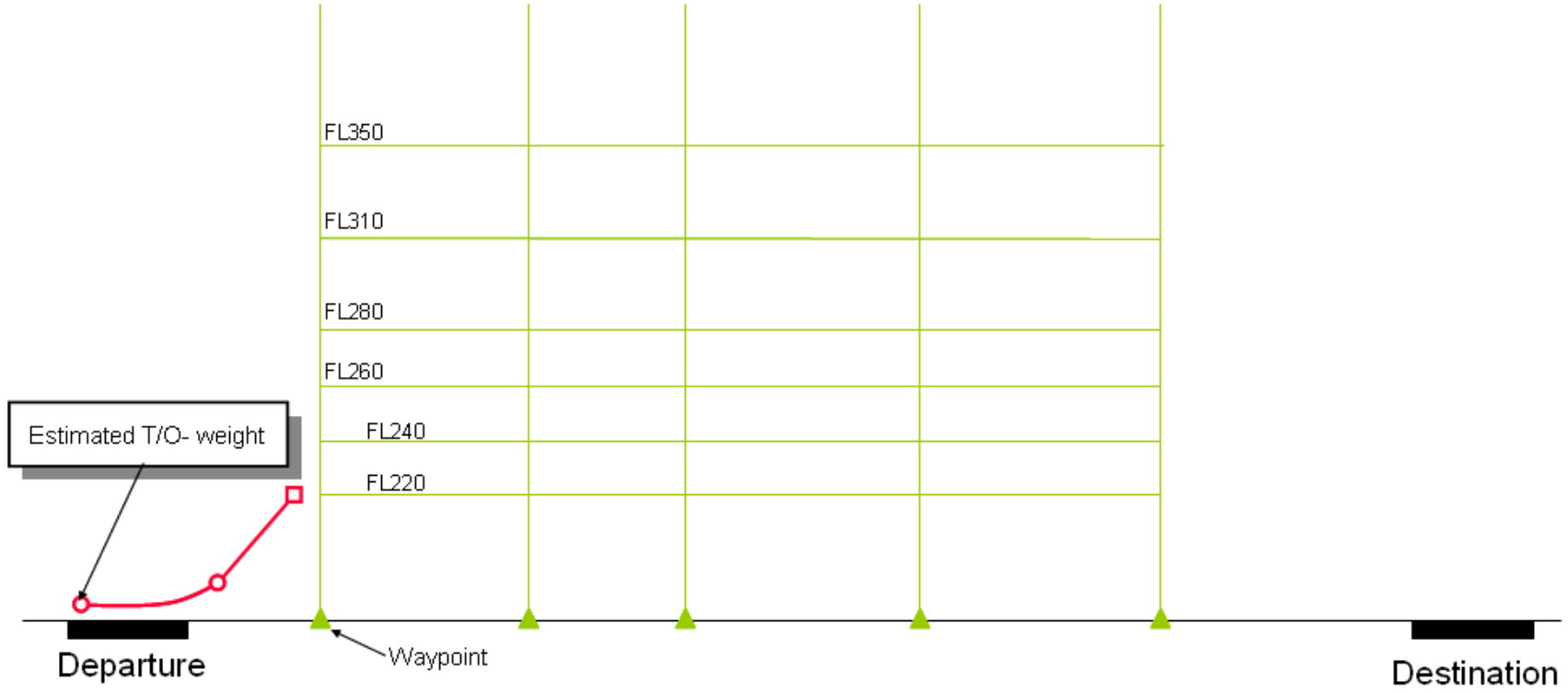

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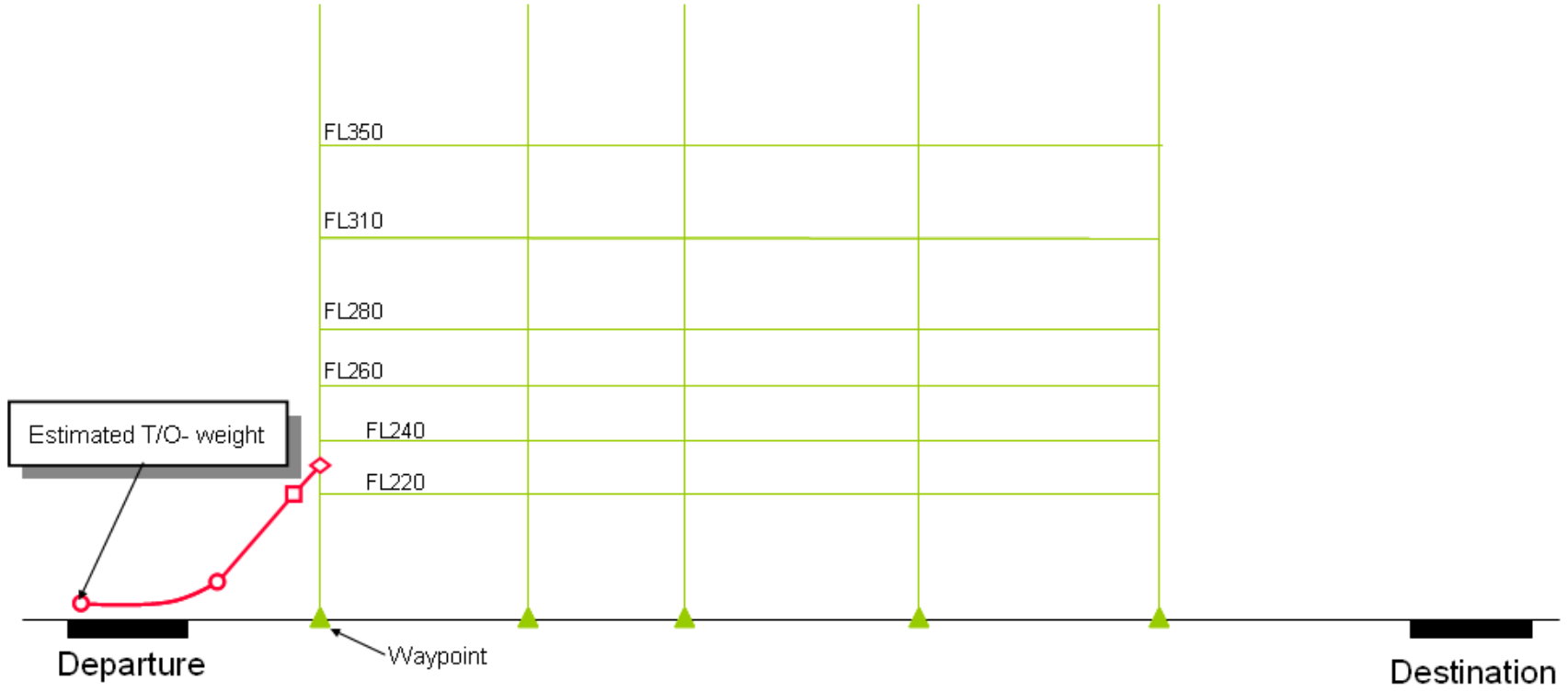

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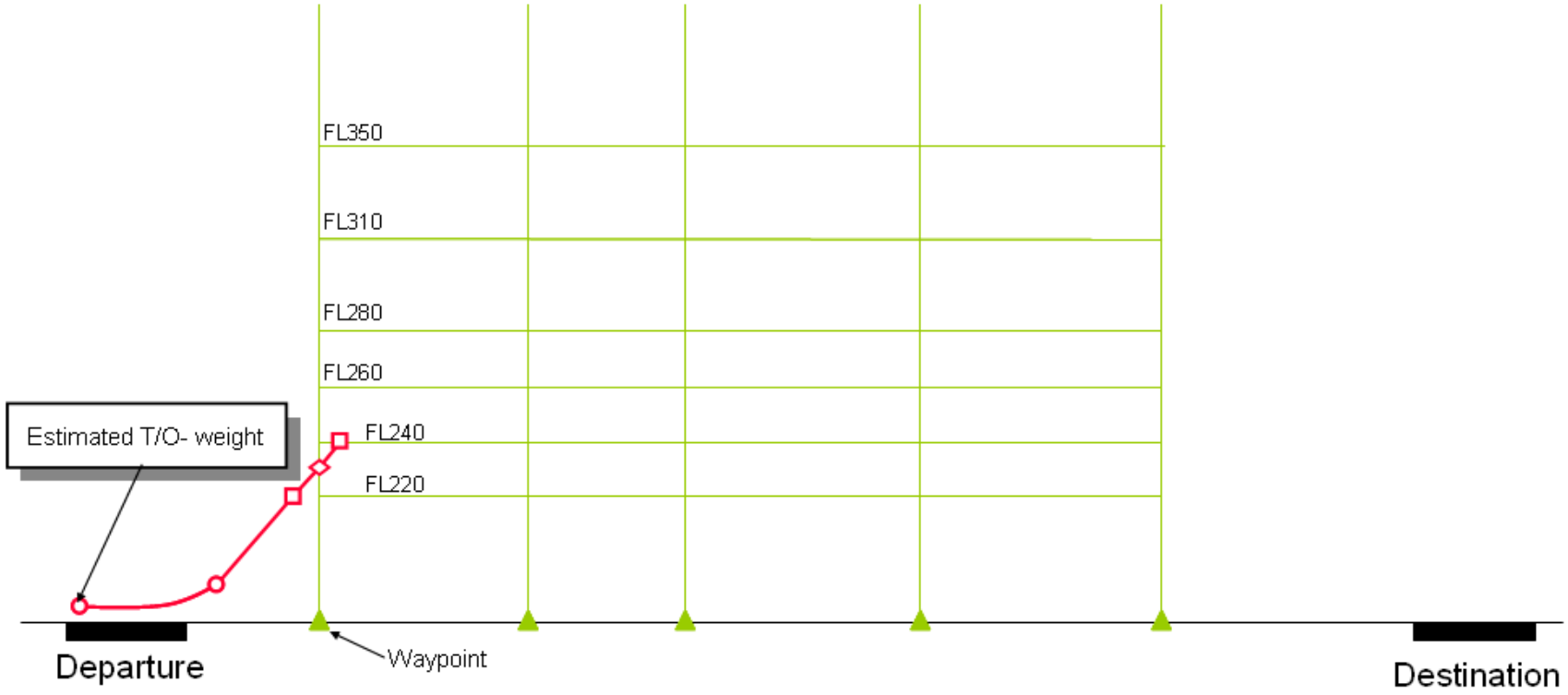

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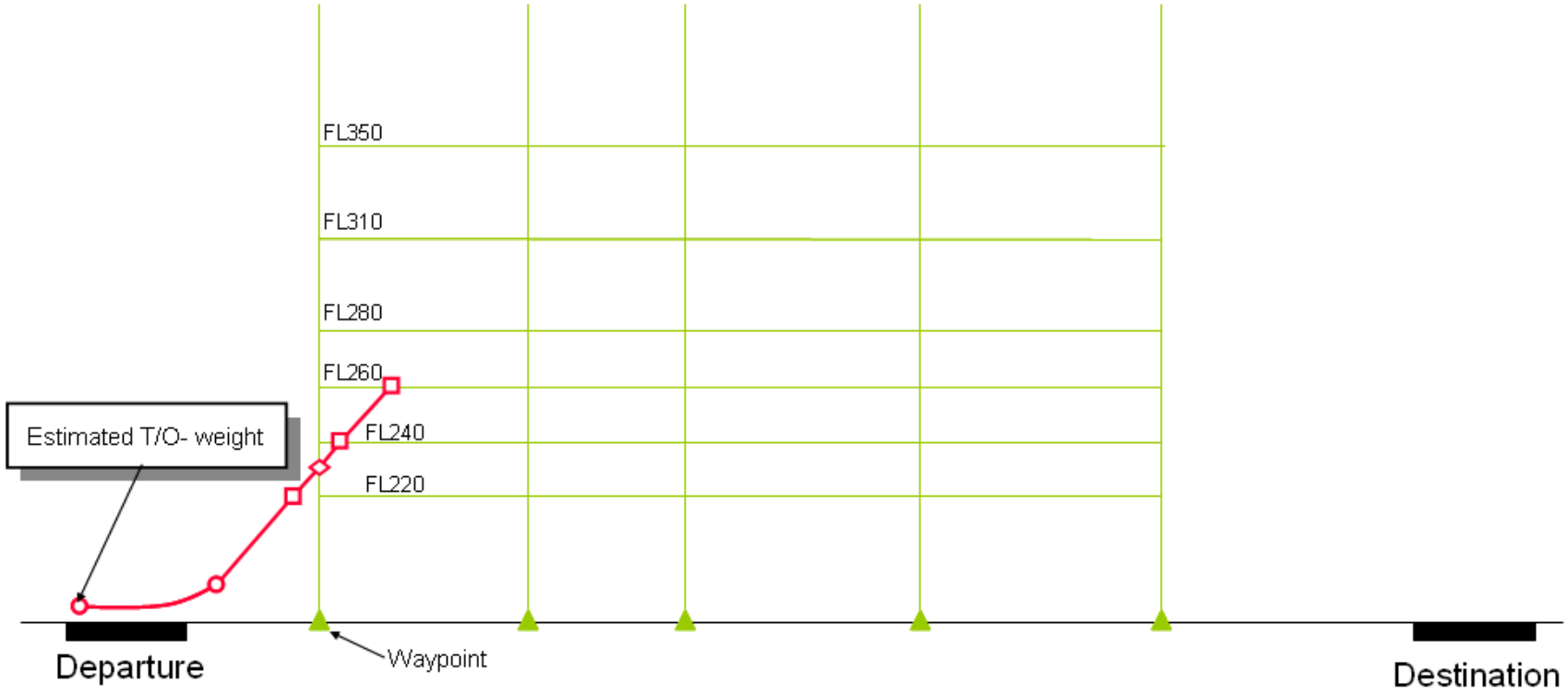
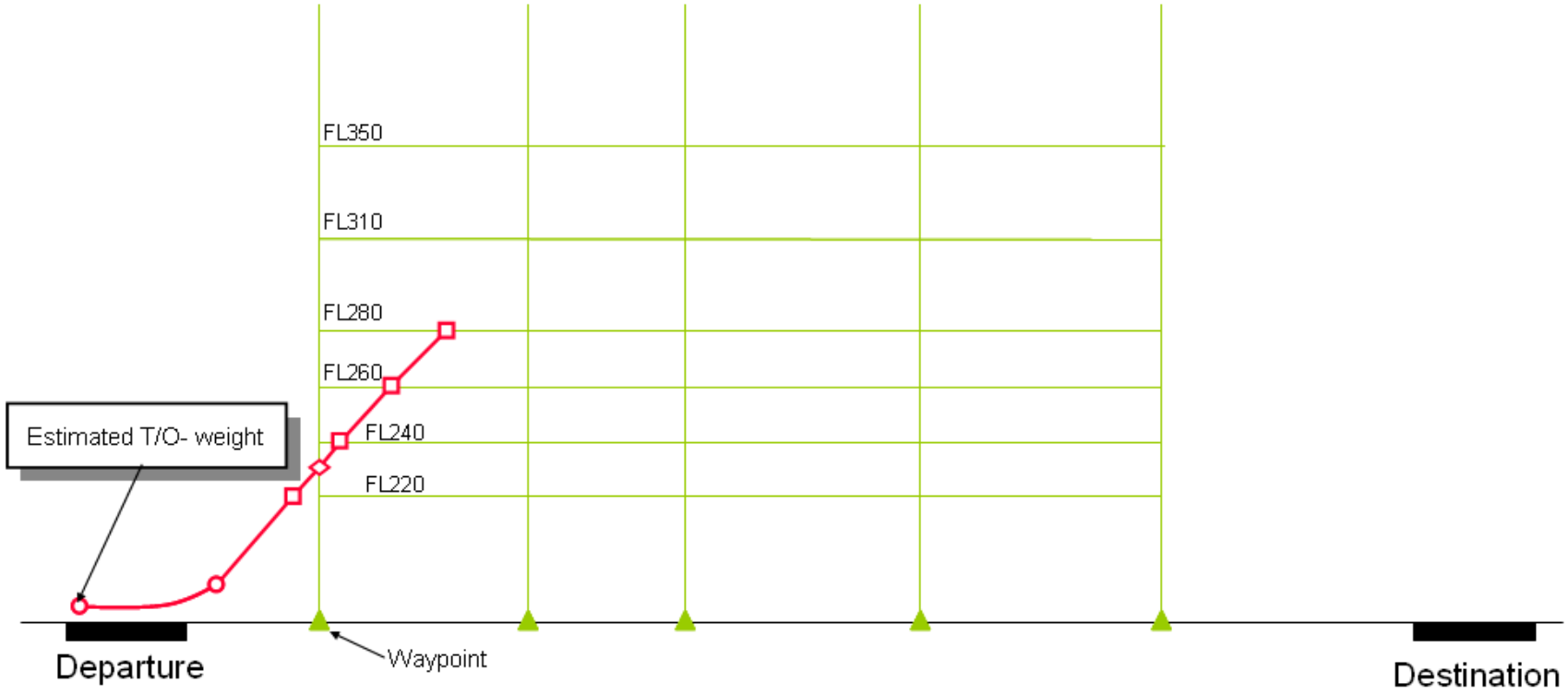
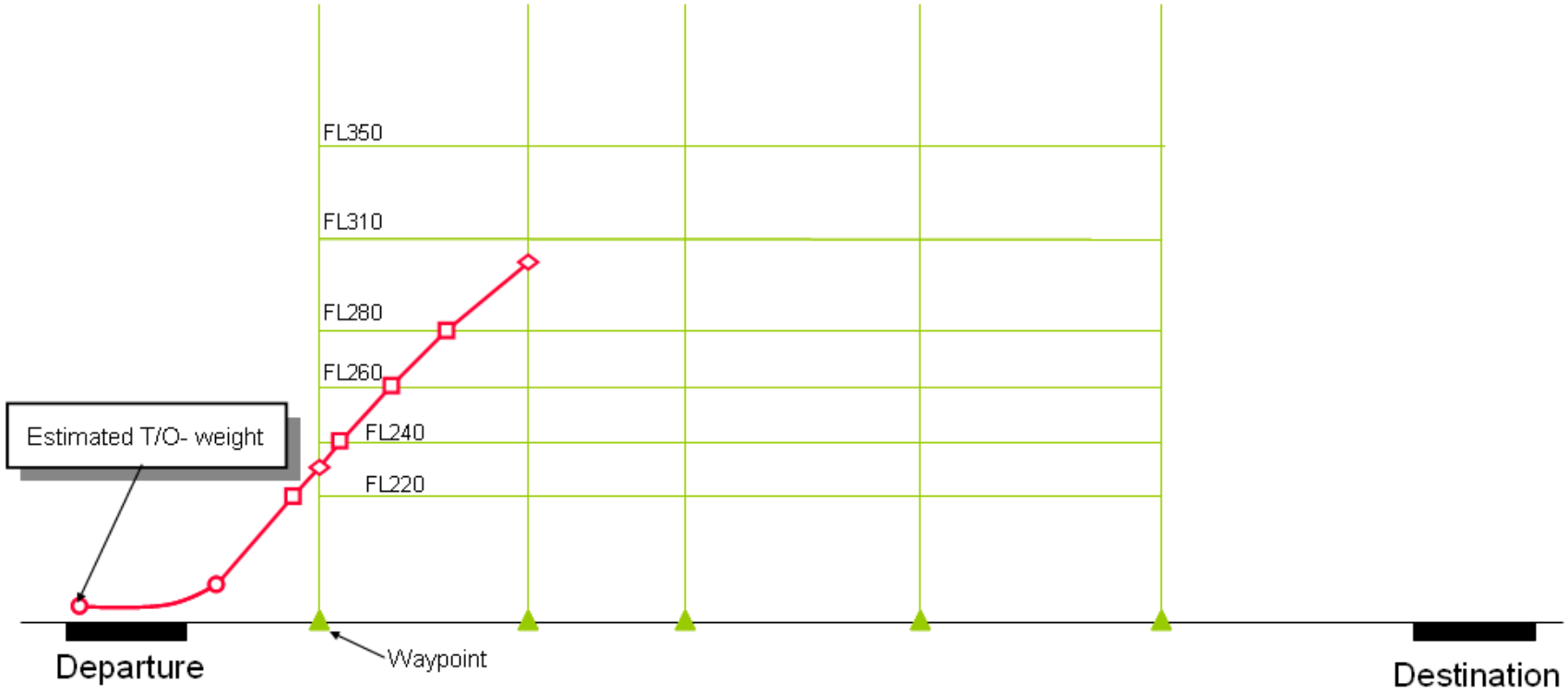


