A View from the Cockpit: Exploring Pilot Reactions to Attacks on Avionic Systems

Matt Smith[$], Martin Strohmeier[$†], Jonathan Harman, Vincent Lenders[†] and Ivan Martinovic[$]

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Network and Distributed Systems Symposium (NDSS) 2020

23-26th February 2020

Security Research in Aviation

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Wireless Attacks on Aircraft Instrument Landing Systems

Harshad Sathaye, Domien Schepers, Aanjhan Ranganathan, and Guevara Noubir
Khoury College of Computer Sciences
Northeastern University, Boston, MA, USA

USENIX 2019

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Ghost in the Air(Traffic): On insecurity of ADS-B protocol and practical attacks on ADS-B devices

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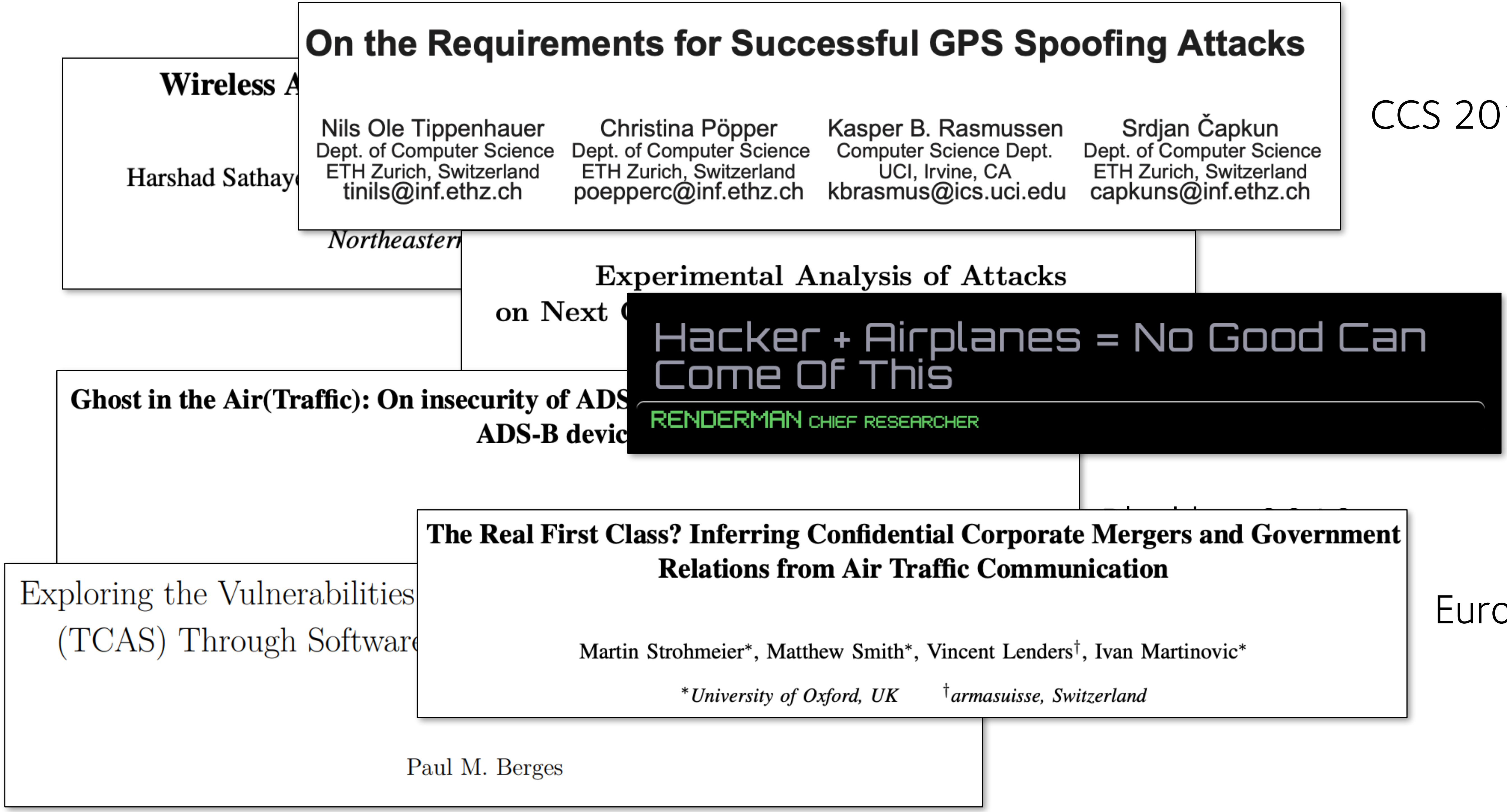
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Exploring the Vulnerabilities
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How well do pilots handle these attacks?