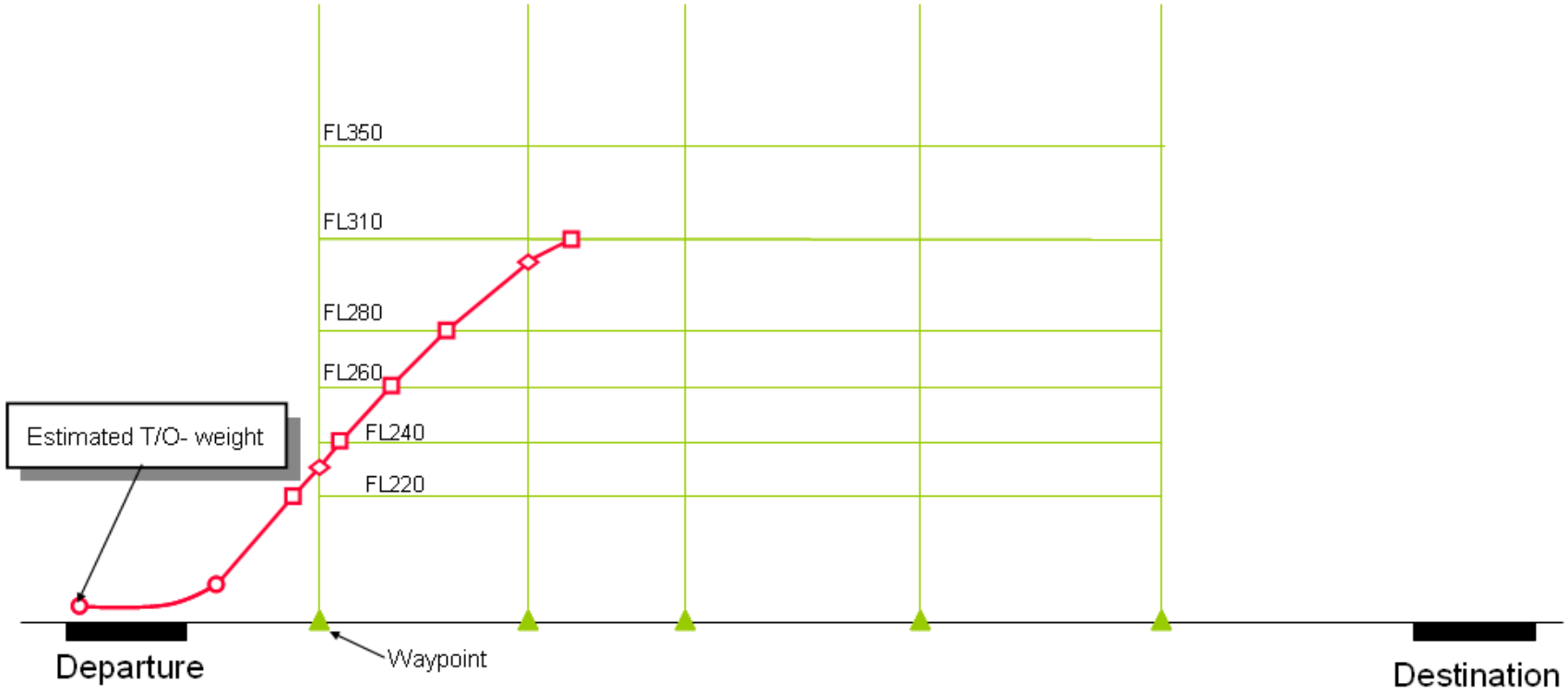
# Vertical optimization



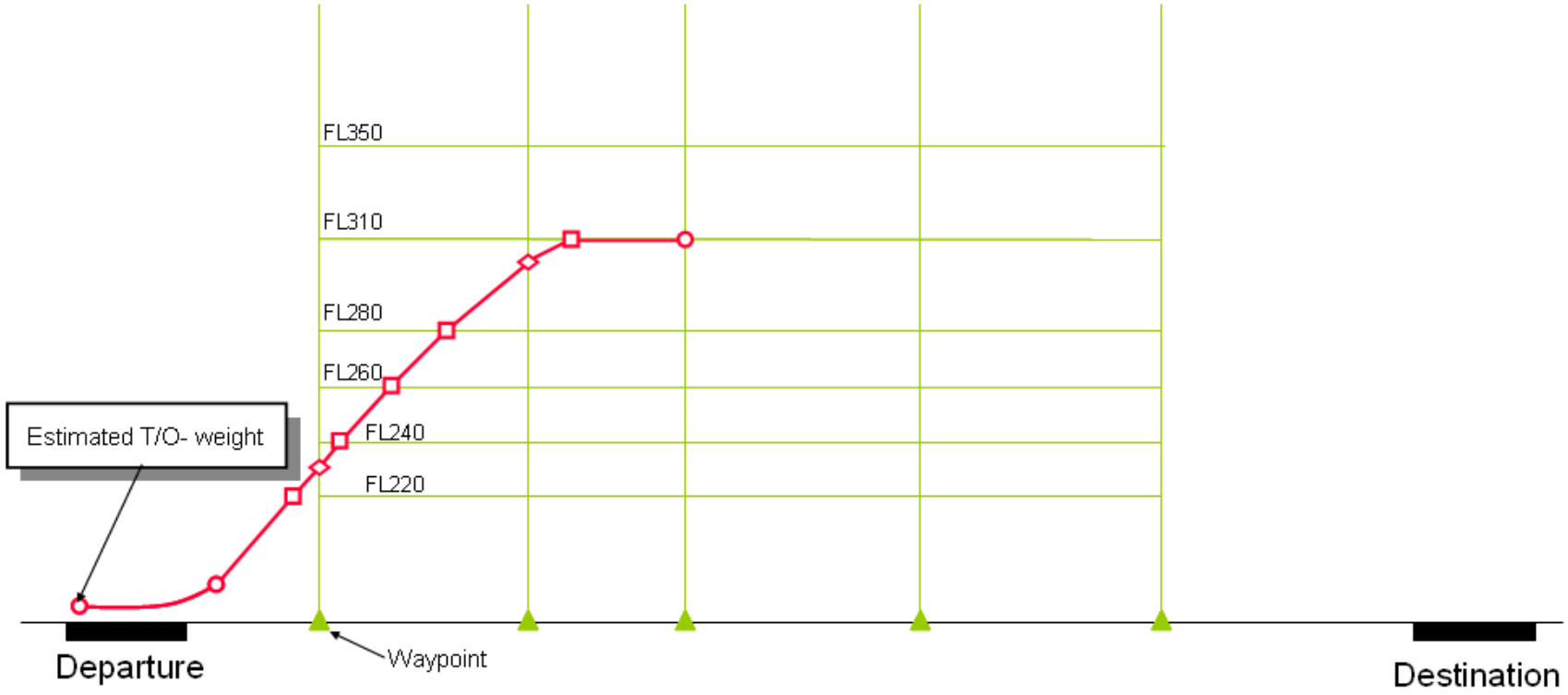
# Vertical optimization



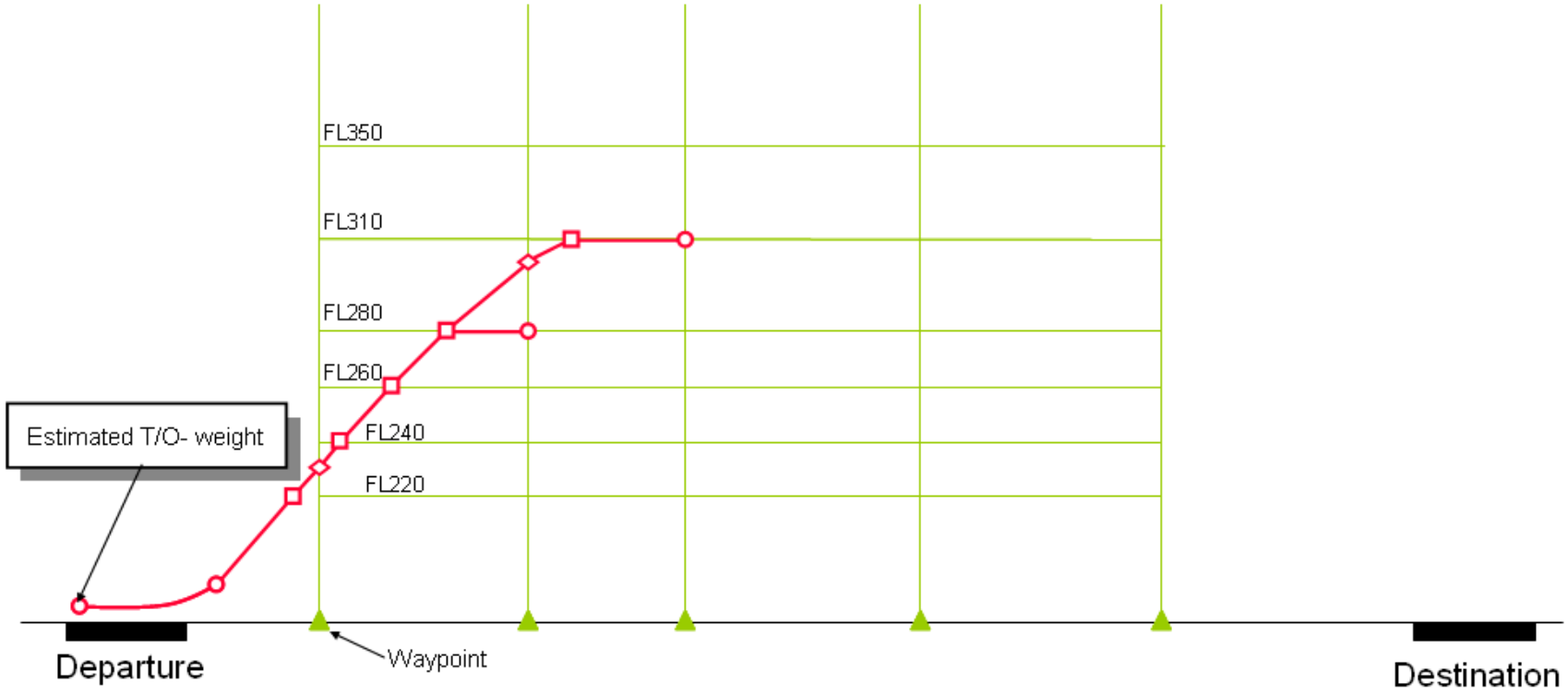
# Vertical optimization



# Vertical optimization



# Vertical optimization



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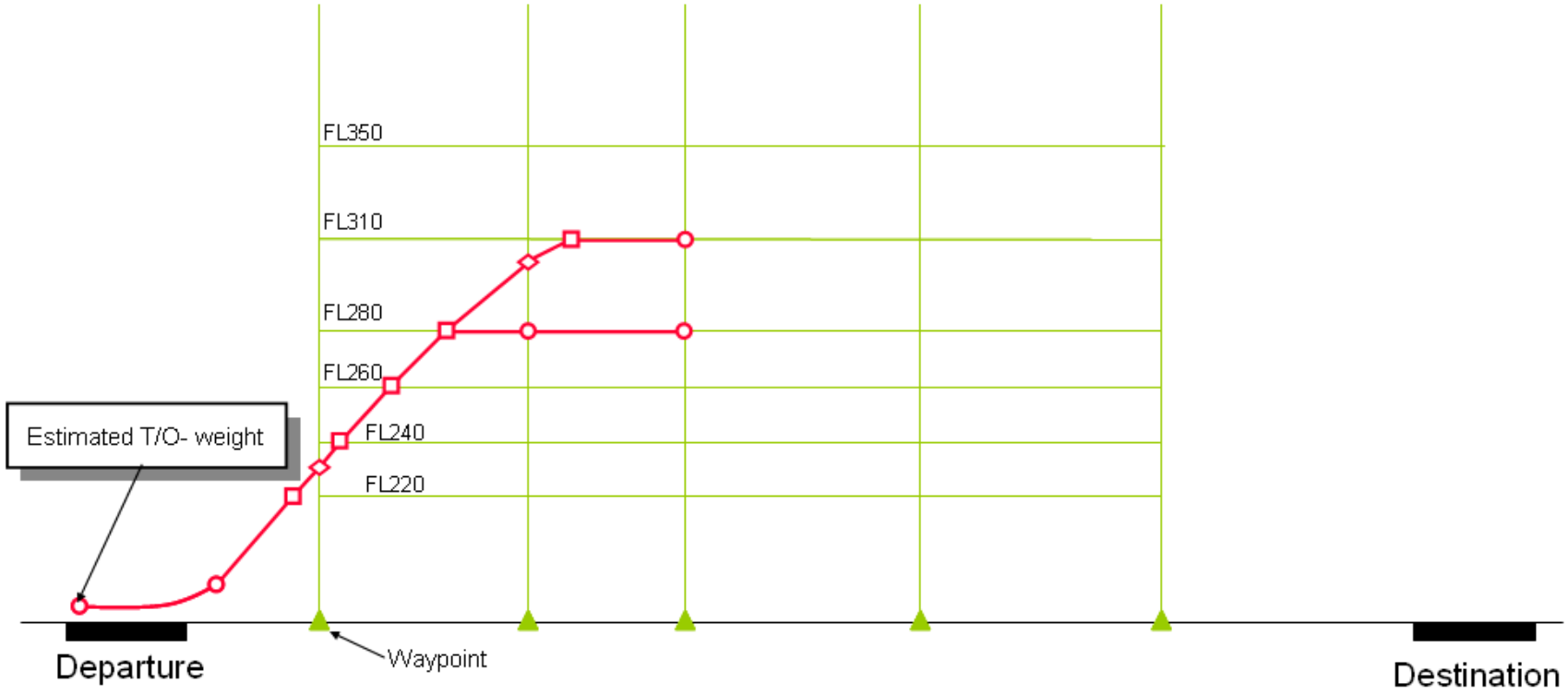

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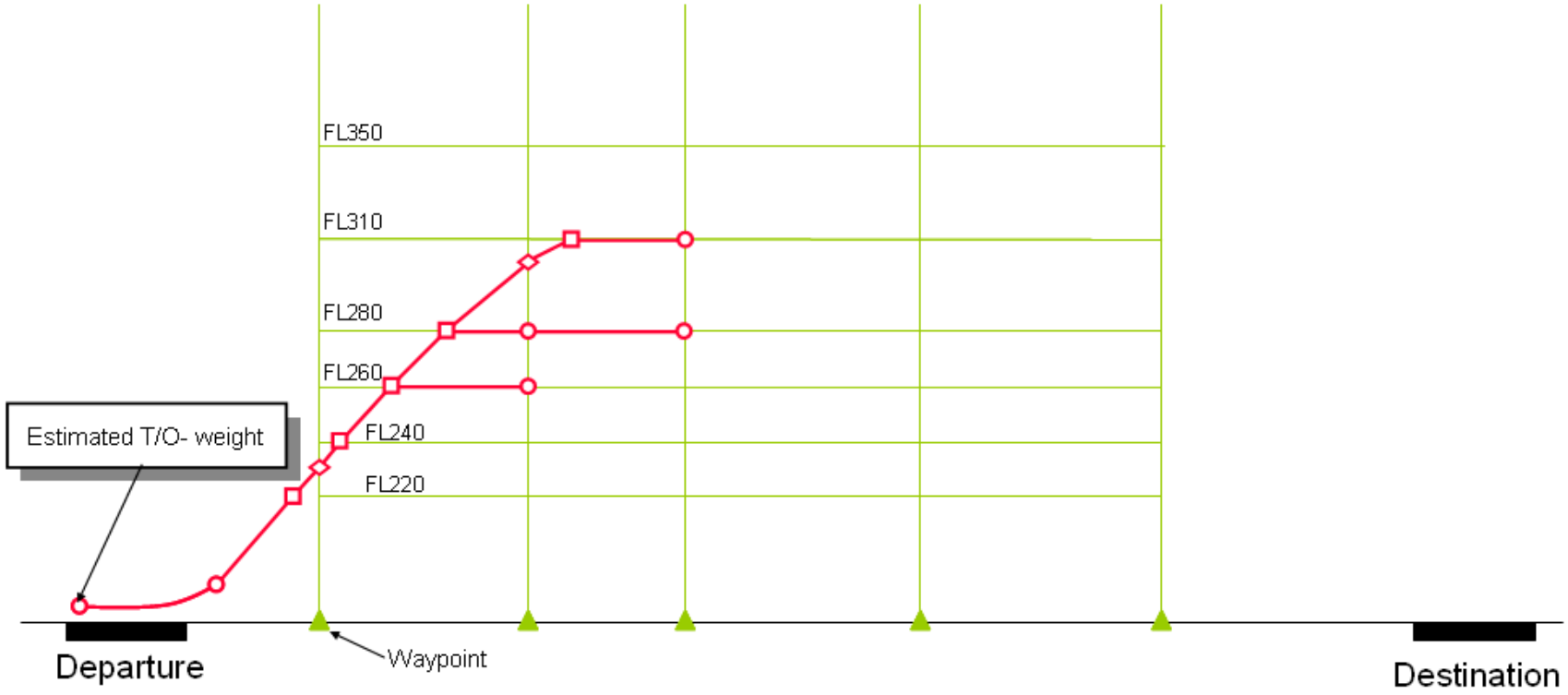

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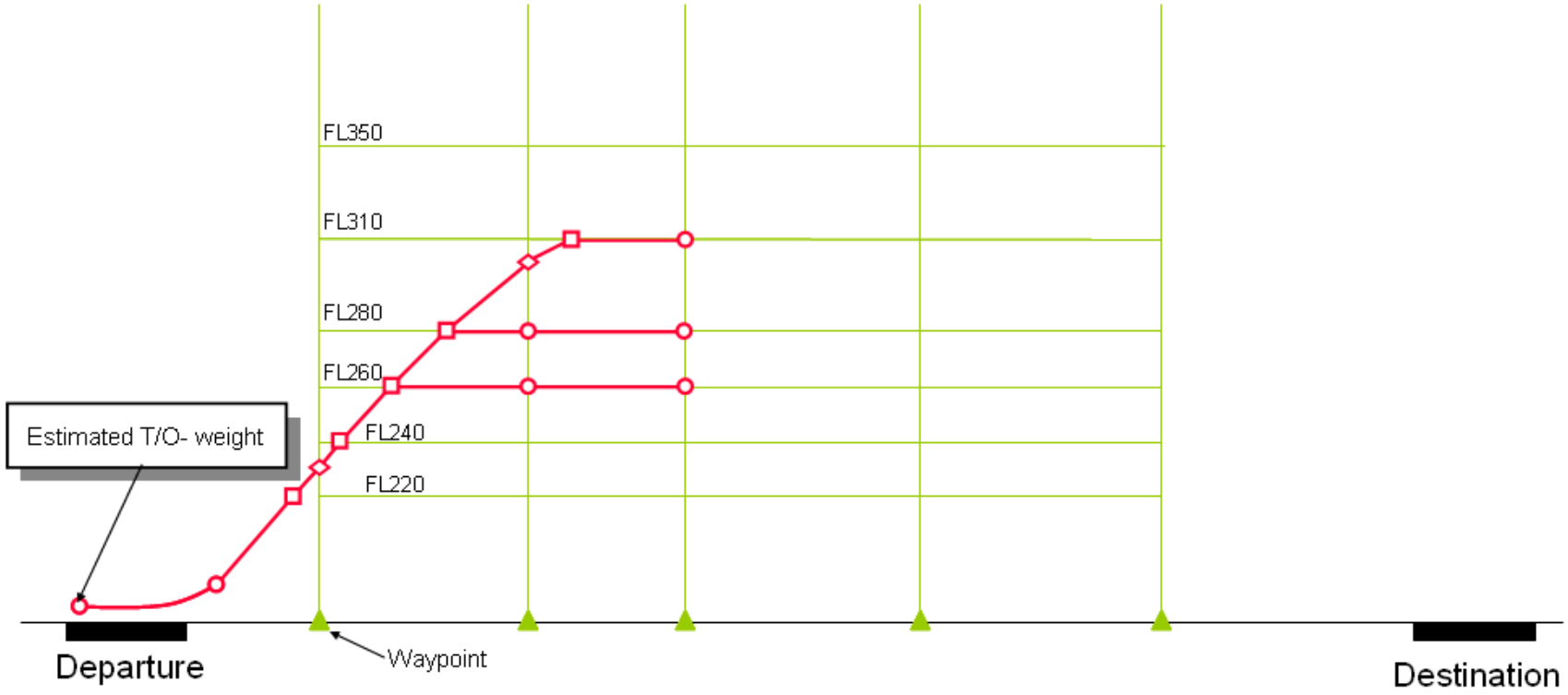
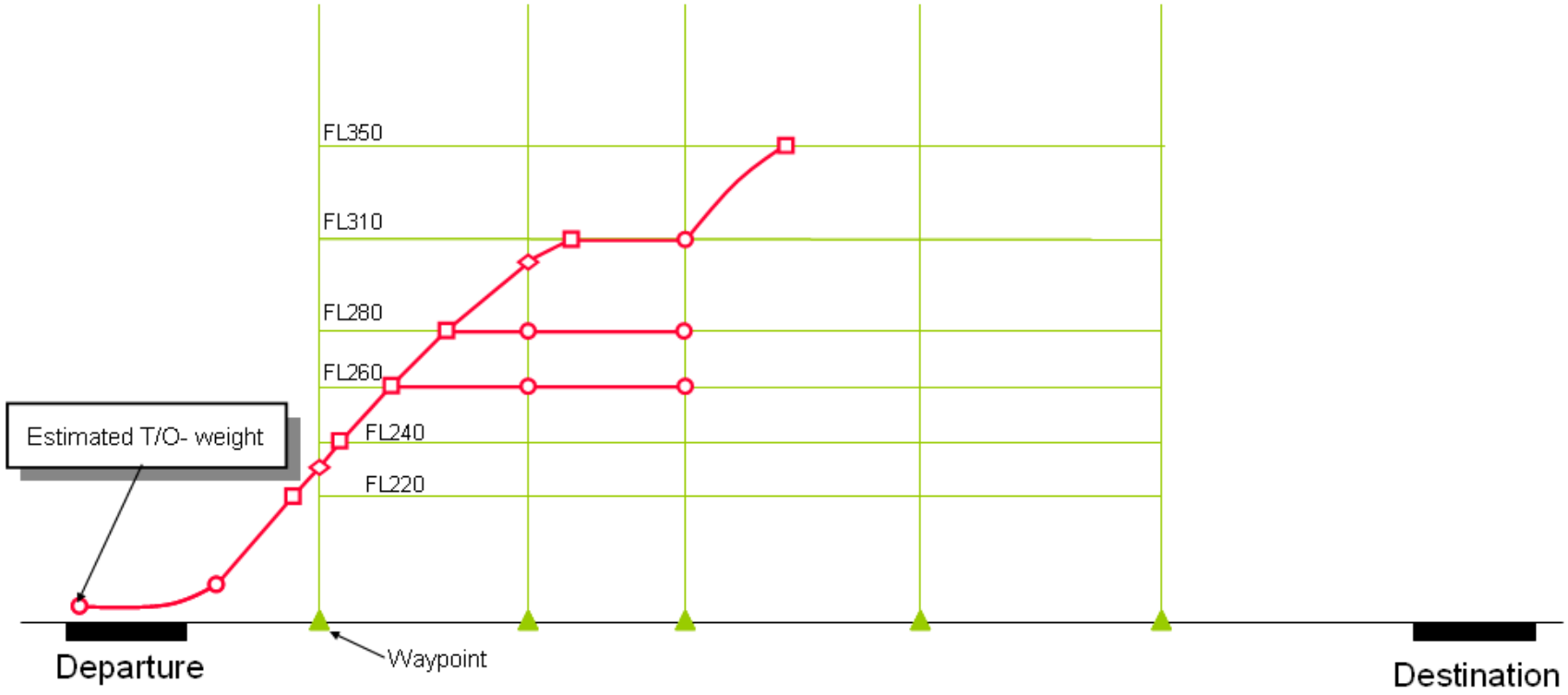
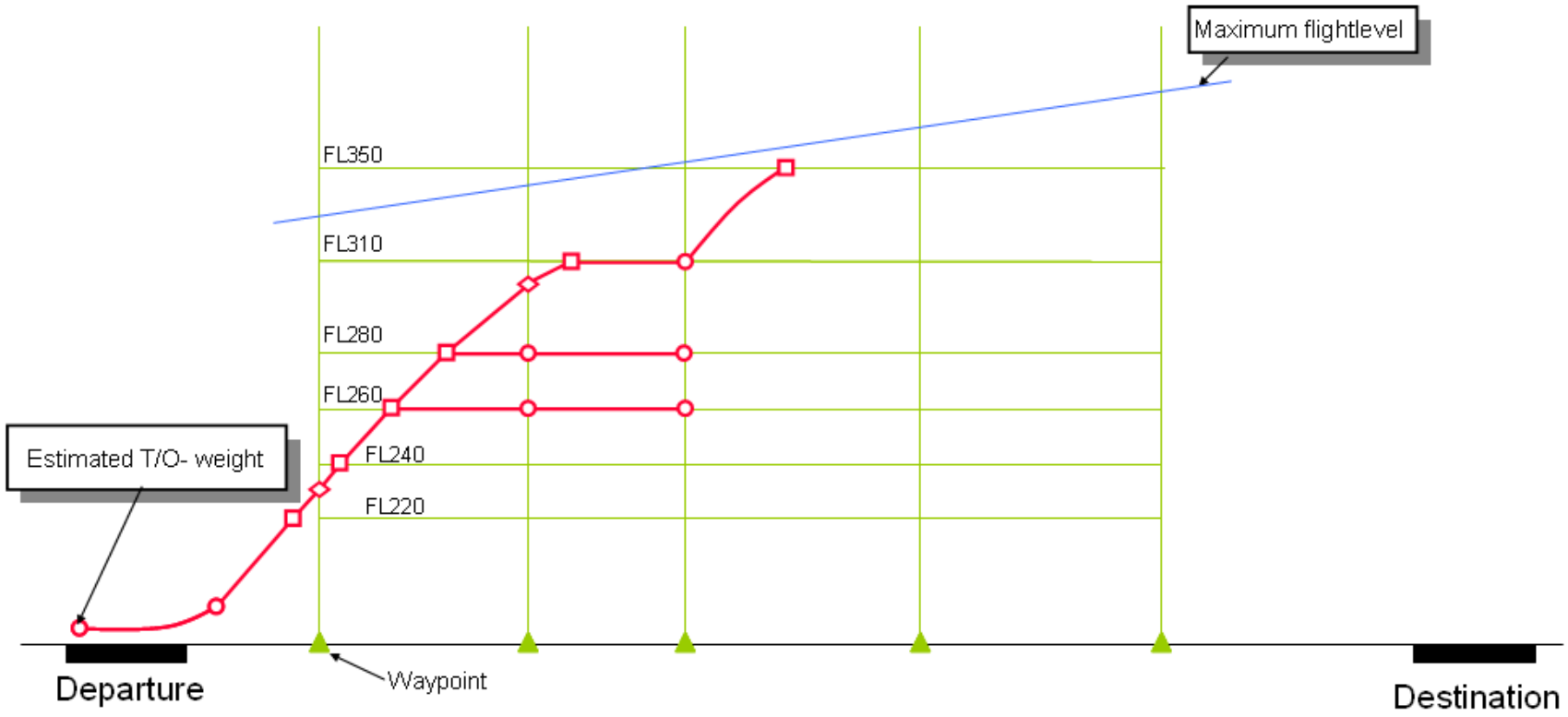


# Vertical optimization



# Vertical optimization



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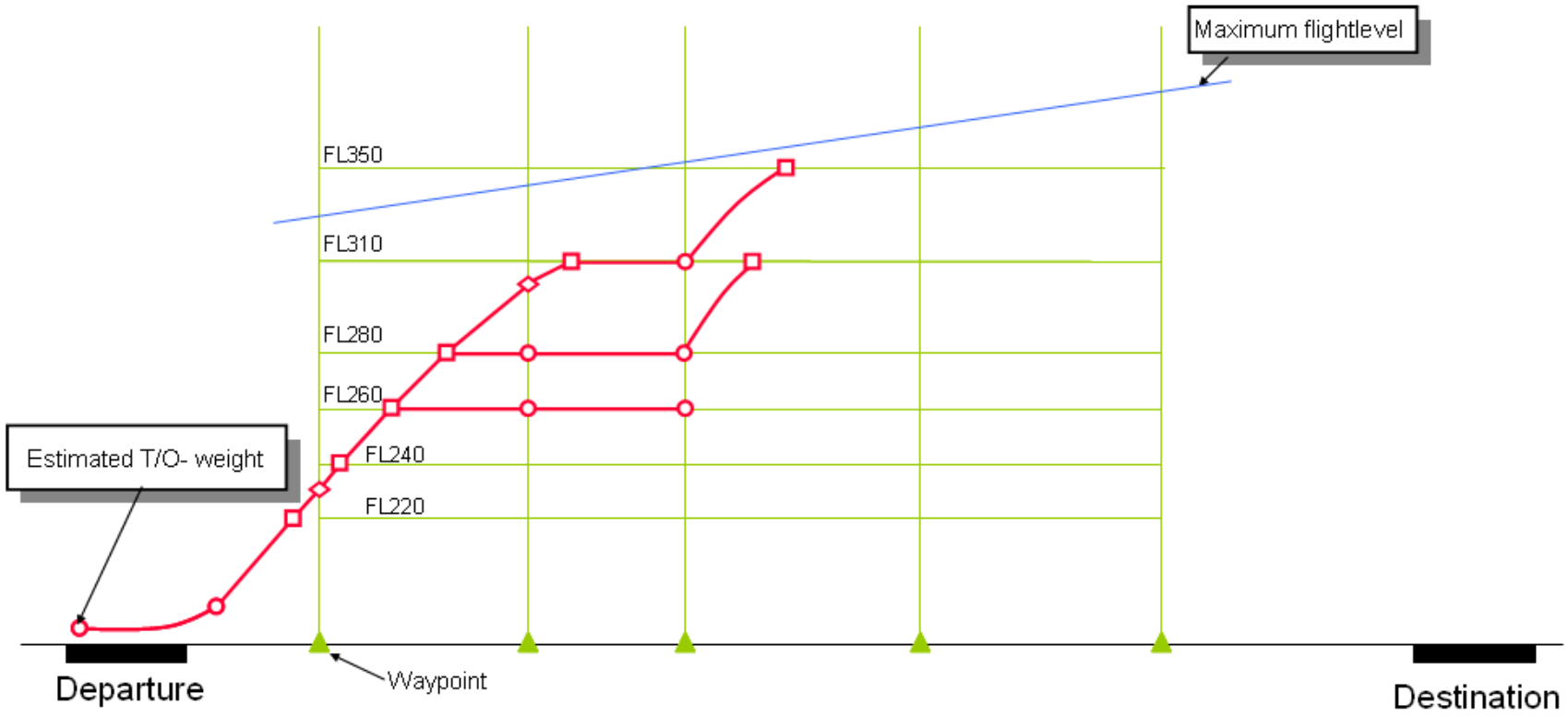
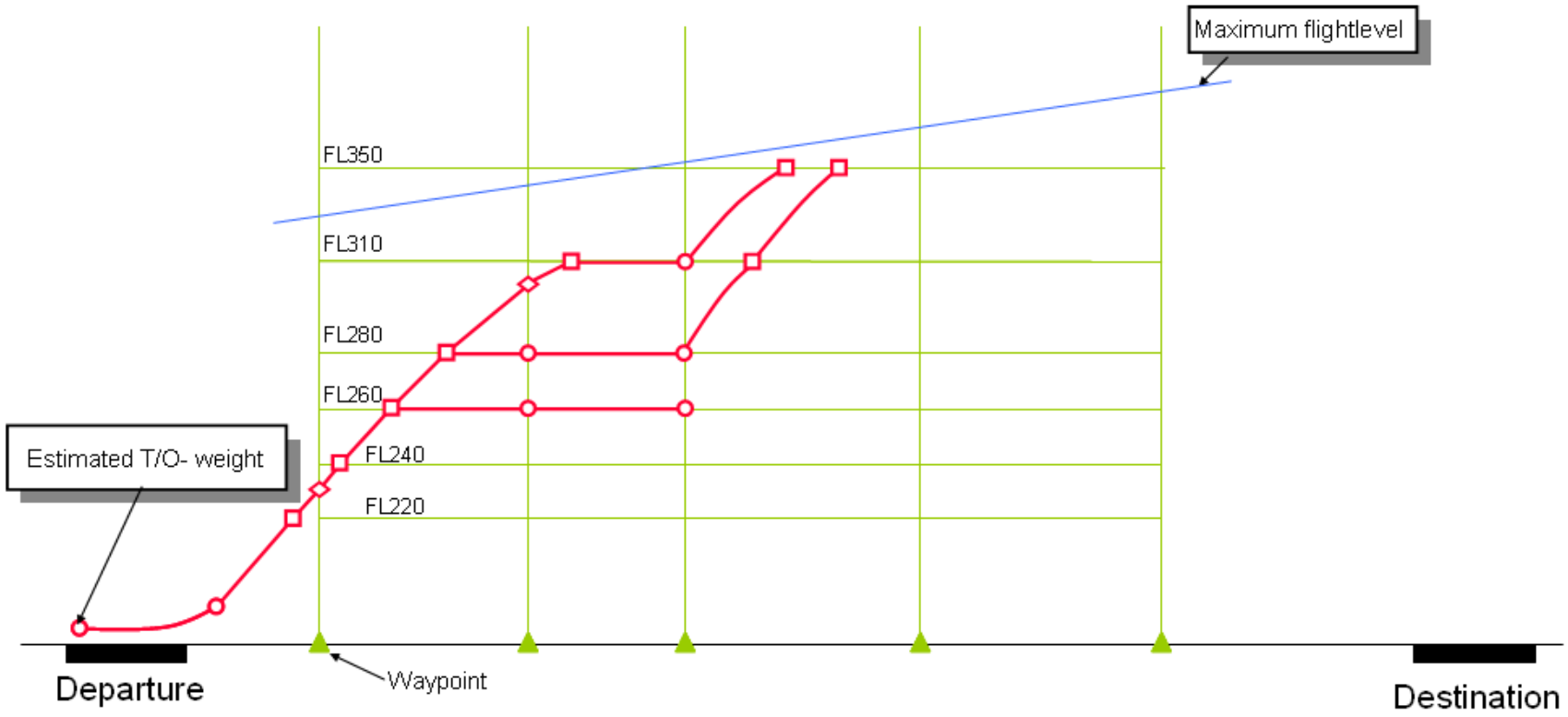


# Vertical optimization



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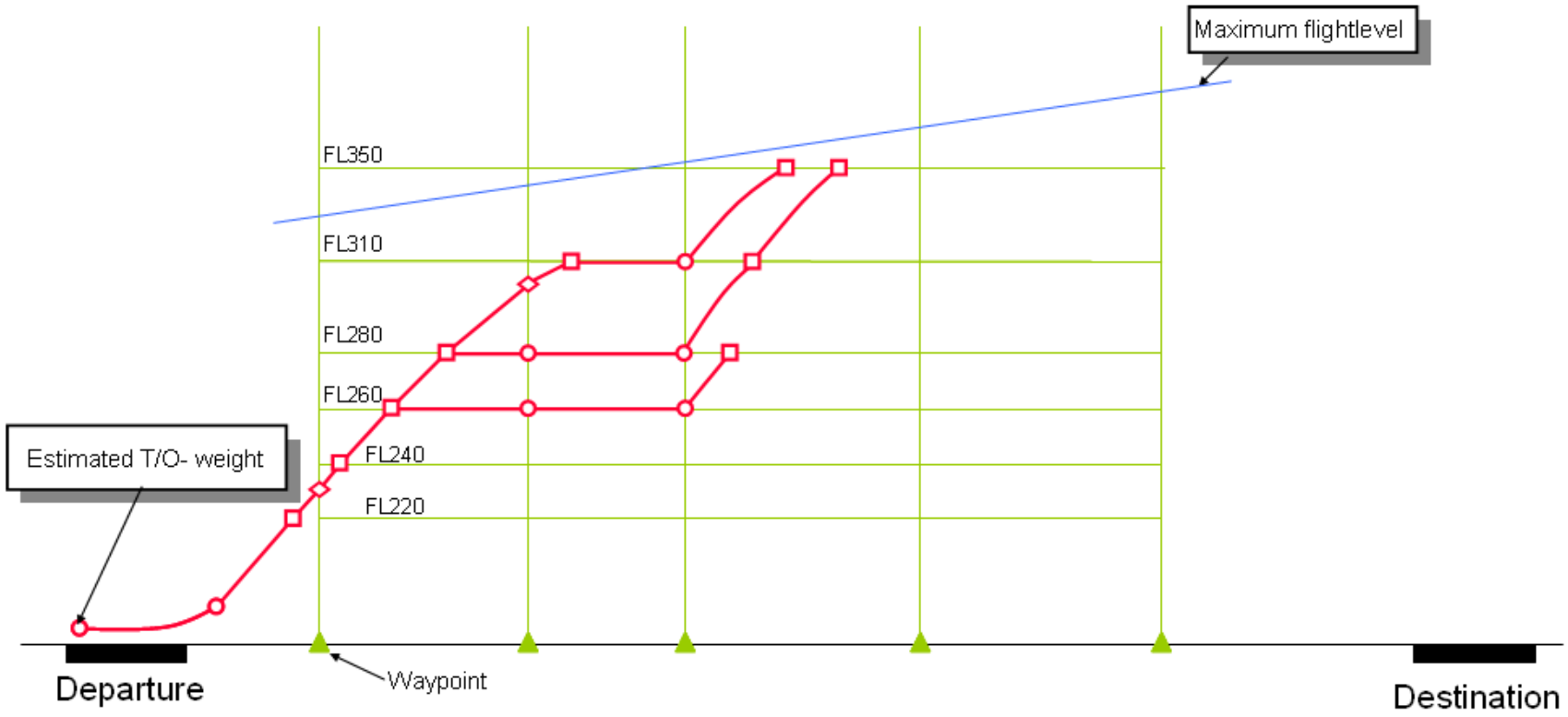

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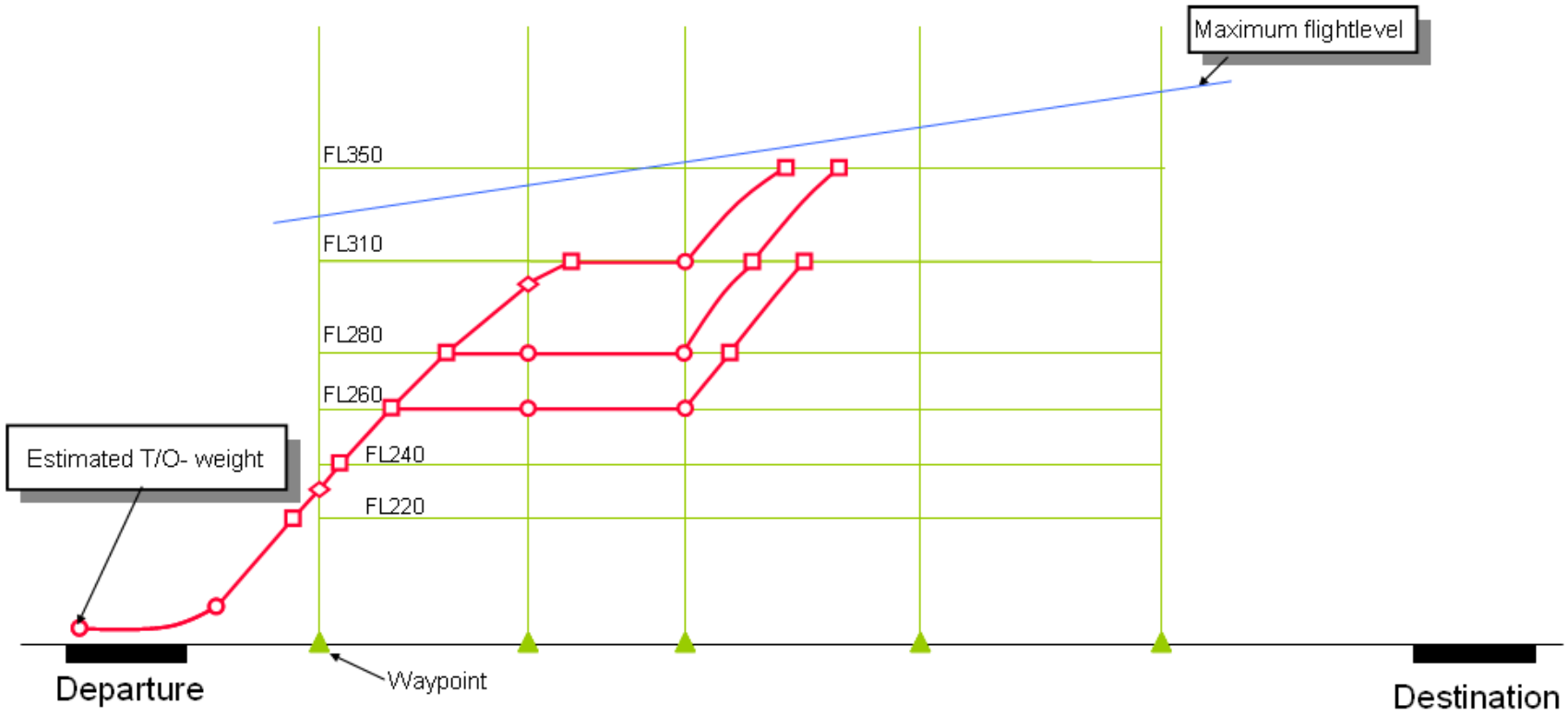

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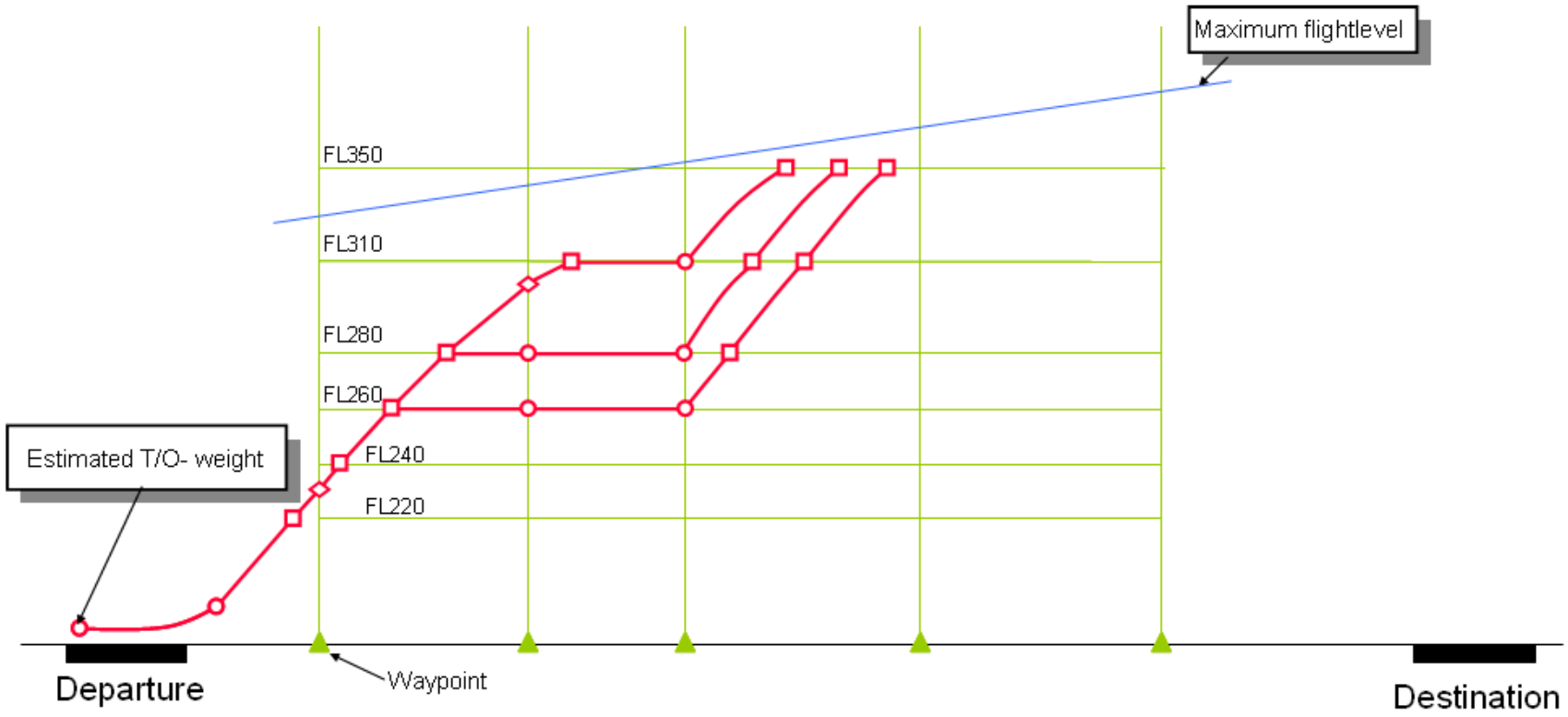
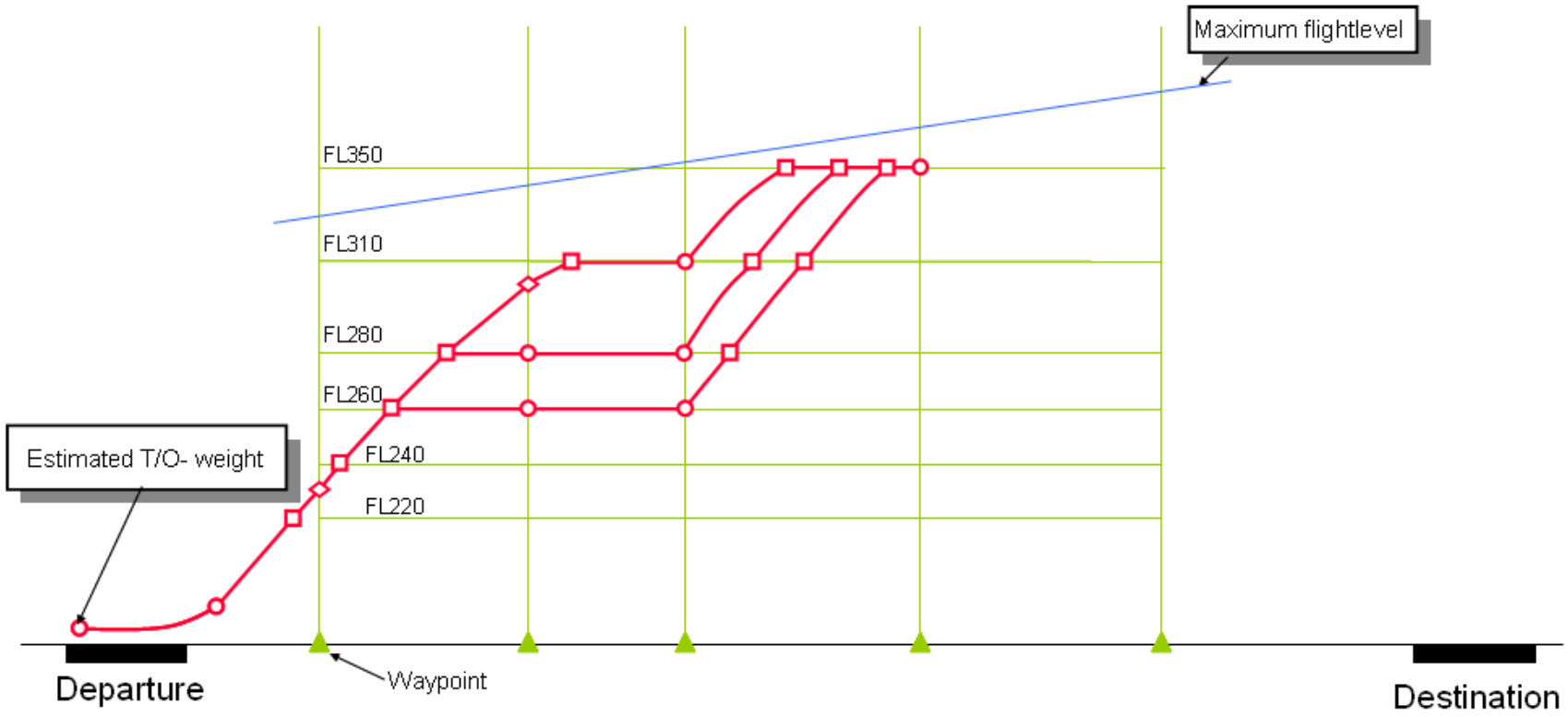