Last Line of Defence

Pilots are regularly assessed on their fault-handling abilities, usually in a flight simulator

Baltic Aviation Academy, Wikipedia [5]

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How well does fault-handling skill translate to attack mitigation?

Can we use flight simulation to understand the impact of attacks?

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Method

- We invited 30 currently type-rated A320 pilots to fly scenarios in our simulator

Photo of simulator set up

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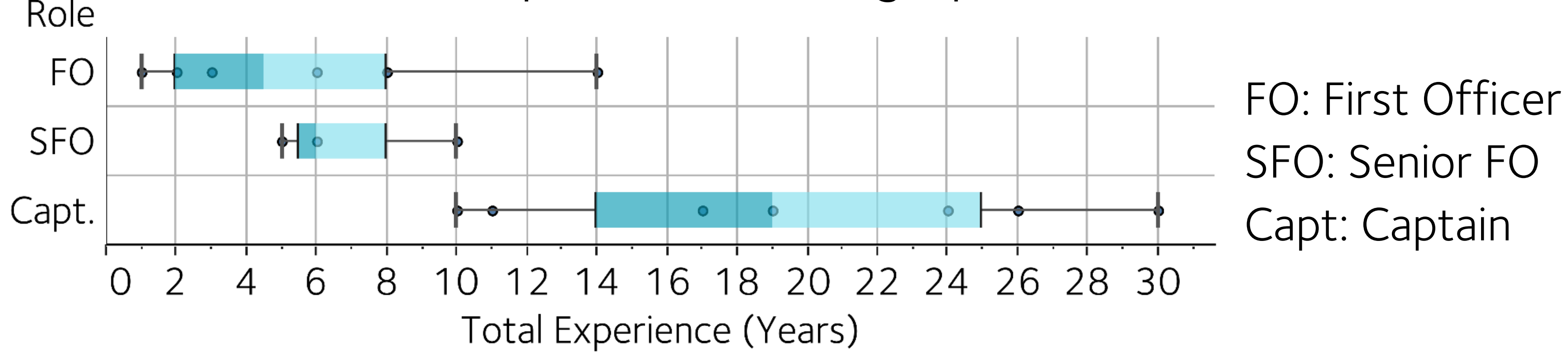
Experience demographics



Attacker Model

Capabilities

Motivation	Cause delay, financial loss, reputational harm or a reduction in safety