# Vertical optimization



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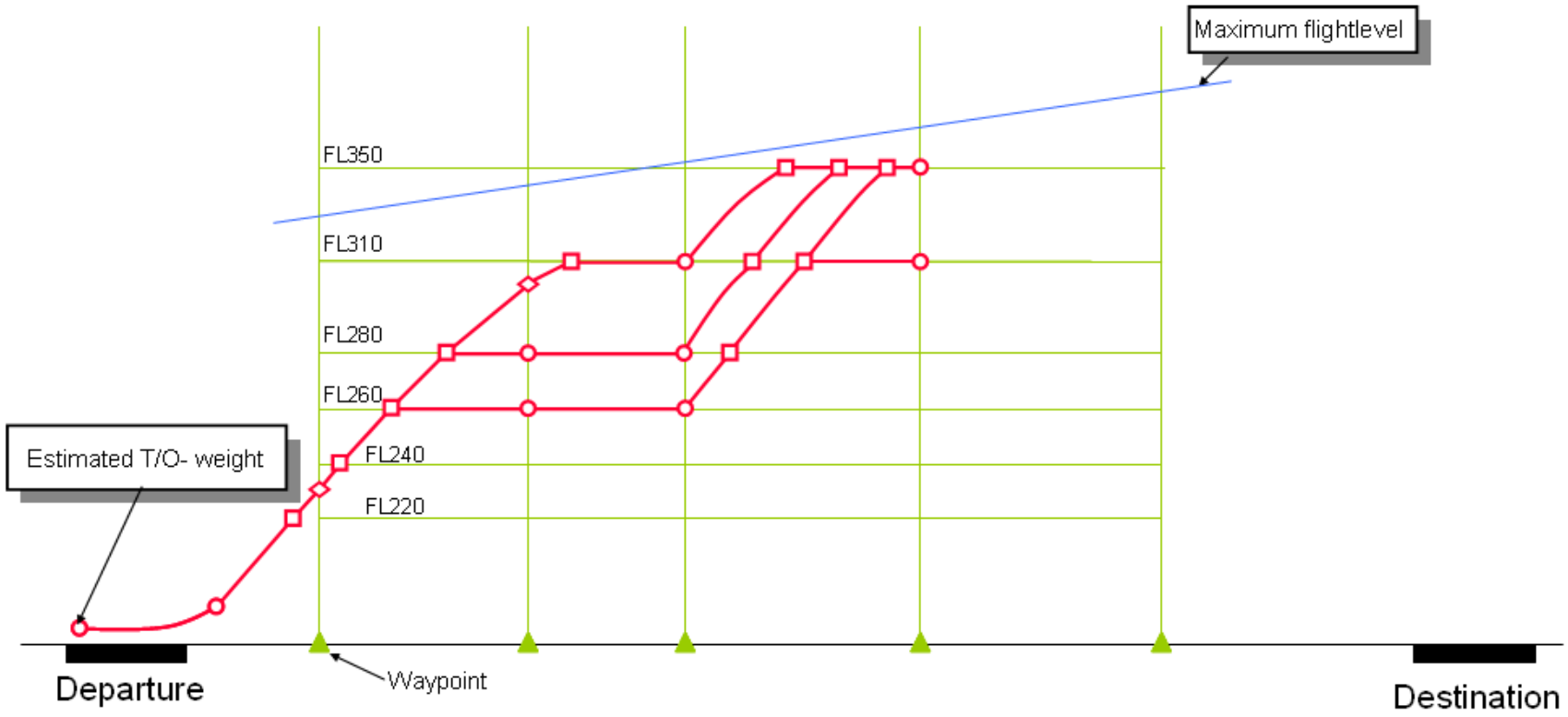
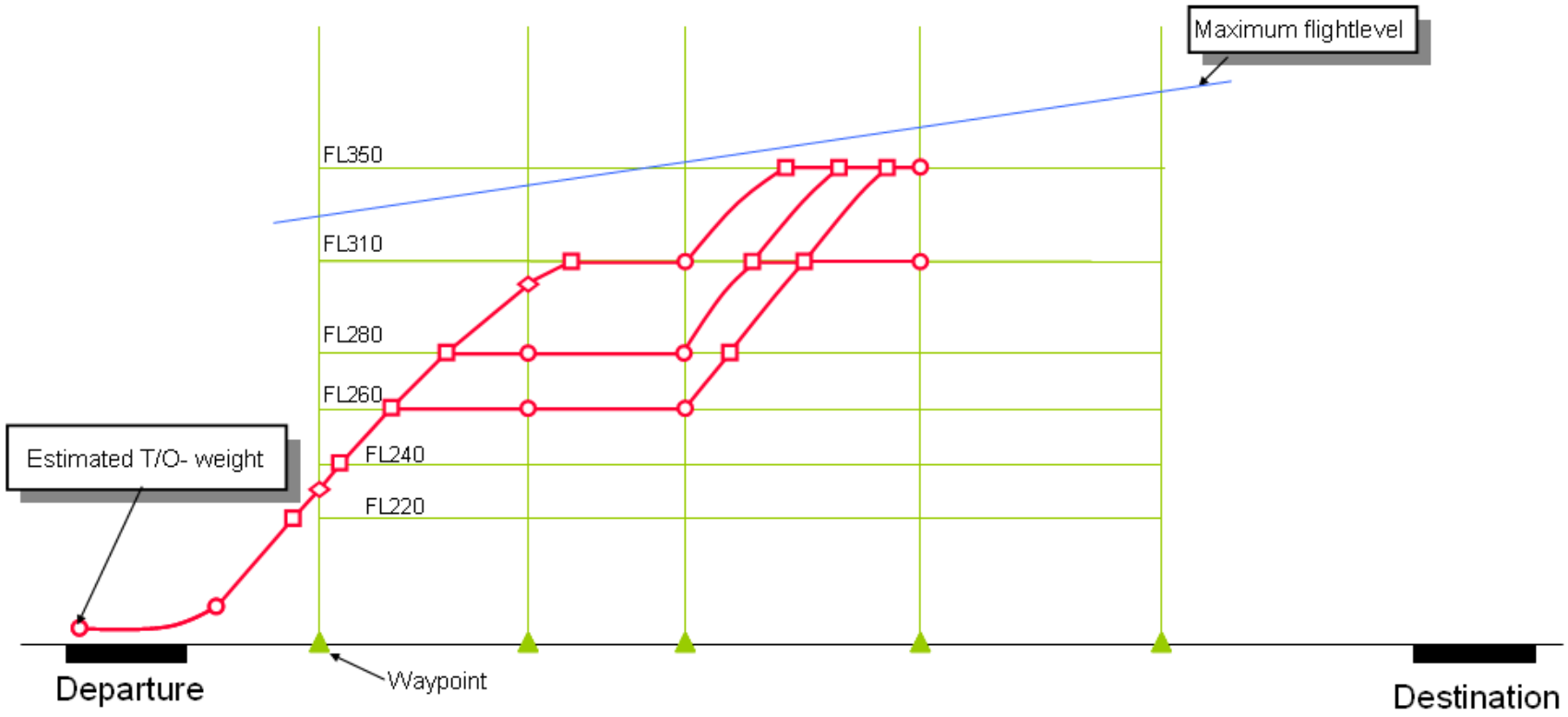


# Vertical optimization



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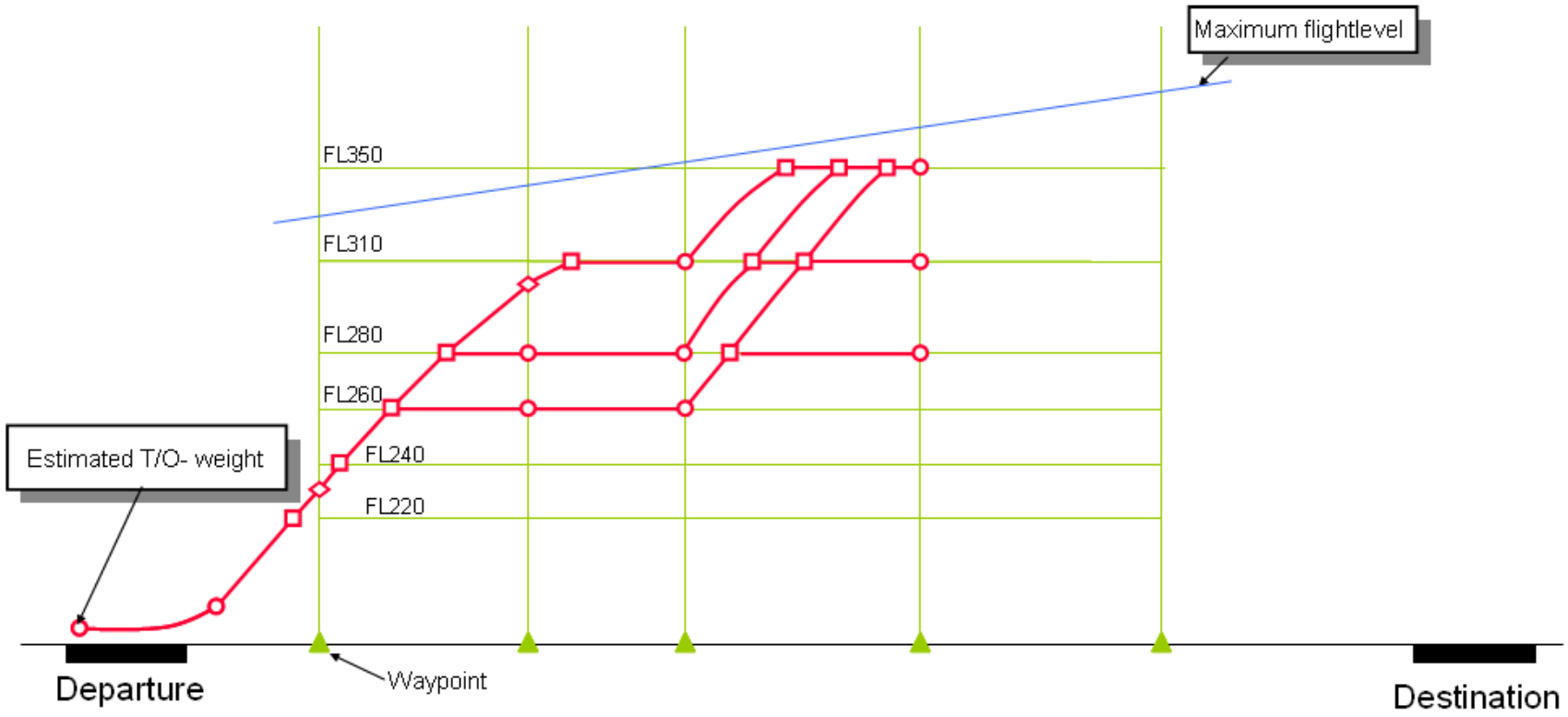

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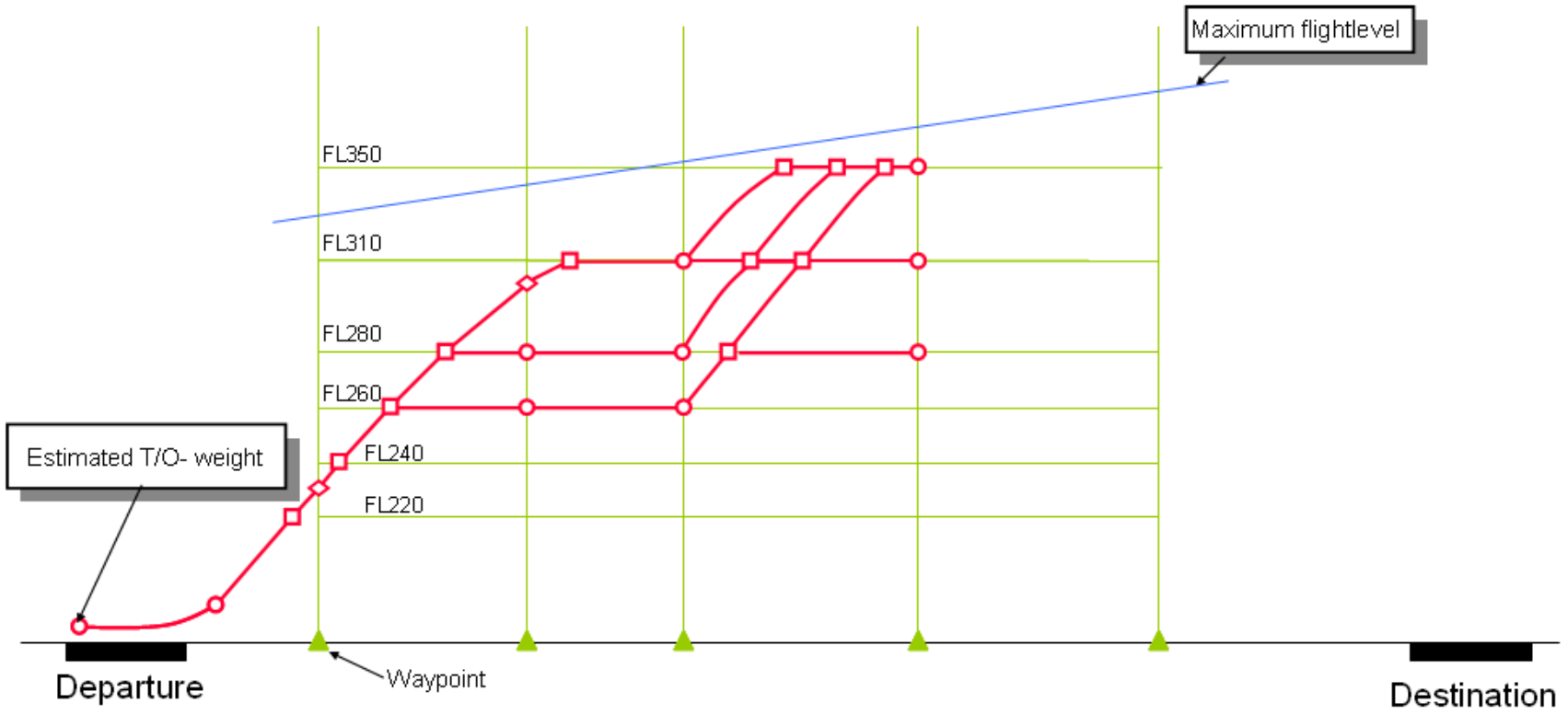

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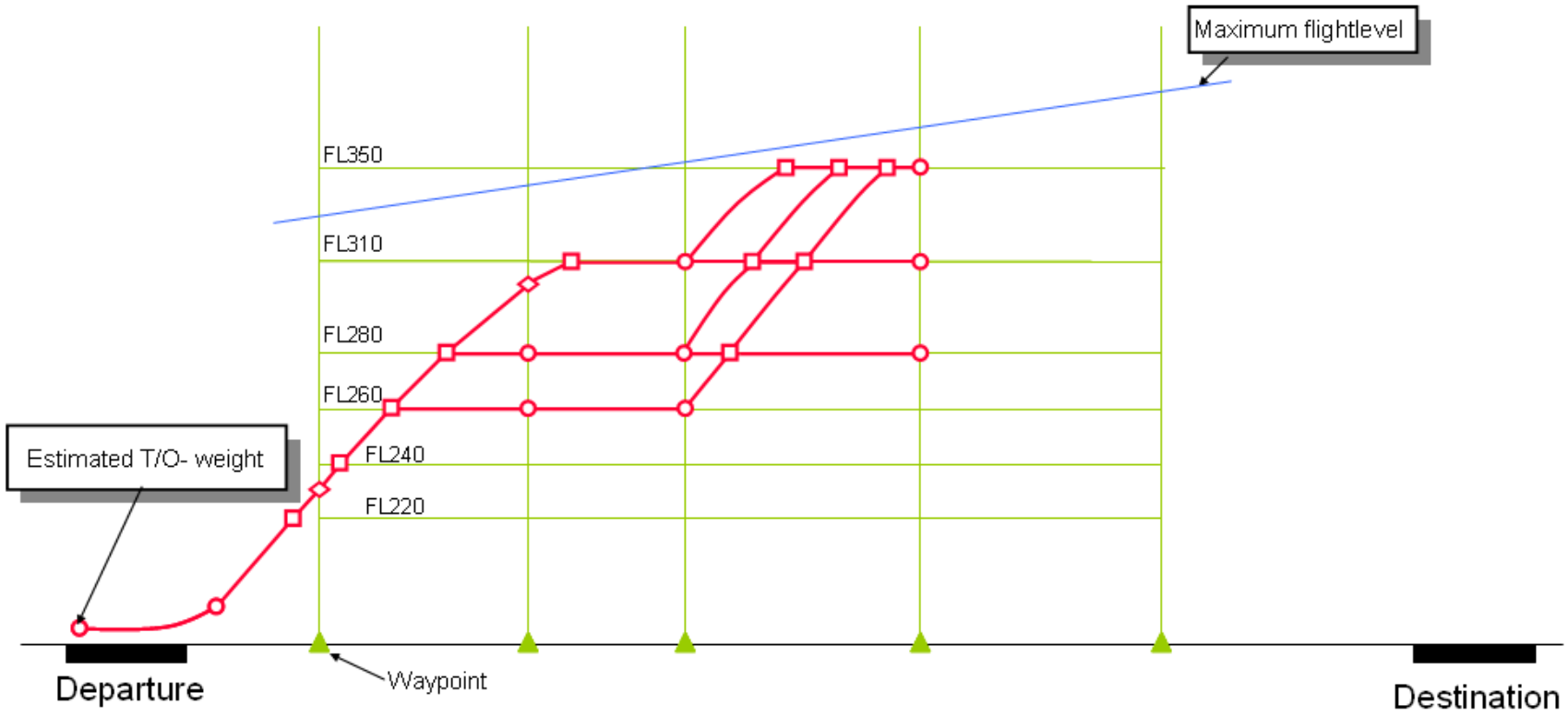
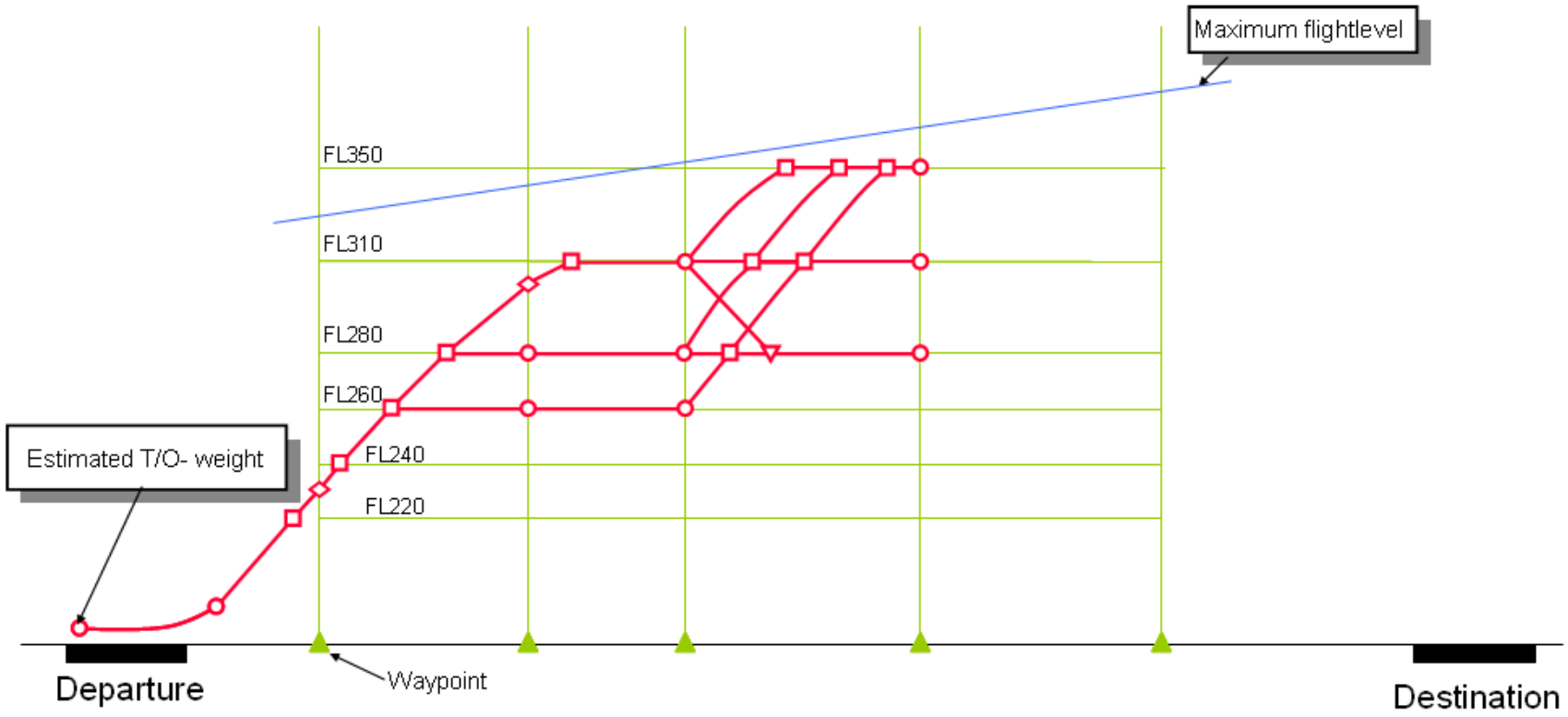
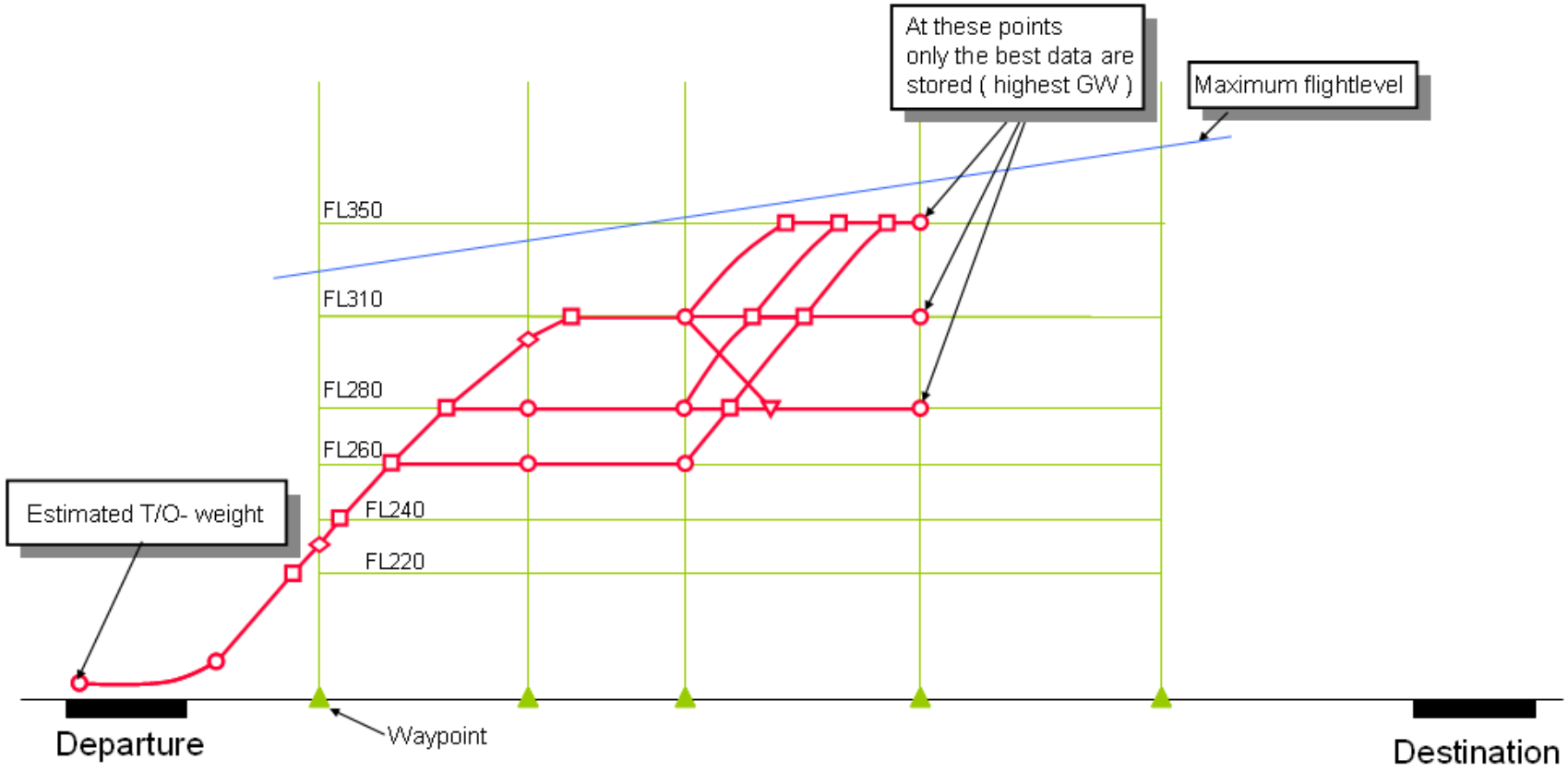


# Vertical optimization



# Vertical optimization



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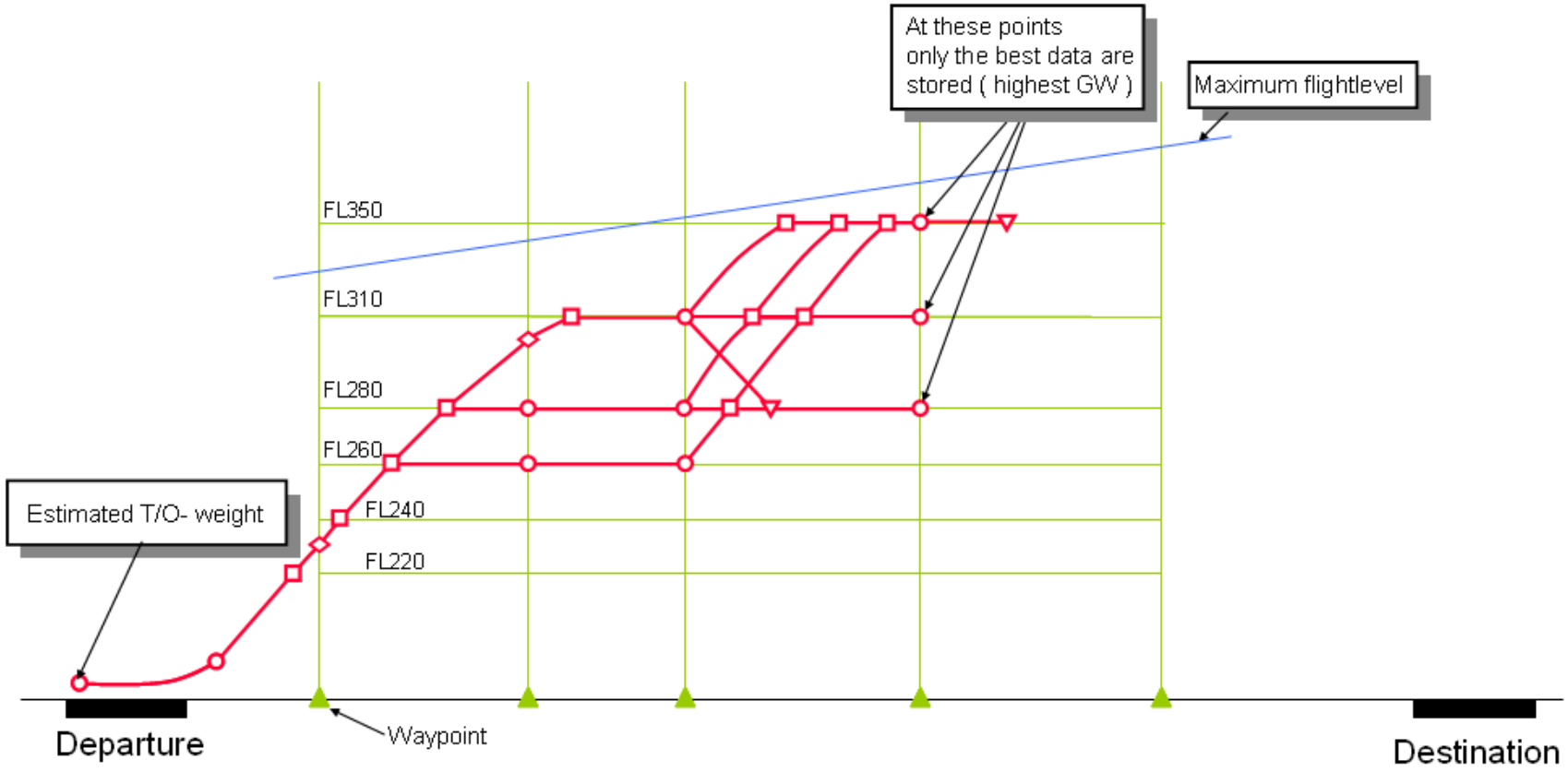
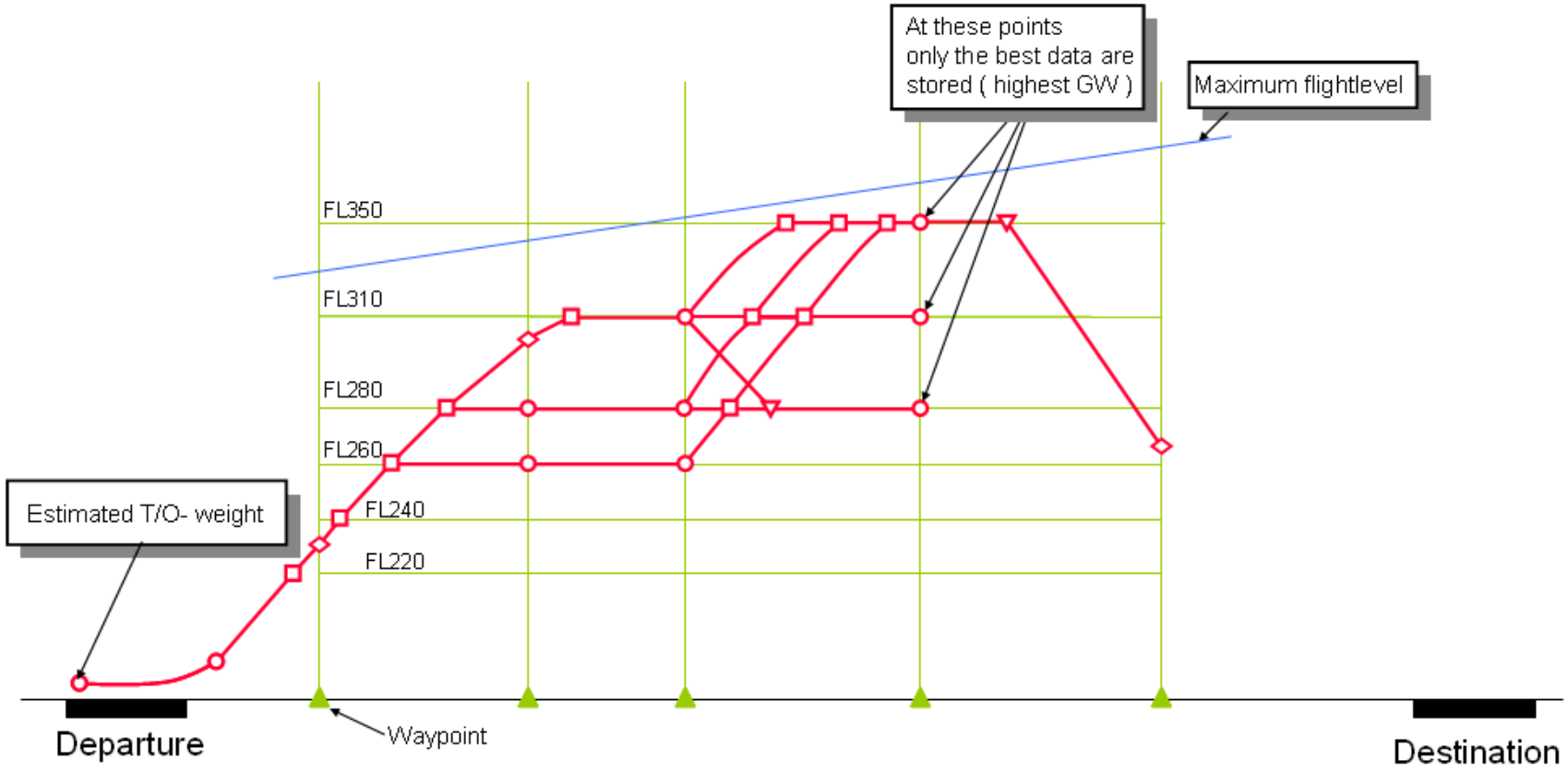
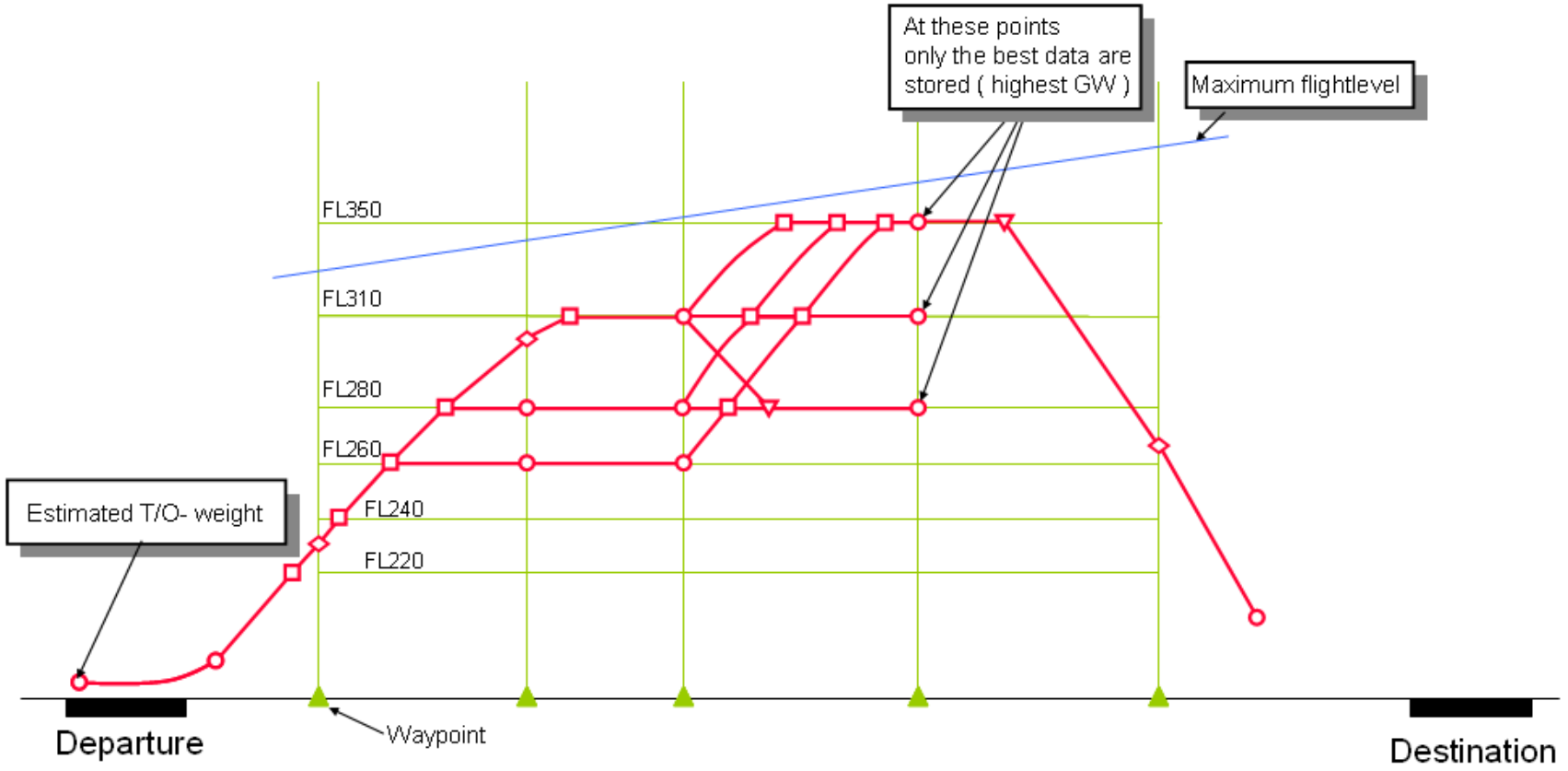


# Vertical optimization



# Vertical optimization



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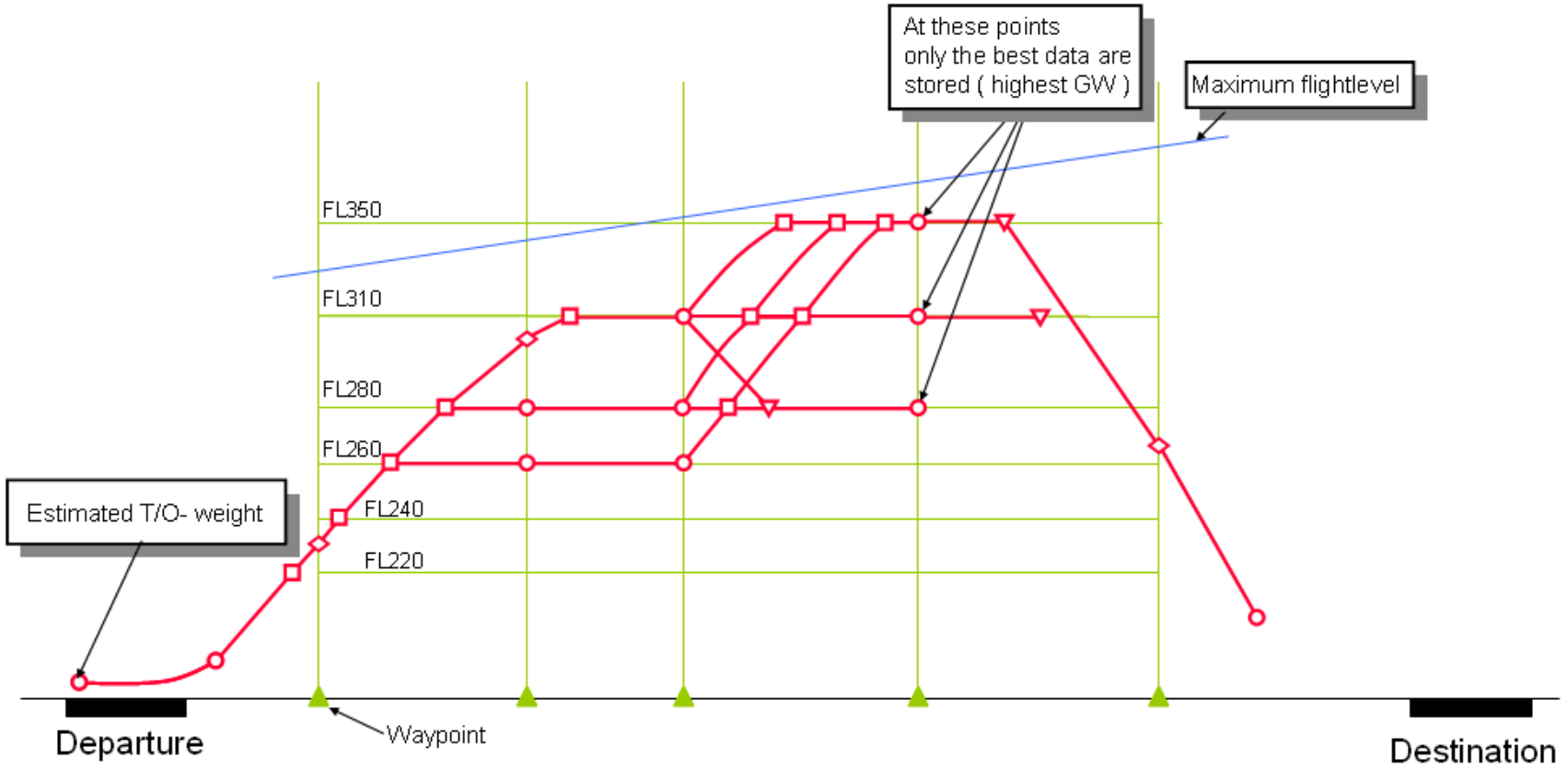

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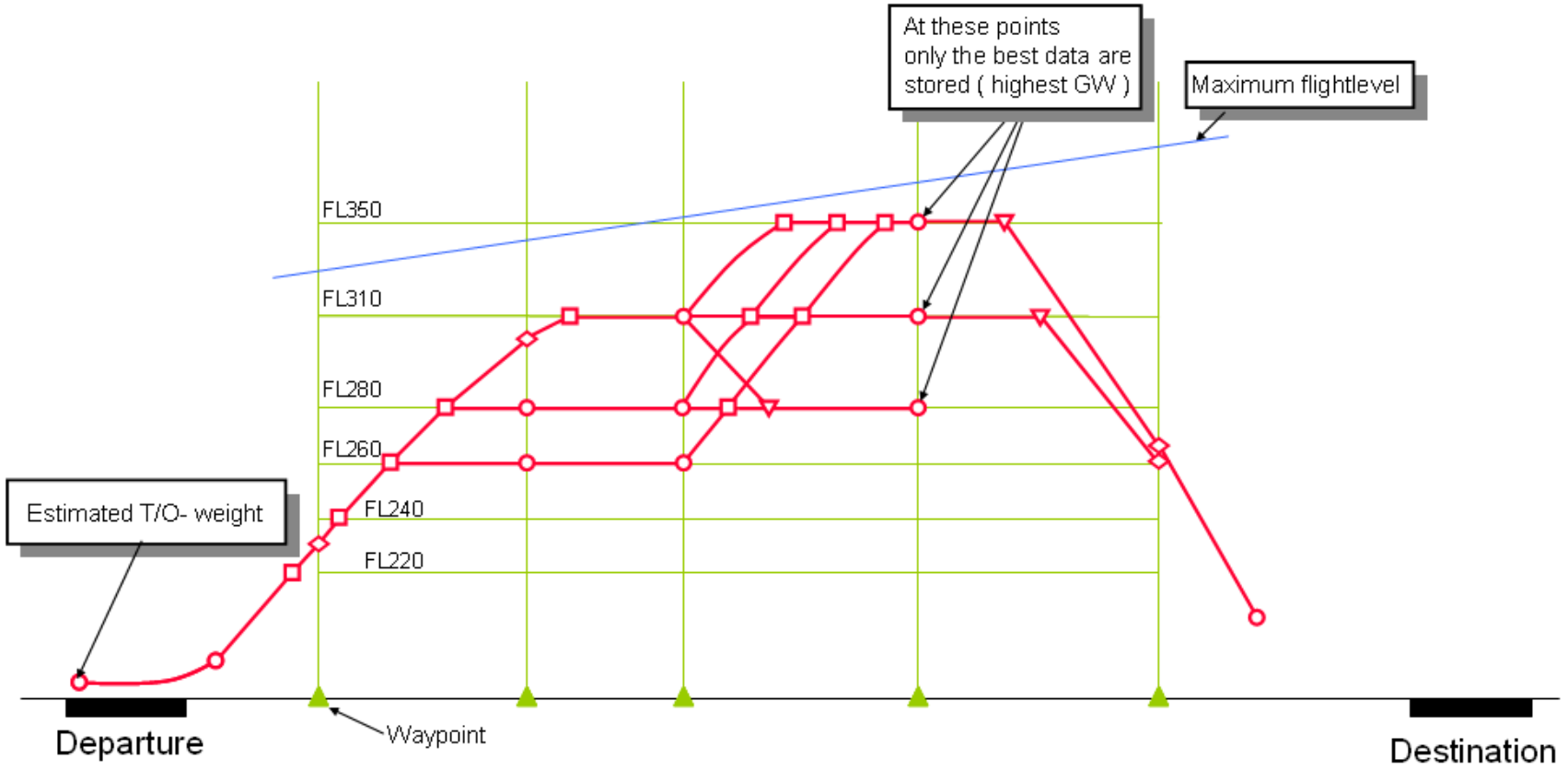