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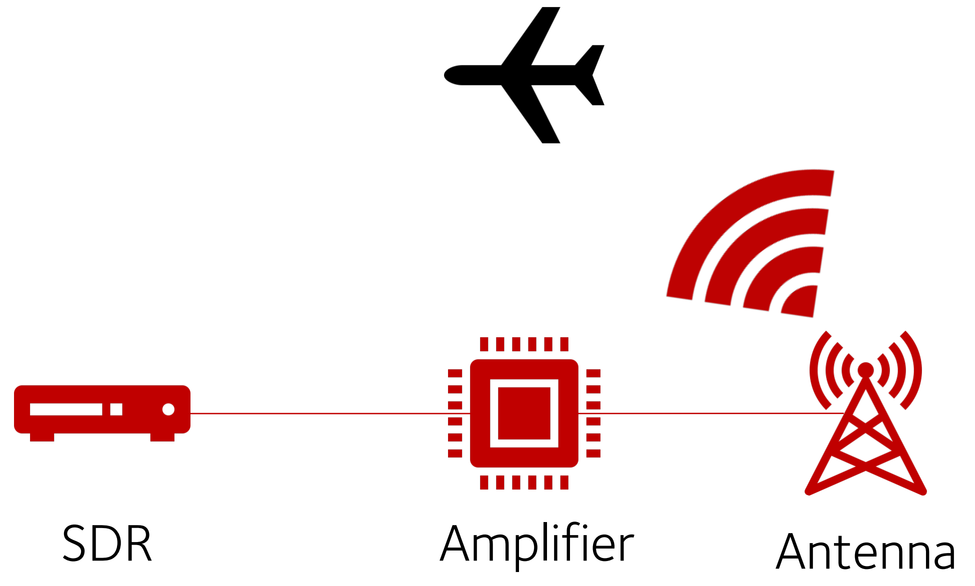
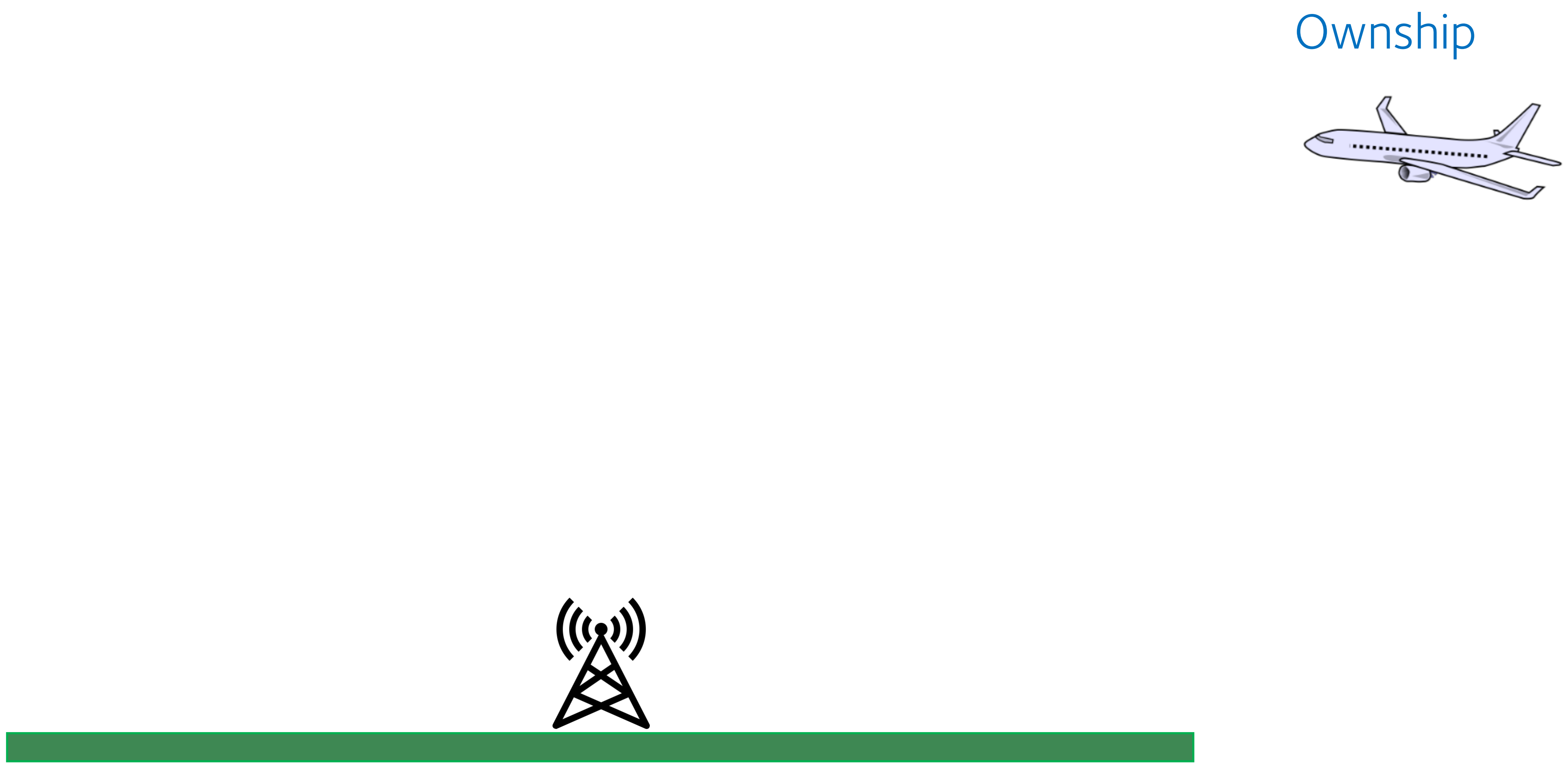


- Scientific-grade Software Defined Radio (SDR) e.g. Ettus USRP
- High-gain amplifier
- Directional antenna

Traffic Collision Avoidance System

TCAS aims to prevent mid-air collisions by automatically de-conflicting potential close-encounters