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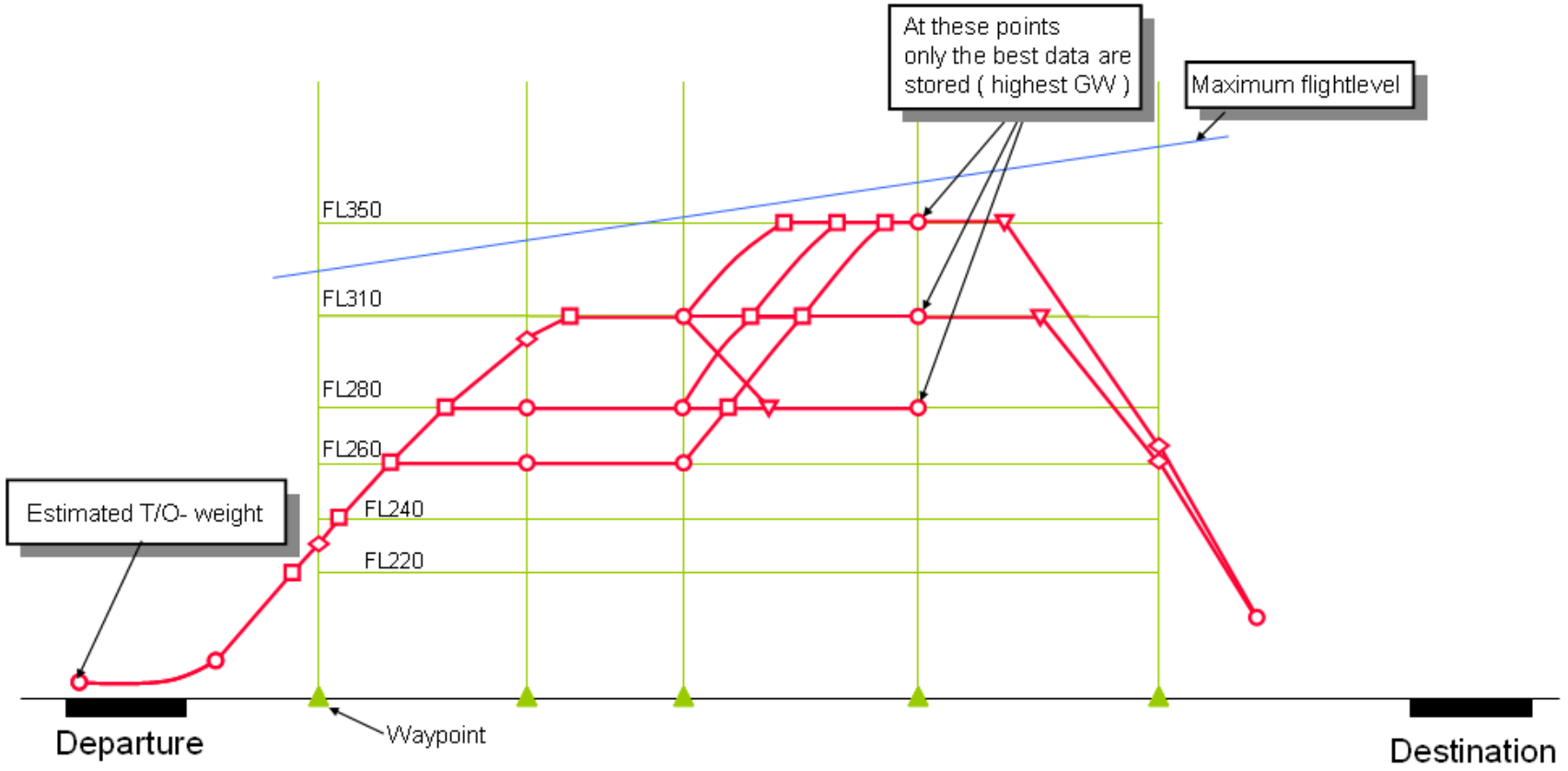
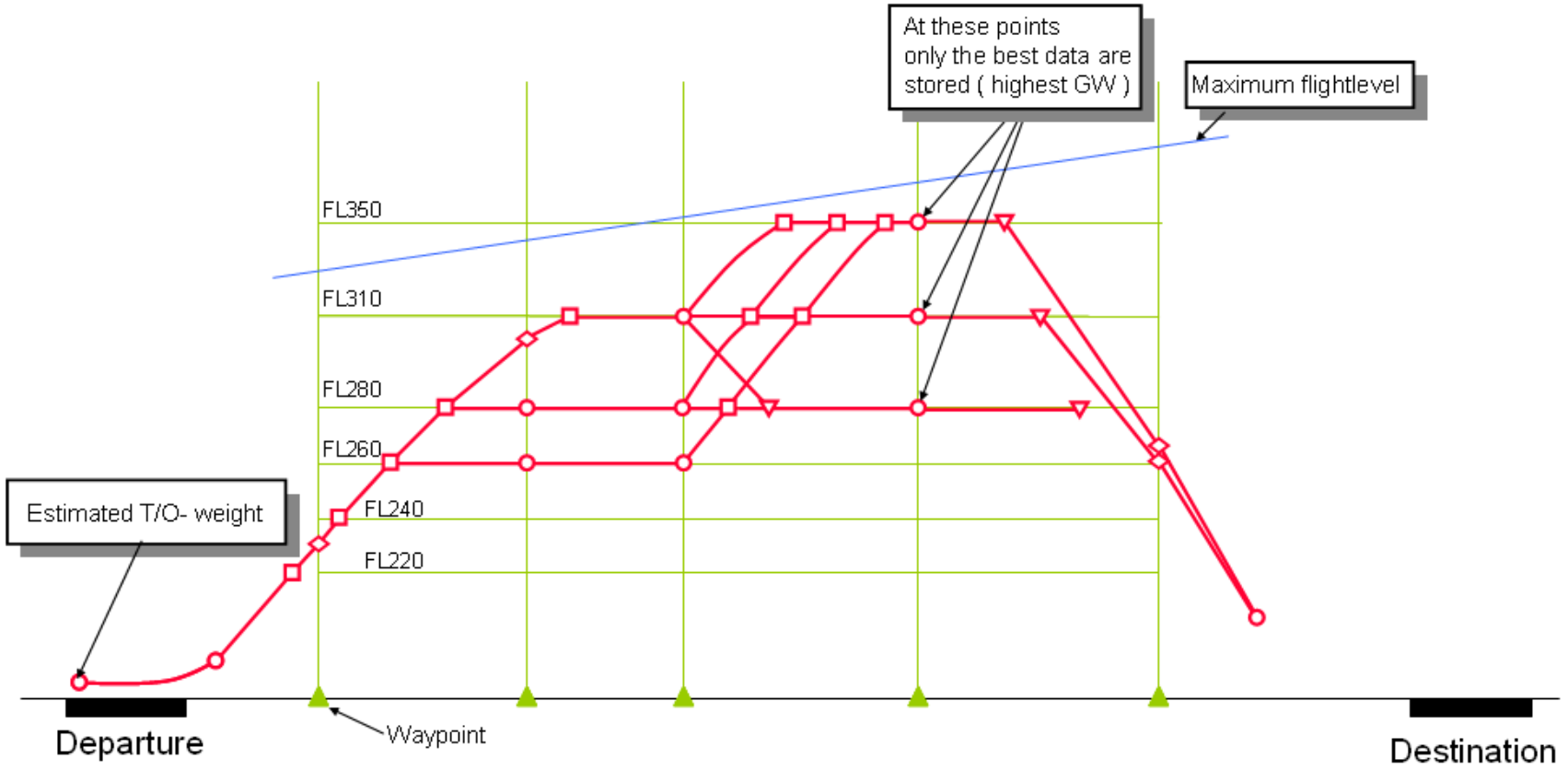
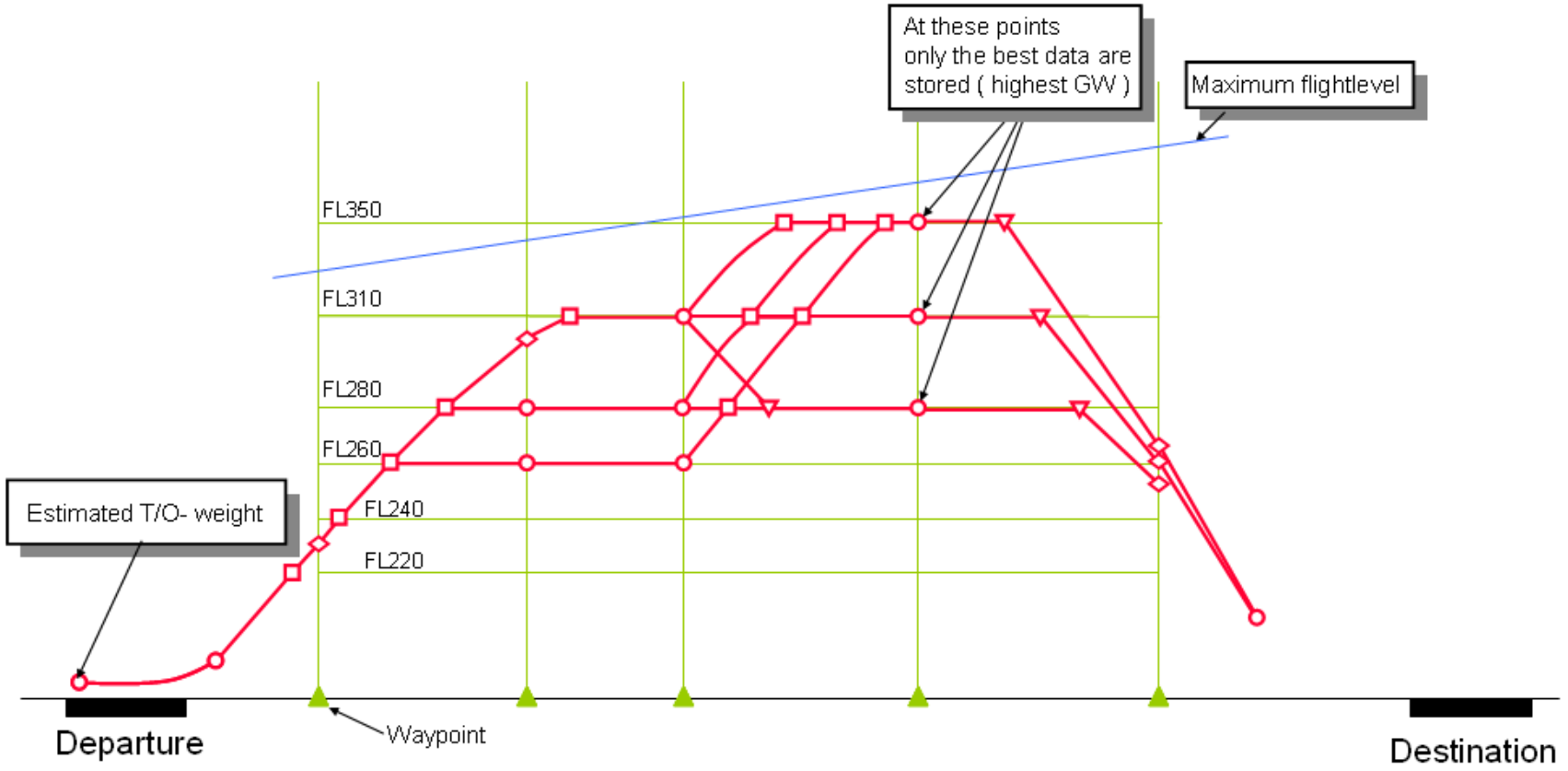


# Vertical optimization



# Vertical optimization



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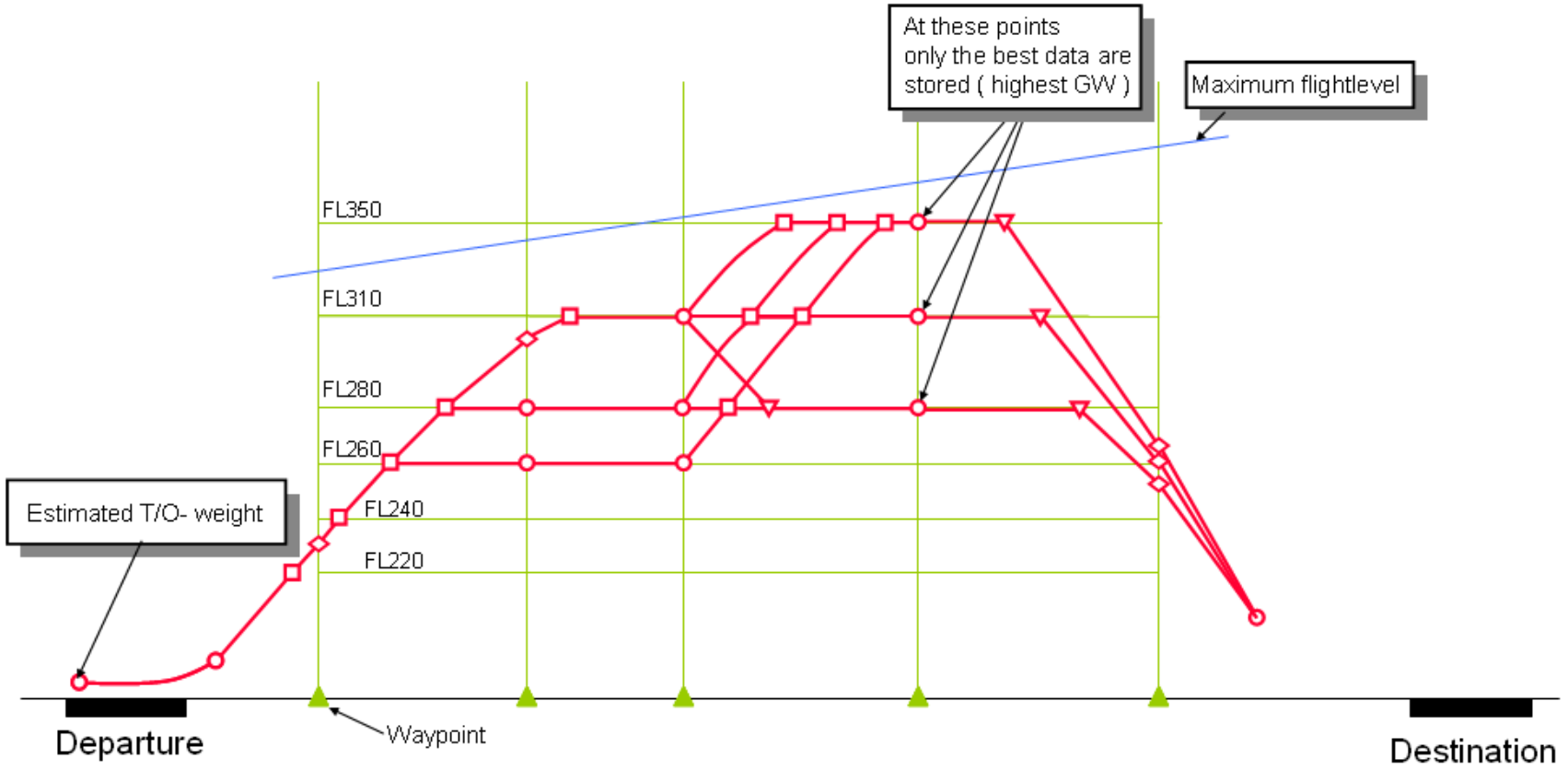
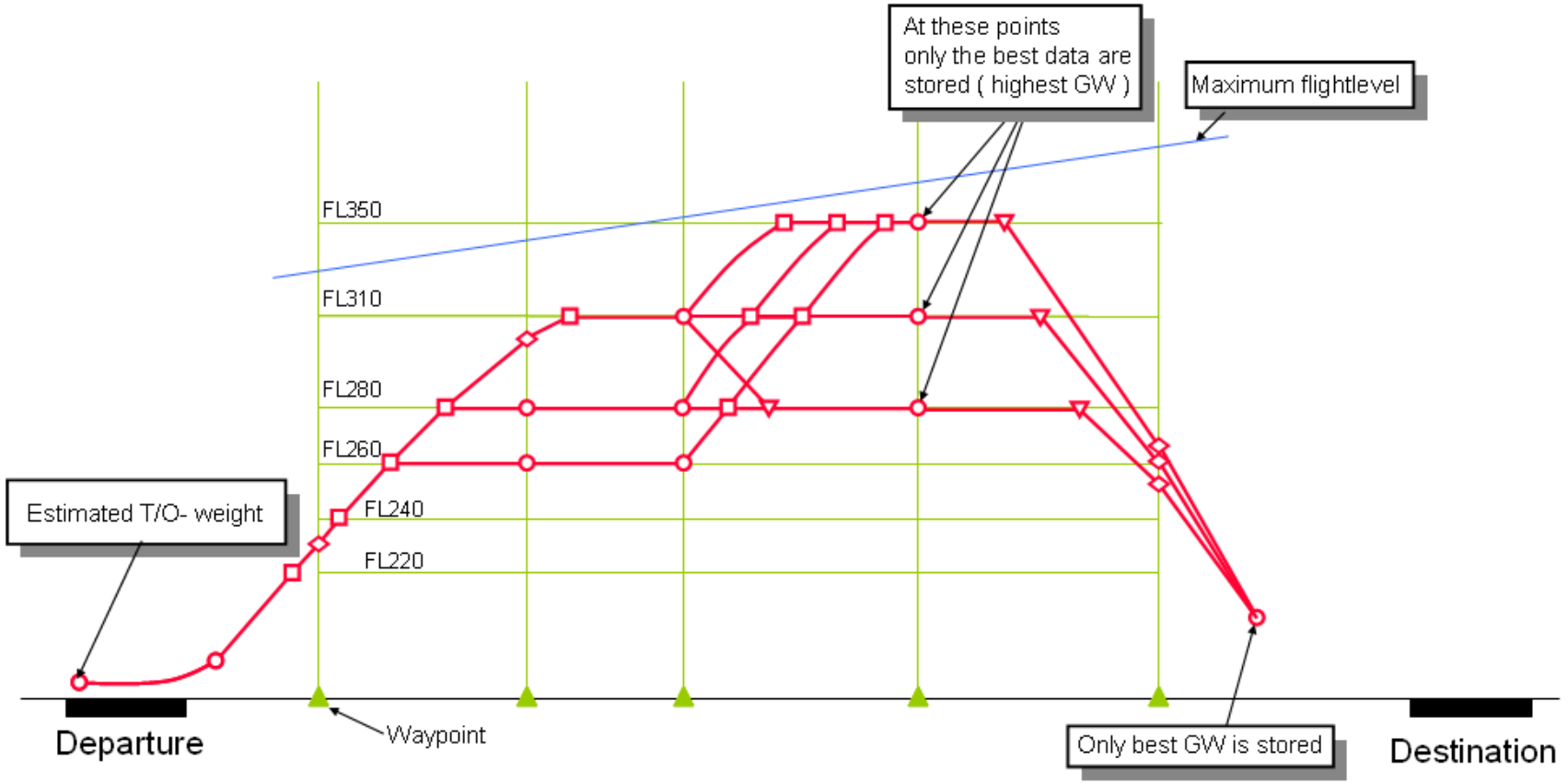
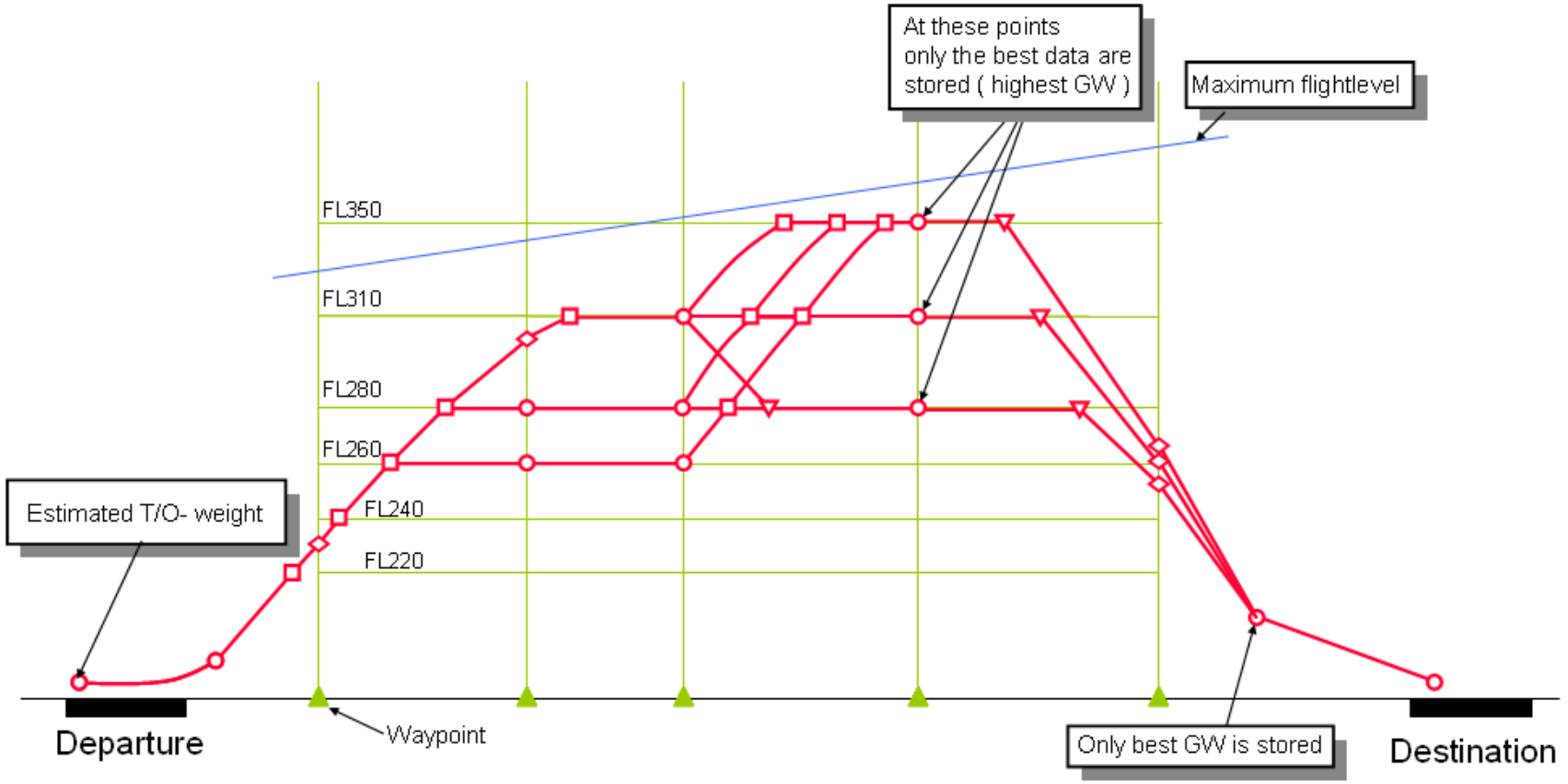