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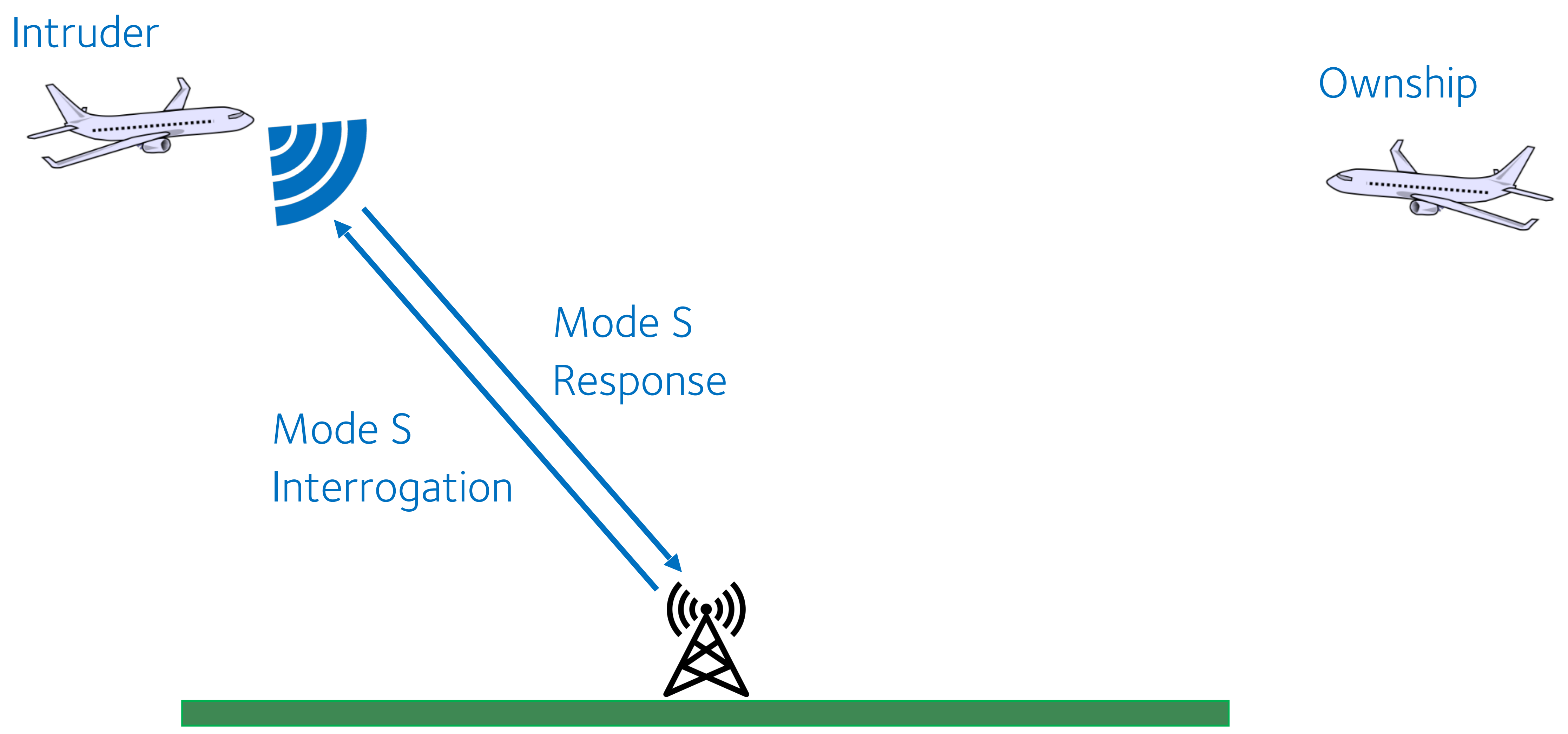