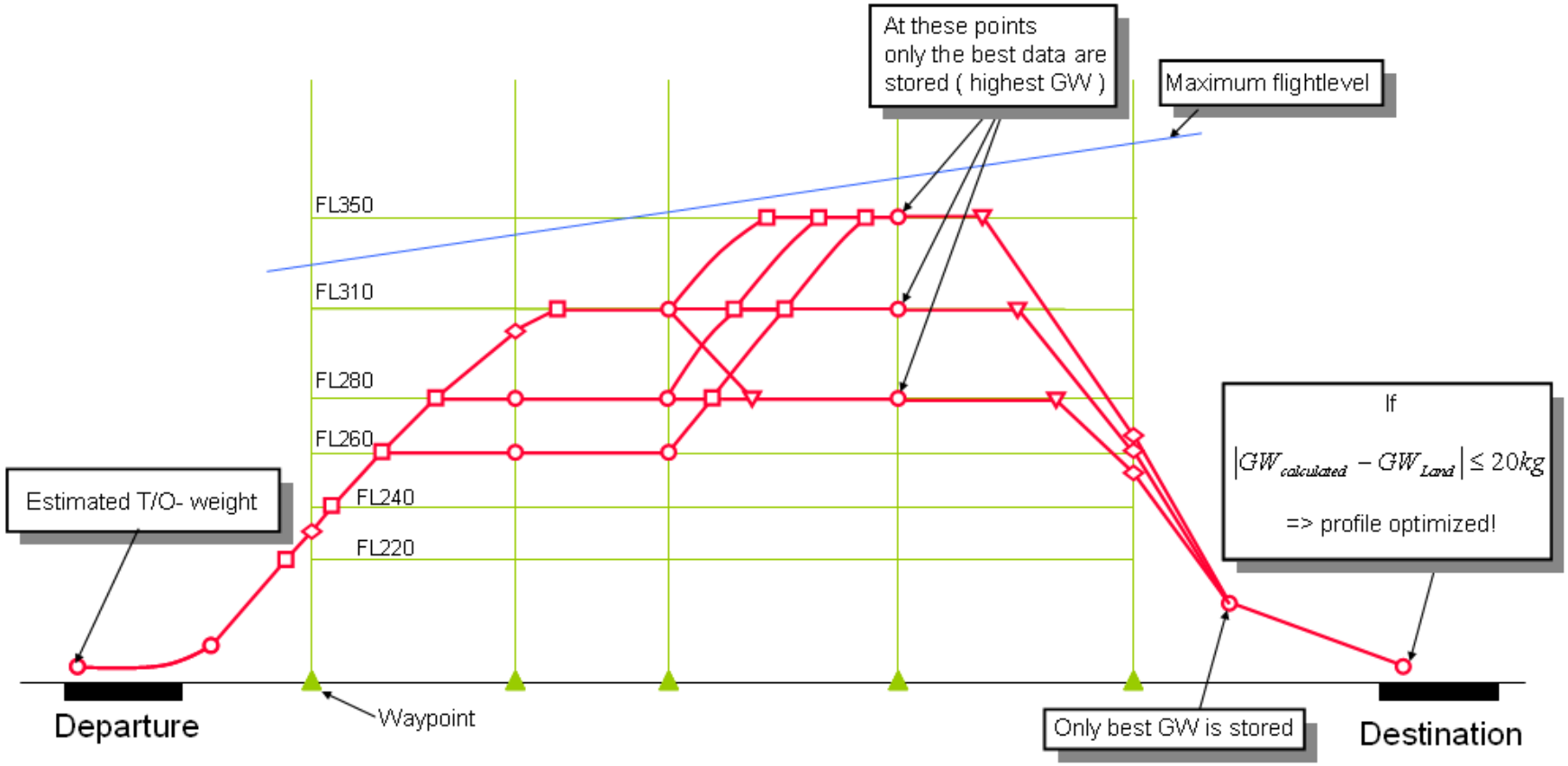
# Vertical optimization



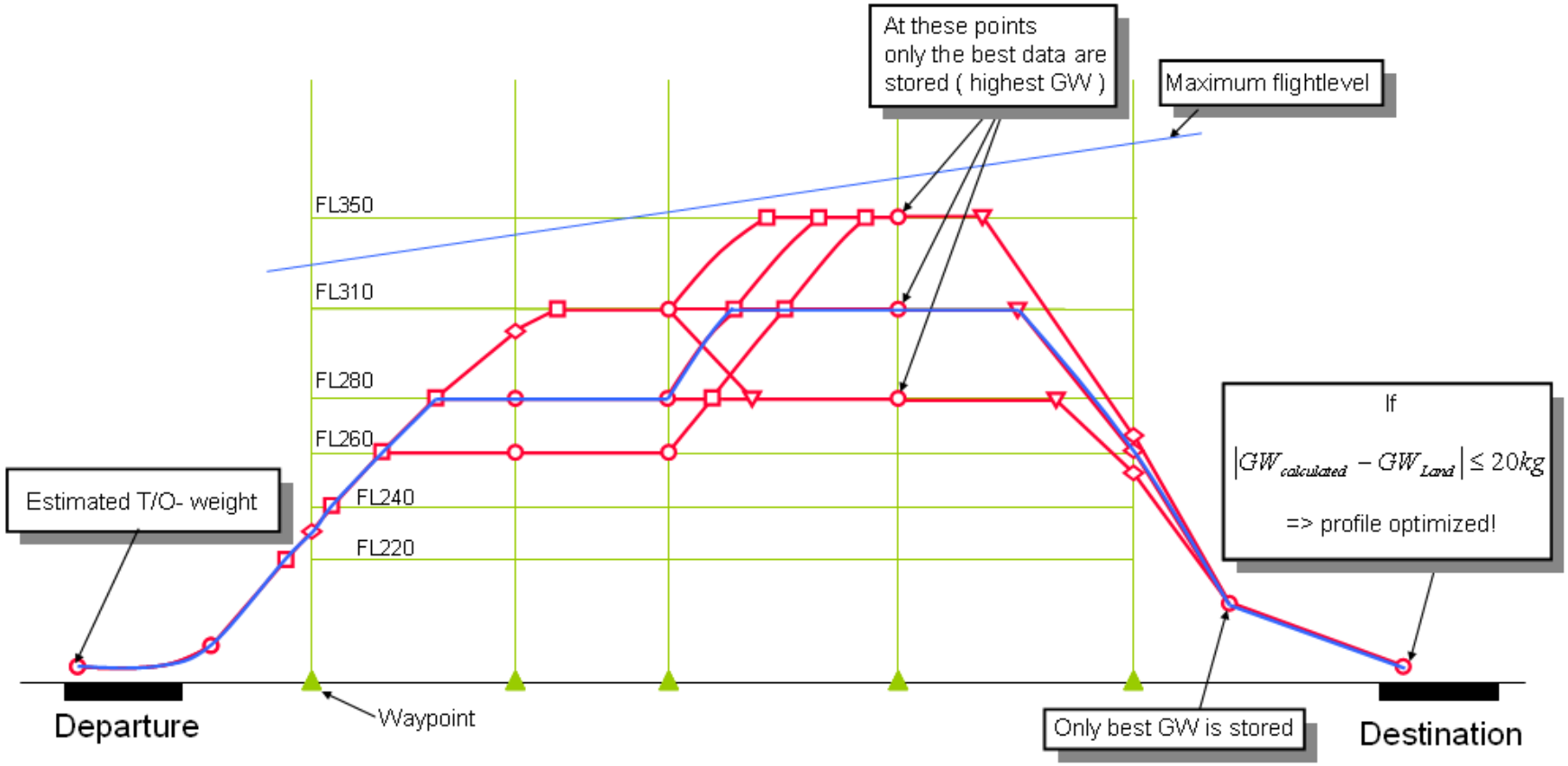
# Vertical optimization



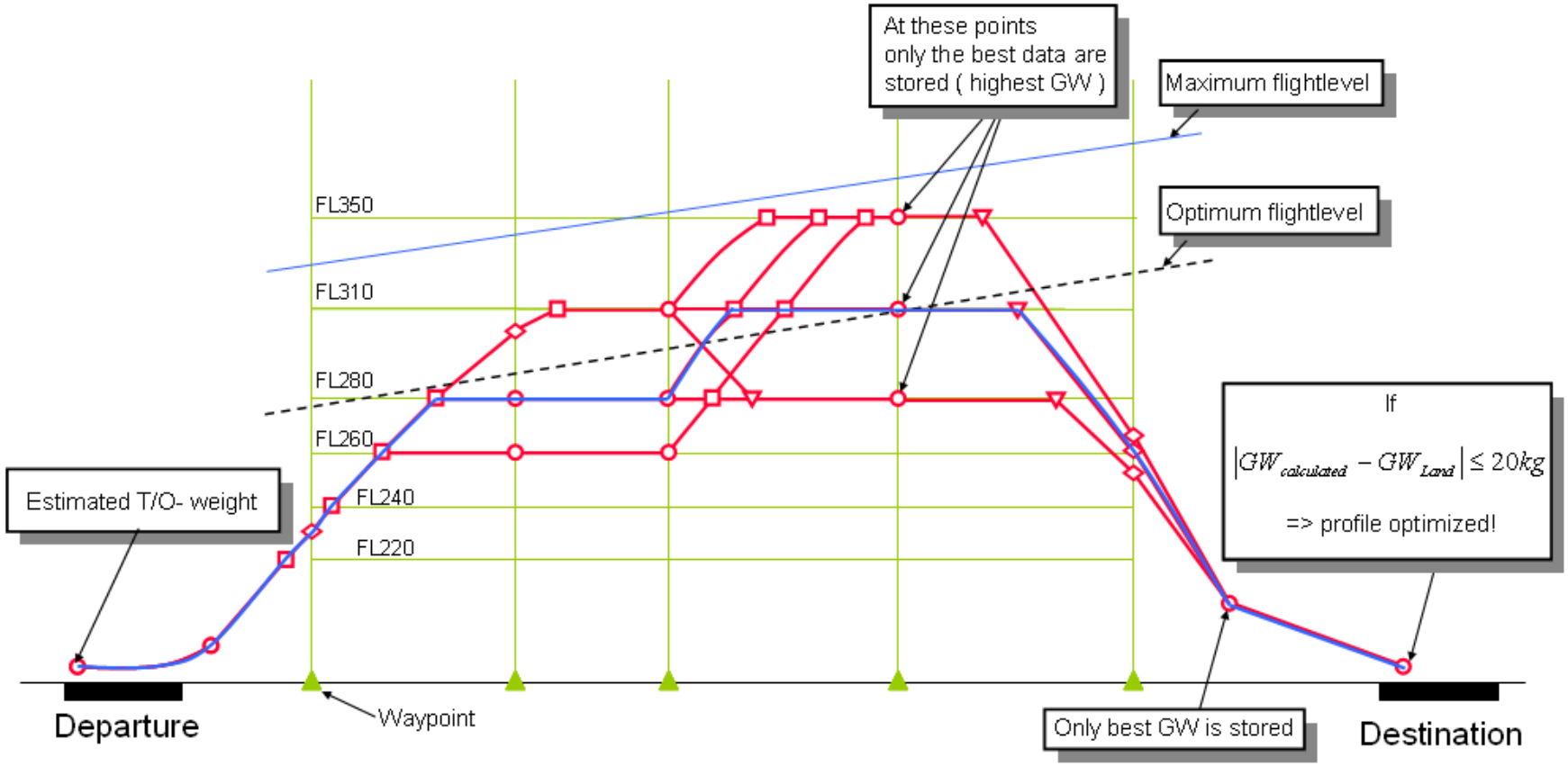
# Vertical optimization



# Vertical optimization

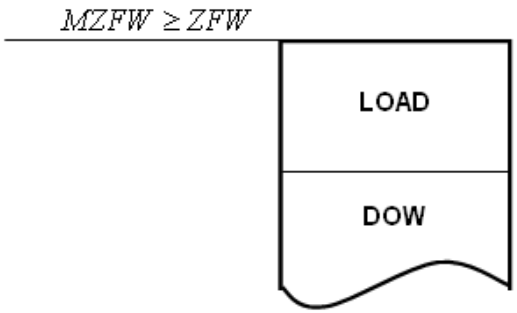


# Vertical optimization

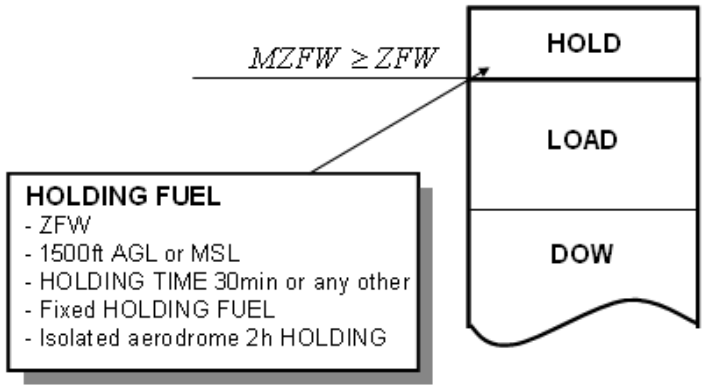


# Fuel policy

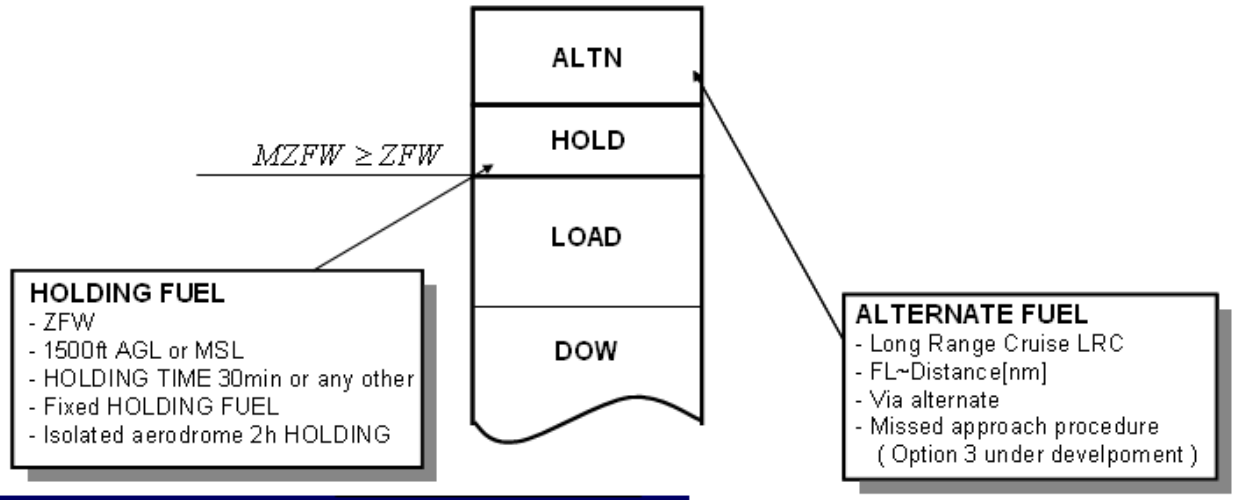
# Fuel policy



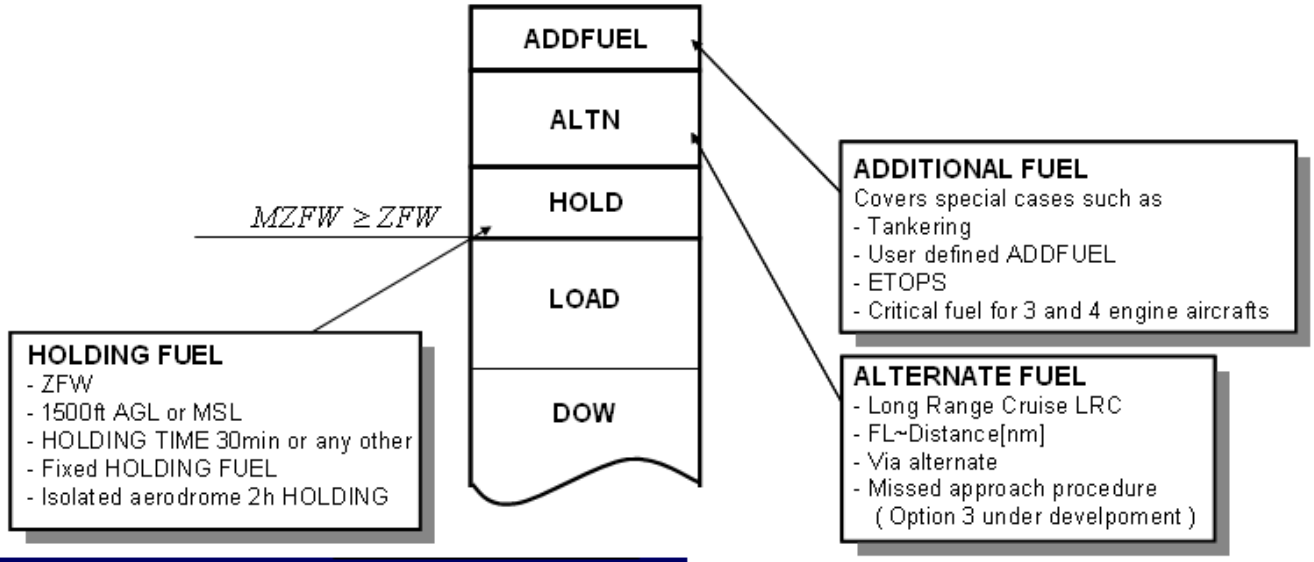
# Fuel policy


MZFW ≥ ZFW
HOLD
LOAD
DOW
HOLDING FUEL
- ZFW
- 1500ft AGL or MSL
- HOLDING TIME 30min or any other
- Fixed HOLDING FUEL
- Isolated aerodrome 2h HOLDING

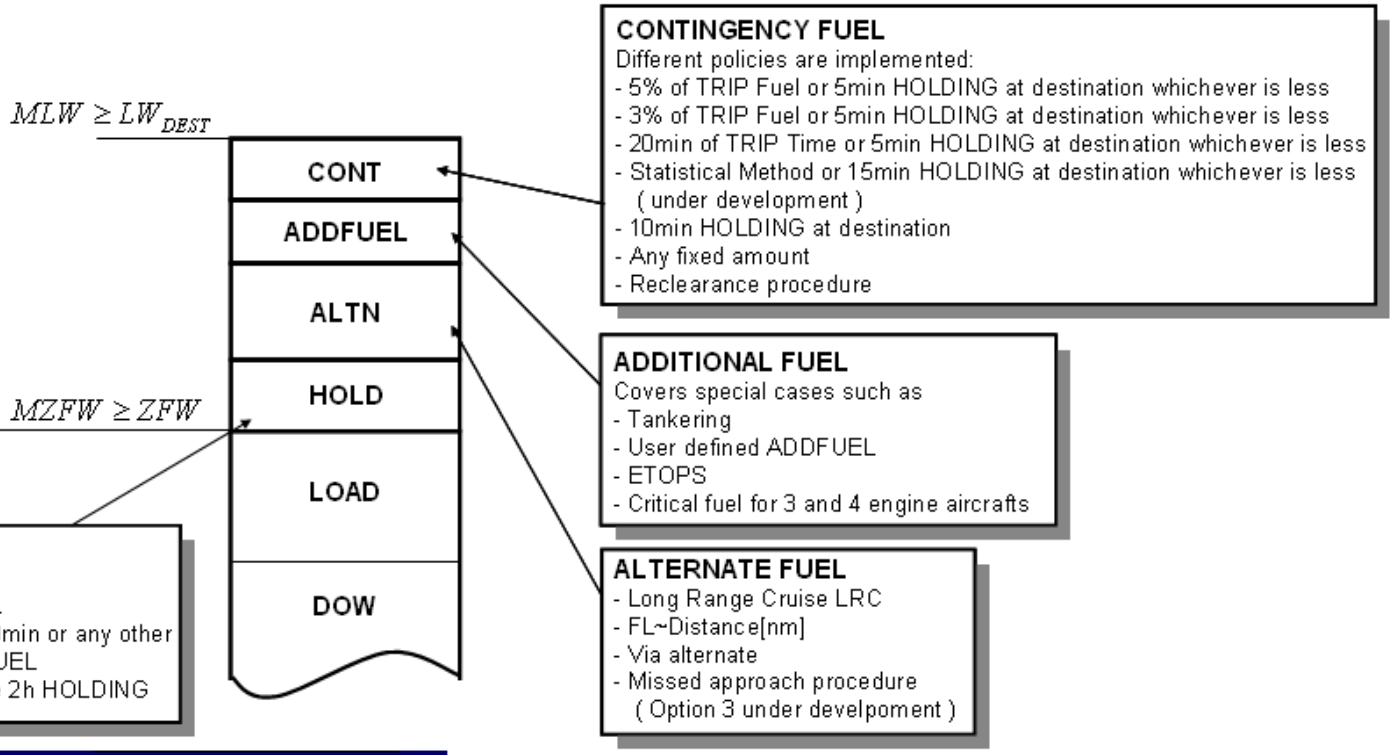
# Fuel policy


ALTN
HOLD
LOAD
DOW
MZFW ≥ ZFW
HOLDING FUEL
- ZFW
- 1500ft AGL or MSL
- HOLDING TIME 30min or any other
- Fixed HOLDING FUEL
- Isolated aerodrome 2h HOLDING
ALTERNATE FUEL
- Long Range Cruise LRC
- FL~Distance[nm]
- Via alternate
- Missed approach procedure
( Option 3 under develpoment )

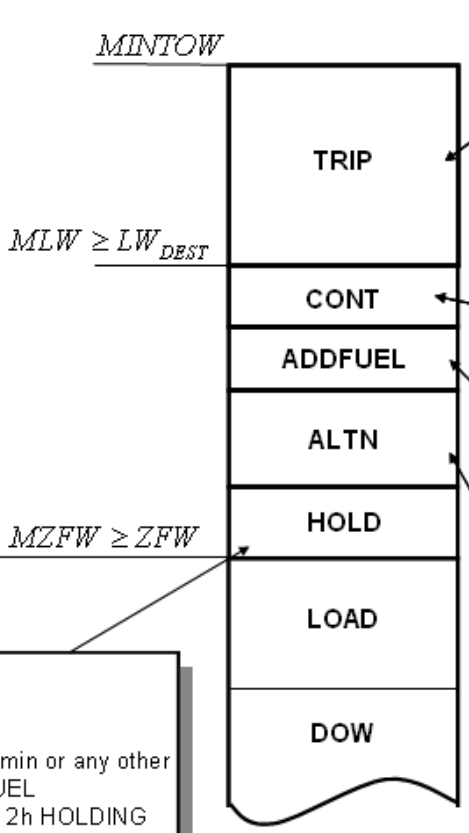
# Fuel policy


ADDFUEL
ALTN
HOLD
LOAD
DOW
MZFW ≥ ZFW
HOLDING FUEL
- ZFW
- 1500ft AGL or MSL
- HOLDING TIME 30min or any other
- Fixed HOLDING FUEL
- Isolated aerodrome 2h HOLDING
ADDITIONAL FUEL
Covers special cases such as
- Tankering
- User defined ADDFUEL
- ETOPS
- Critical fuel for 3 and 4 engine aircrafts
ALTERNATE FUEL
- Long Range Cruise LRC
- FL~Distance[nm]
- Via alternate
- Missed approach procedure
( Option 3 under develpoment )

# Fuel policy


$MLW \geq LW_{DEST}$
CONT
ADDFUEL
ALTN
HOLD
$MZFW \geq ZFW$
LOAD
DOW
CONTINGENCY FUEL
Different policies are implemented:
- 5% of TRIP Fuel or 5min HOLDING at destination whichever is less
- 3% of TRIP Fuel or 5min HOLDING at destination whichever is less
- 20min of TRIP Time or 5min HOLDING at destination whichever is less
- Statistical Method or 15min HOLDING at destination whichever is less
( under development )
- 10min HOLDING at destination
- Any fixed amount
- Reclearance procedure
ADDITIONAL FUEL
Covers special cases such as
- Tankering
- User defined ADDFUEL
- ETOPS
- Critical fuel for 3 and 4 engine aircrafts
ALTERNATE FUEL
- Long Range Cruise LRC
- FL~Distance[nm]
- Via alternate
- Missed approach procedure
( Option 3 under develpoment )
HOLDING FUEL
- ZFW
- 1500ft AGL or MSL
- HOLDING TIME 30min or any other
- Fixed HOLDING FUEL
- Isolated aerodrome 2h HOLDING

# Fuel policy




**TRIP FUEL**
contains transport fuel required to carry CONT, ADDFUEL, ALTN and HOLD to destination

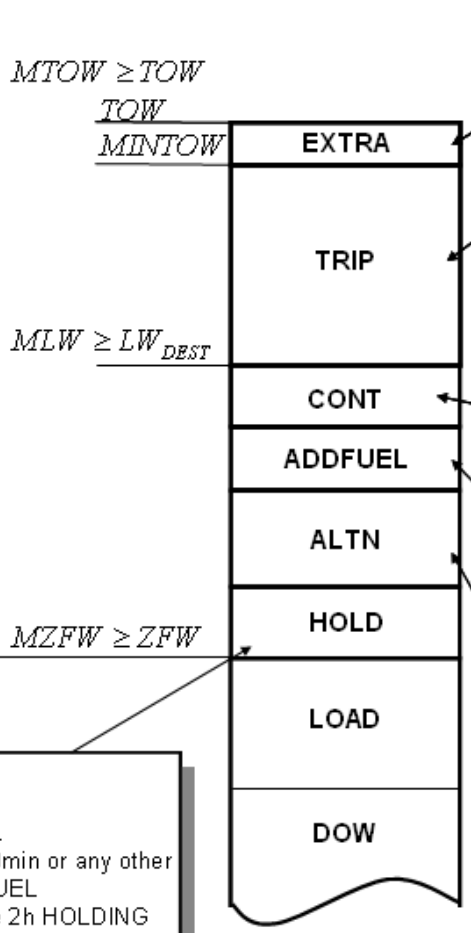
**CONTINGENCY FUEL**
Different policies are implemented:
- 5% of TRIP Fuel or 5min HOLDING at destination whichever is less
- 3% of TRIP Fuel or 5min HOLDING at destination whichever is less
- 20min of TRIP Time or 5min HOLDING at destination whichever is less
- Statistical Method or 15min HOLDING at destination whichever is less ( under development )
- 10min HOLDING at destination
- Any fixed amount
- Reclearance procedure

**ADDITIONAL FUEL**
Covers special cases such as
- Tankering
- User defined ADDFUEL
- ETOPS
- Critical fuel for 3 and 4 engine aircrafts

**ALTERNATE FUEL**
- Long Range Cruise LRC
- FL~Distance[nm]
- Via alternate
- Missed approach procedure ( Option 3 under develpoment )

**HOLDING FUEL**
- ZFW
- 1500ft AGL or MSL
- HOLDING TIME 30min or any other
- Fixed HOLDING FUEL
- Isolated aerodrome 2h HOLDING