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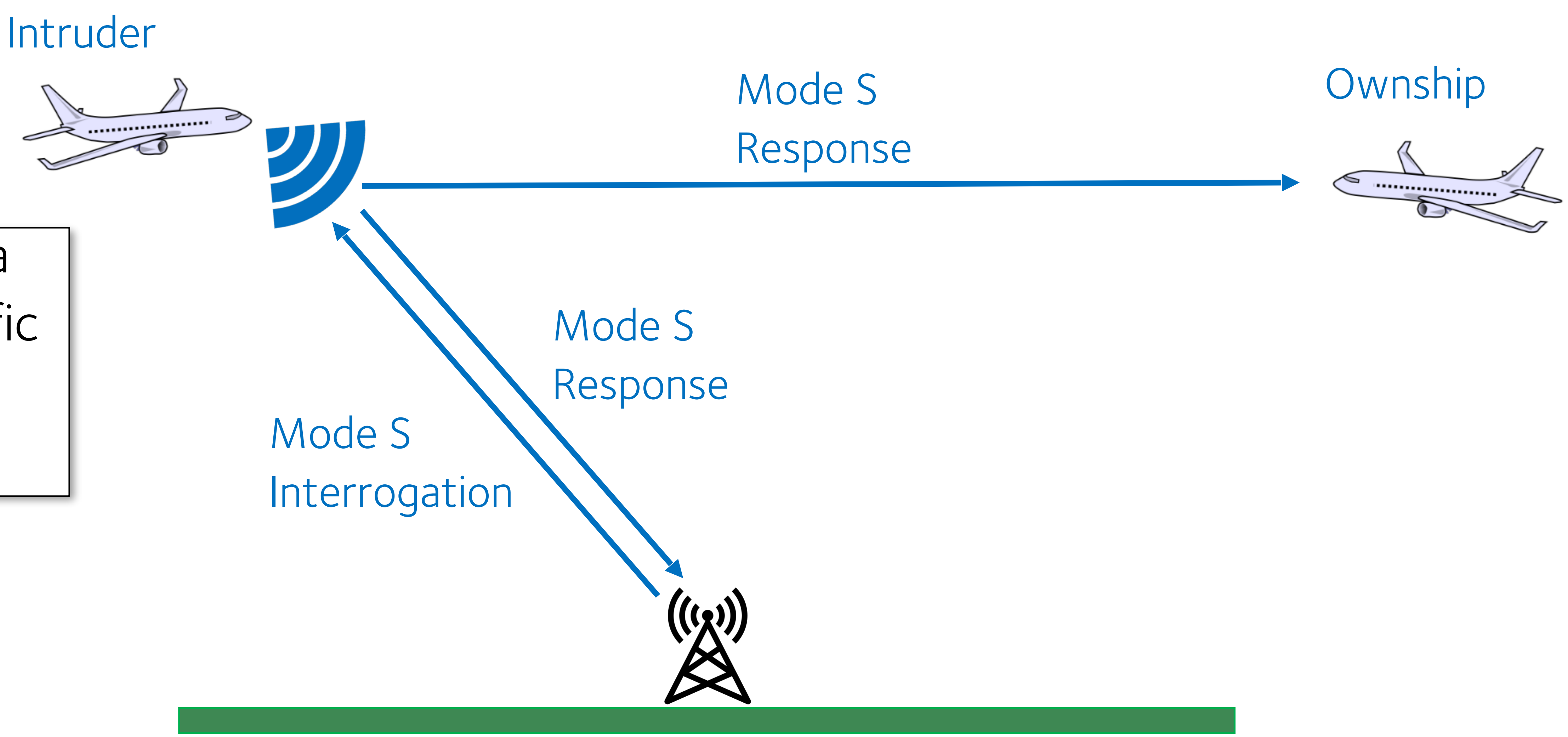

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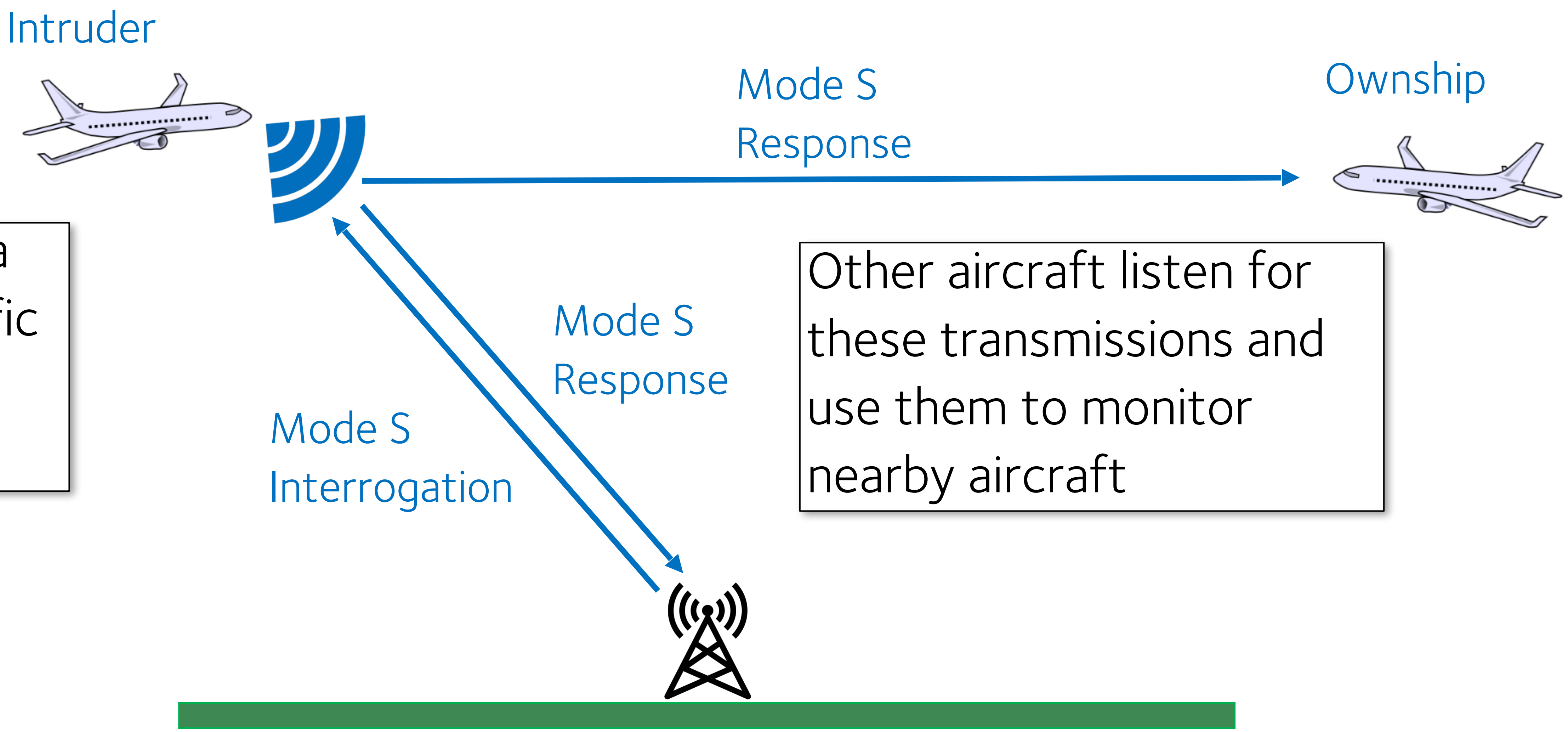