# Fuel policy




**EXTRA FUEL**
ordered by crew

**TRIP FUEL**
contains transport fuel required to carry CONT, ADDFUEL, ALTN and HOLD to destination

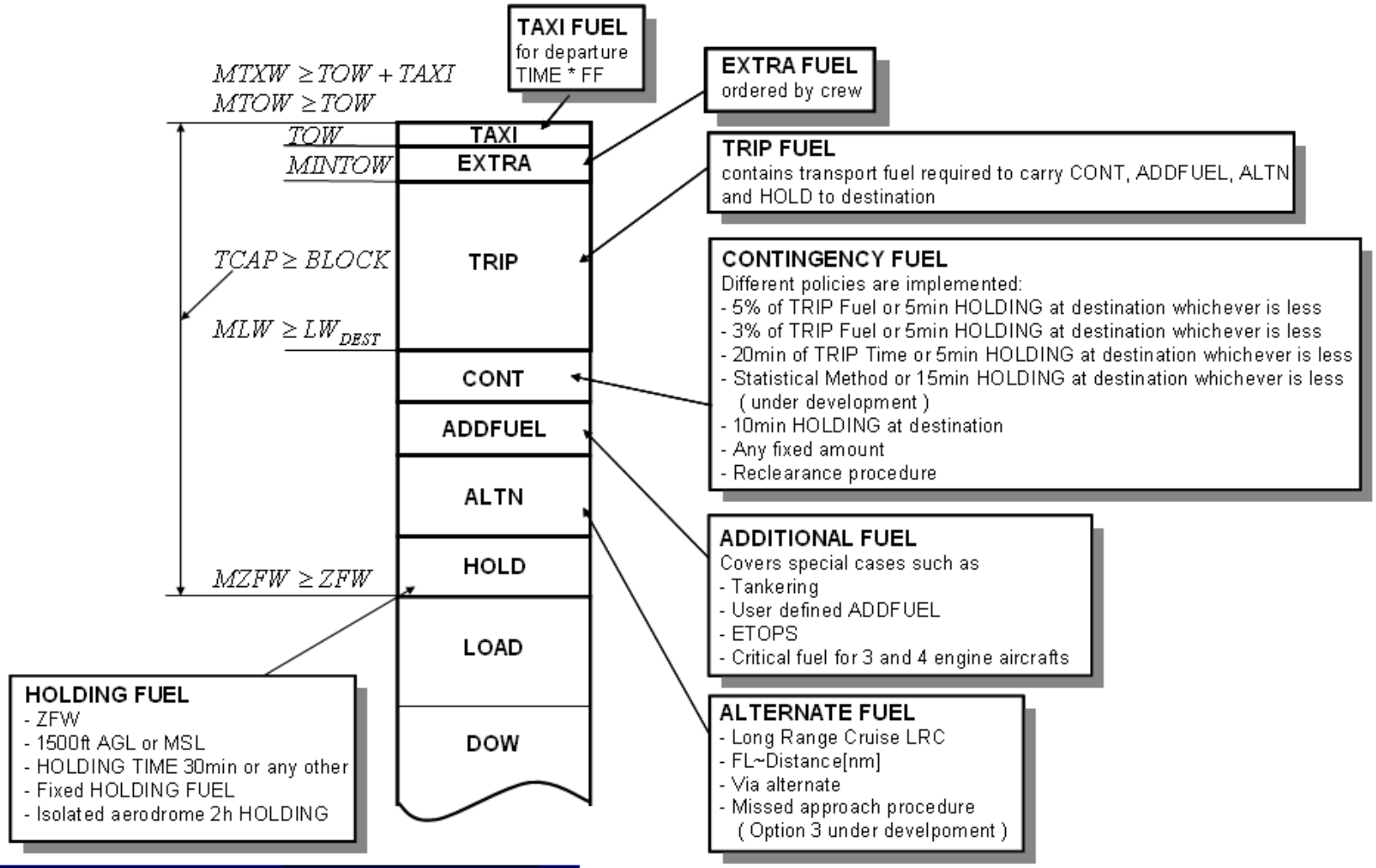
**CONTINGENCY FUEL**
Different policies are implemented:
- 5% of TRIP Fuel or 5min HOLDING at destination whichever is less
- 3% of TRIP Fuel or 5min HOLDING at destination whichever is less
- 20min of TRIP Time or 5min HOLDING at destination whichever is less
- Statistical Method or 15min HOLDING at destination whichever is less ( under development )
- 10min HOLDING at destination
- Any fixed amount
- Reclearance procedure

**ADDITIONAL FUEL**
Covers special cases such as
- Tankering
- User defined ADDFUEL
- ETOPS
- Critical fuel for 3 and 4 engine aircrafts

**ALTERNATE FUEL**
- Long Range Cruise LRC
- FL~Distance[nm]
- Via alternate
- Missed approach procedure ( Option 3 under develpoment )

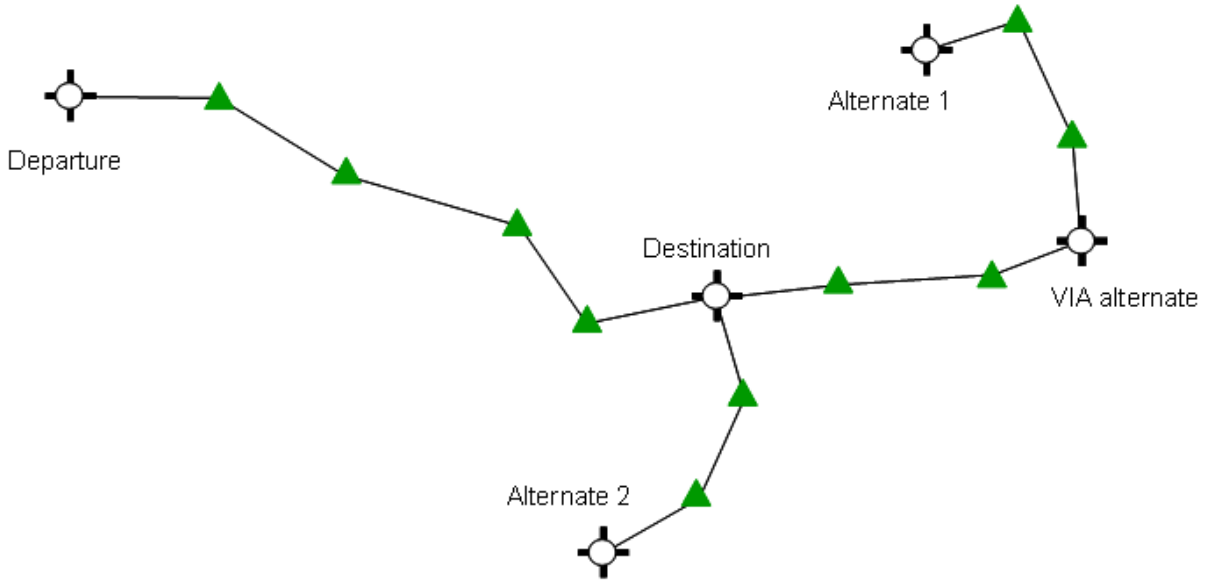
**HOLDING FUEL**
- ZFW
- 1500ft AGL or MSL
- HOLDING TIME 30min or any other
- Fixed HOLDING FUEL
- Isolated aerodrome 2h HOLDING

# Fuel policy

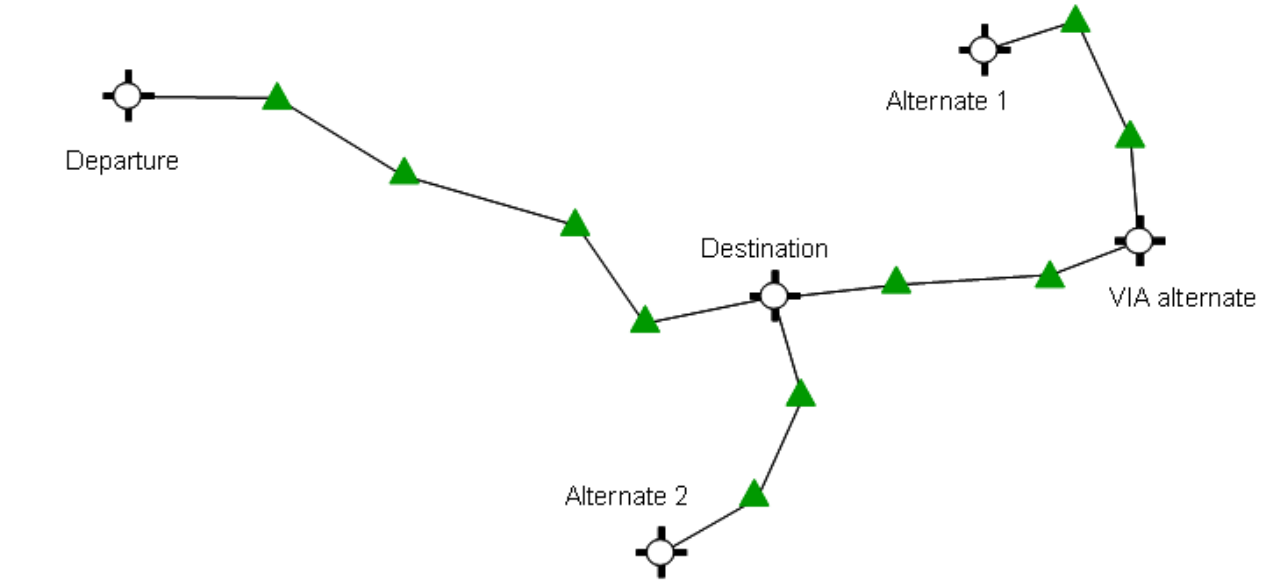

TAXI FUEL
for departure
TIME * FF
EXTRA FUEL
ordered by crew
MTXW ≥ TOW + TAXI
MTOW ≥ TOW
TOW
MINTOW
TAXI
EXTRA
TRIP FUEL
contains transport fuel required to carry CONT, ADDFUEL, ALTN and HOLD to destination
TRIP
TCAP ≥ BLOCK
MLW ≥ LW DEST
CONTINGENCY FUEL
Different policies are implemented:
- 5% of TRIP Fuel or 5min HOLDING at destination whichever is less
- 3% of TRIP Fuel or 5min HOLDING at destination whichever is less
- 20min of TRIP Time or 5min HOLDING at destination whichever is less
- Statistical Method or 15min HOLDING at destination whichever is less
( under development )
- 10min HOLDING at destination
- Any fixed amount
- Reclearance procedure
CONT
ADDFUEL
ALTN
ADDITIONAL FUEL
Covers special cases such as
- Tankering
- User defined ADDFUEL
- ETOPS
- Critical fuel for 3 and 4 engine aircrafts
HOLD
MZFW ≥ ZFW
LOAD
DOW
HOLDING FUEL
- ZFW
- 1500ft AGL or MSL
- HOLDING TIME 30min or any other
- Fixed HOLDING FUEL
- Isolated aerodrome 2h HOLDING
ALTERNATE FUEL
- Long Range Cruise LRC
- FL~Distance[nm]
- Via alternate
- Missed approach procedure
( Option 3 under develpoment )

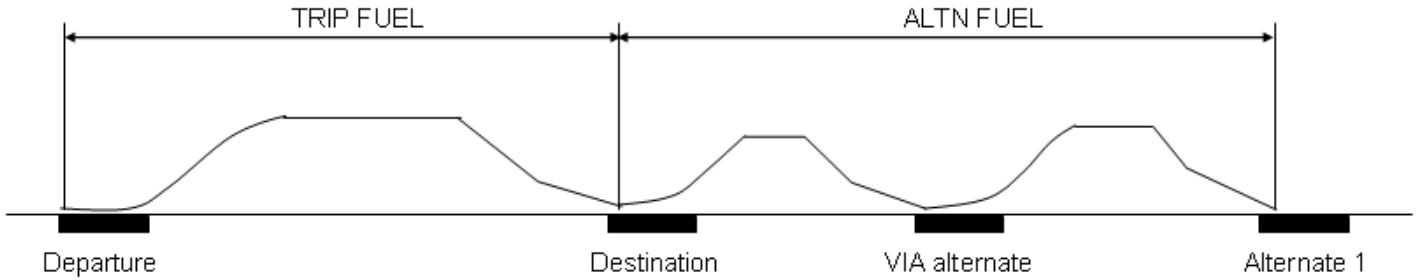
# Fuel policy - VIA alternate

# Fuel policy - VIA alternate

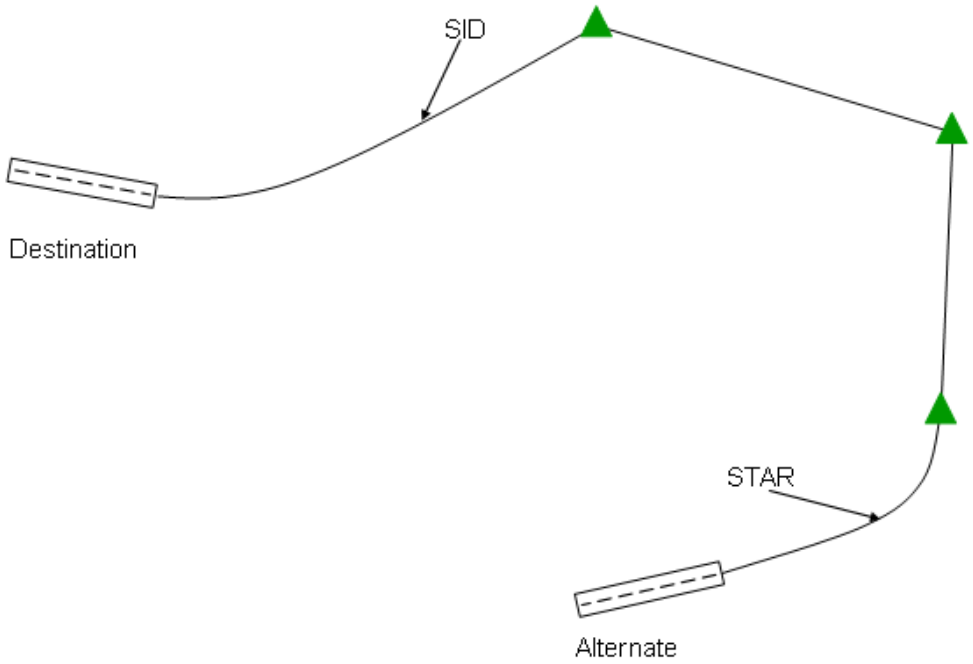


# Fuel policy - VIA alternate

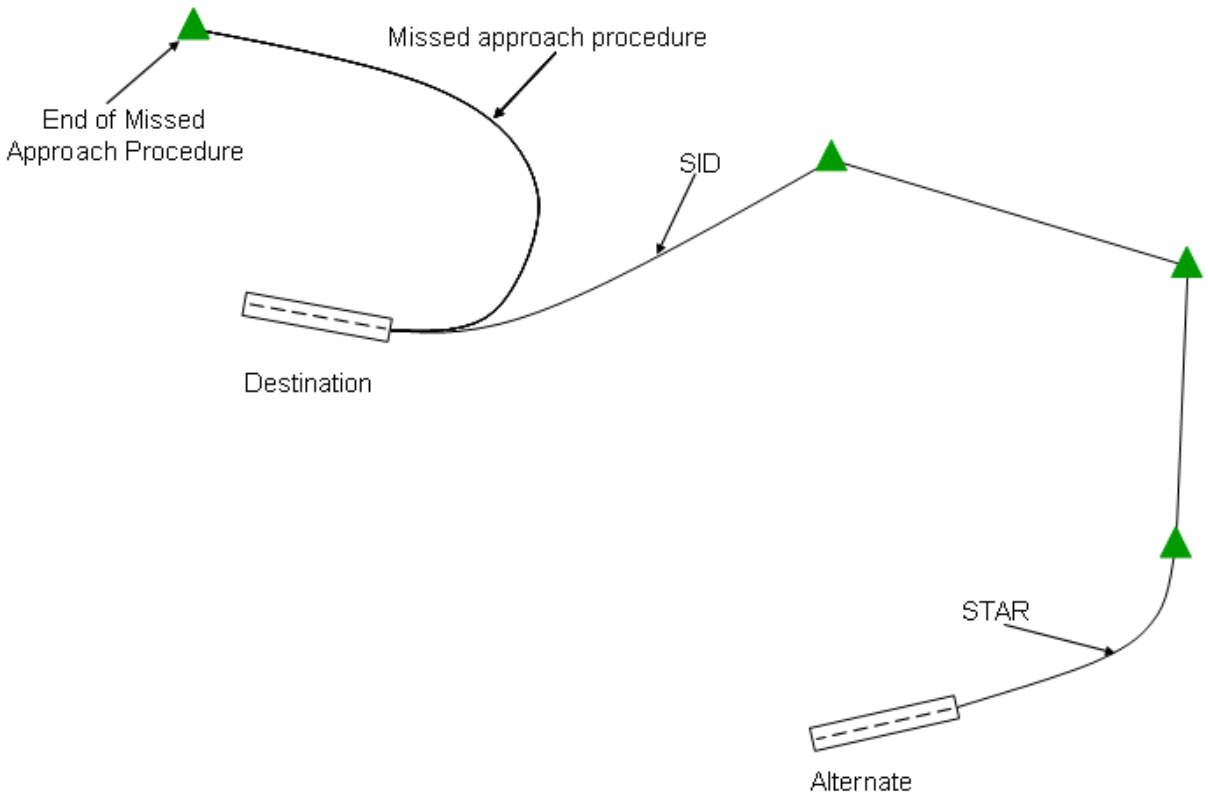


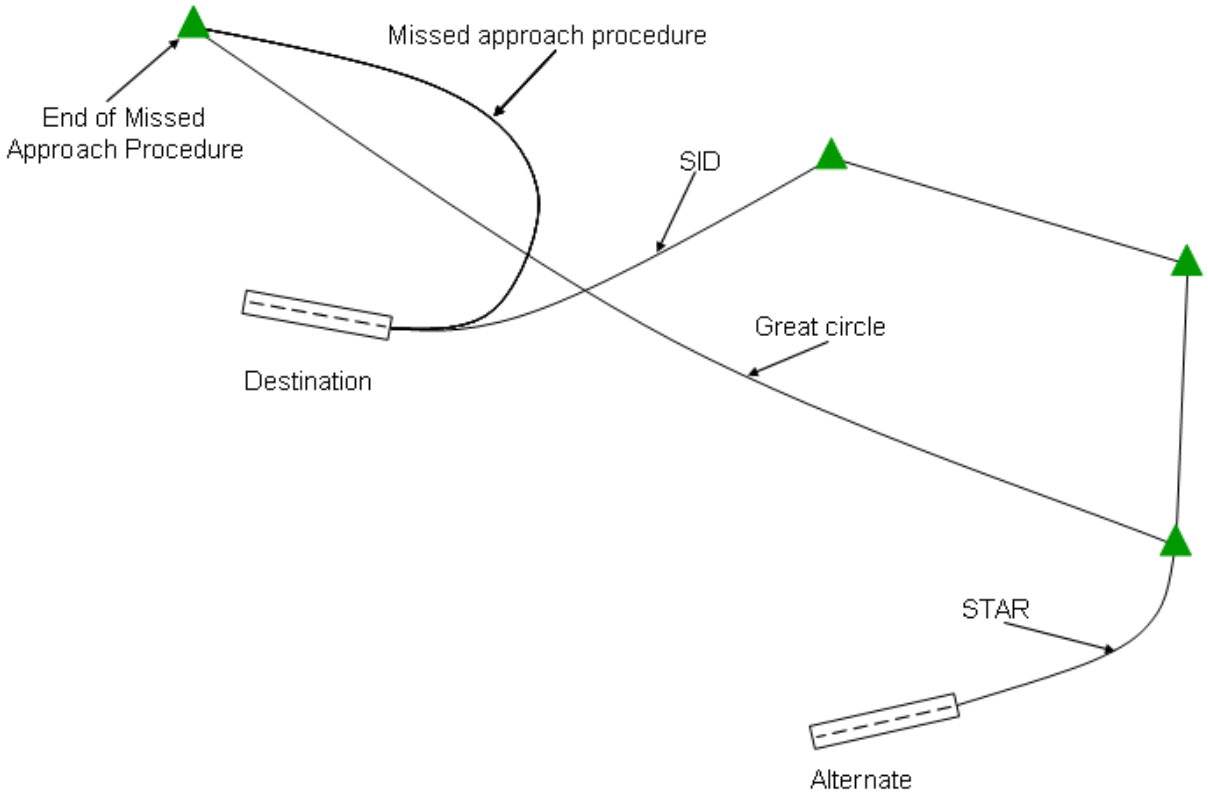
# Fuel policy - alternate fuel (JAR OPS 1.255)



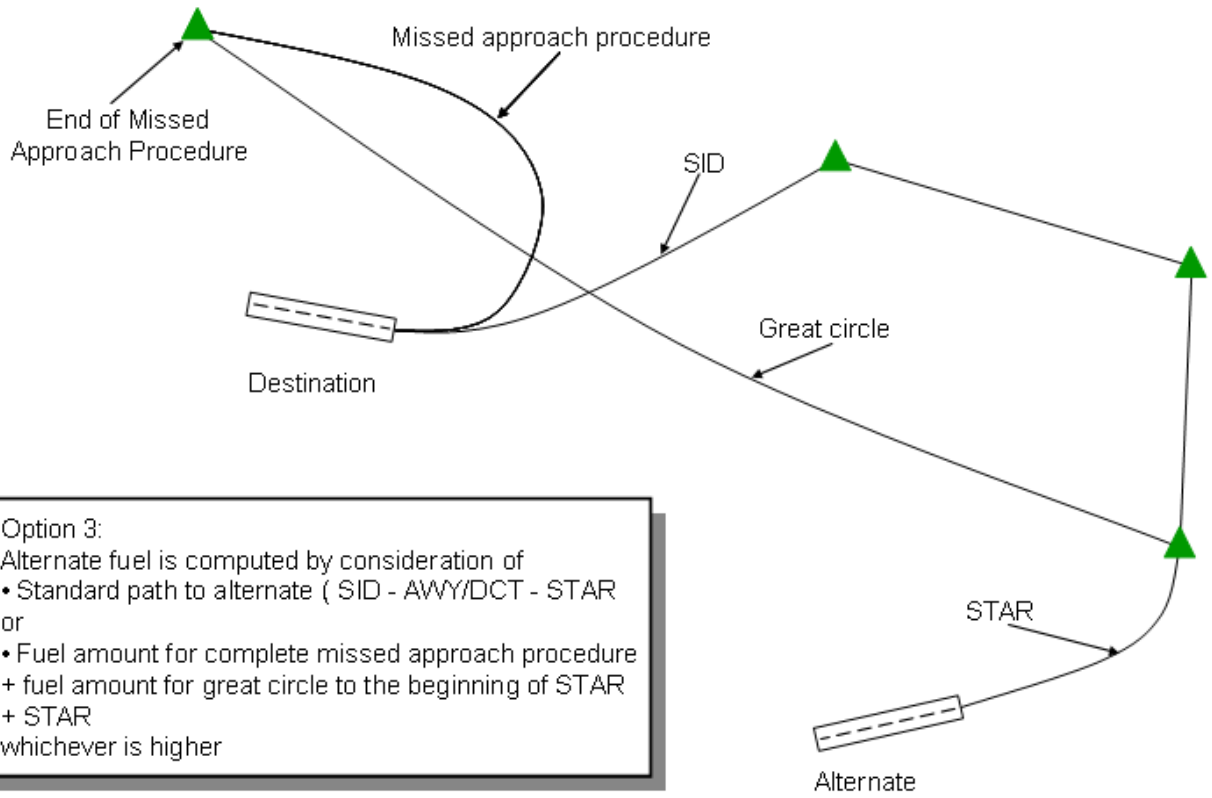
# Fuel policy - alternate fuel (JAR OPS 1.255)



# Fuel policy - alternate fuel (JAR OPS 1.255)



# Fuel policy - alternate fuel (JAR OPS 1.255)




Option 3:
Alternate fuel is computed by consideration of
• Standard path to alternate ( SID - AWY/DCT - STAR
or
• Fuel amount for complete missed approach procedure
+ fuel amount for great circle to the beginning of STAR
+ STAR
whichever is higher

Ende der Bildschirmpräsentation. Zum Beenden klicken.