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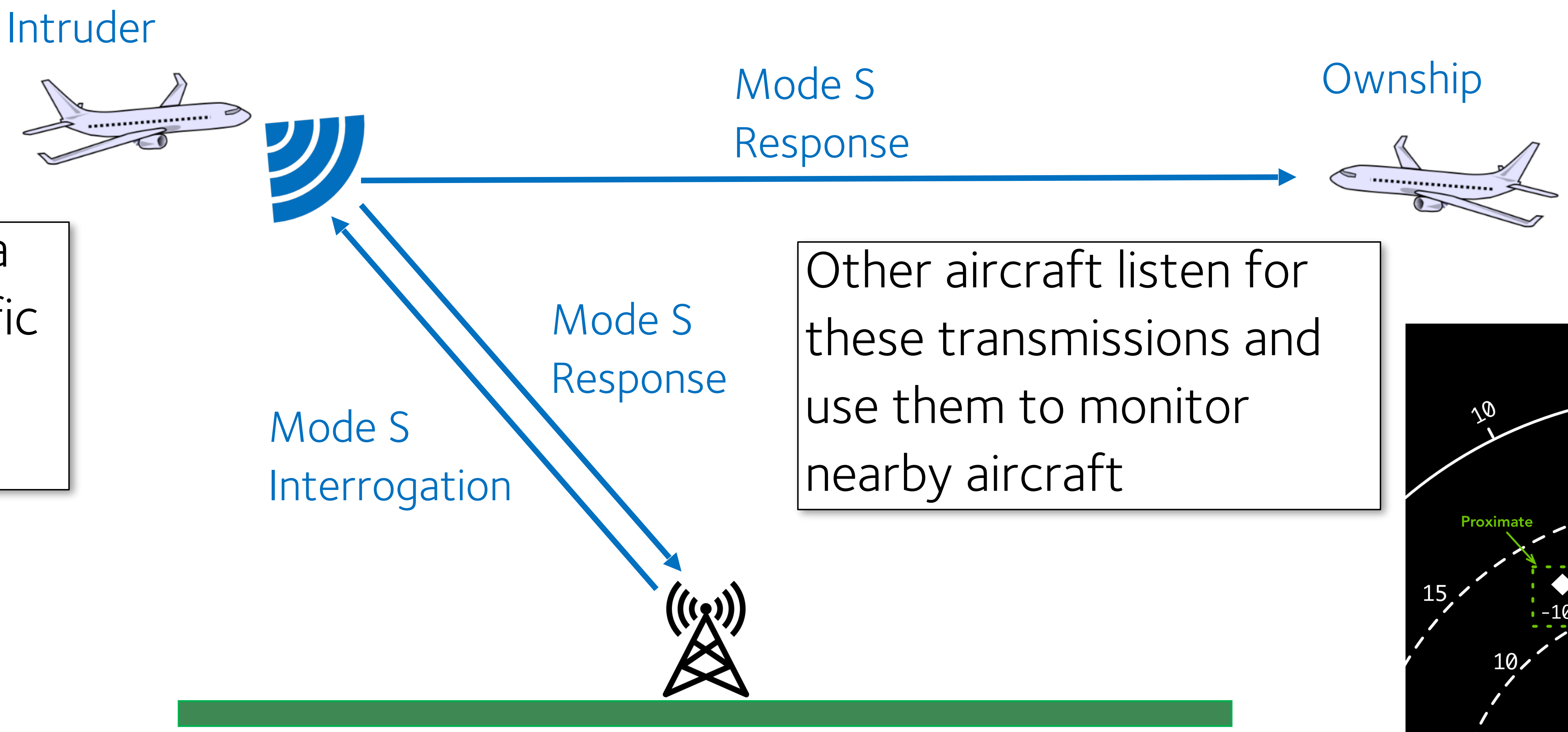

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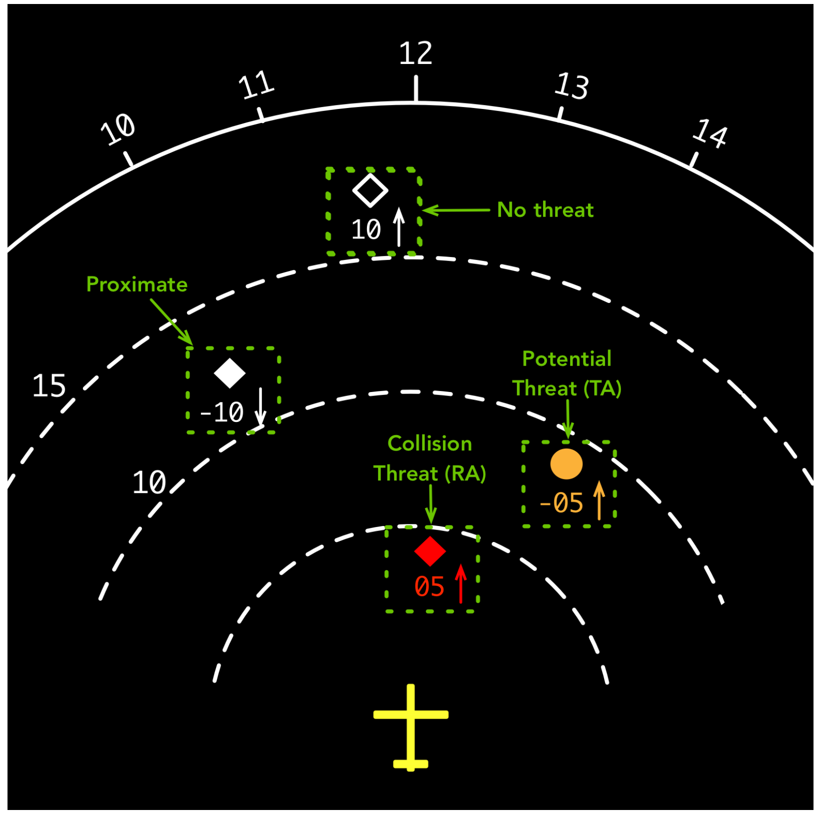

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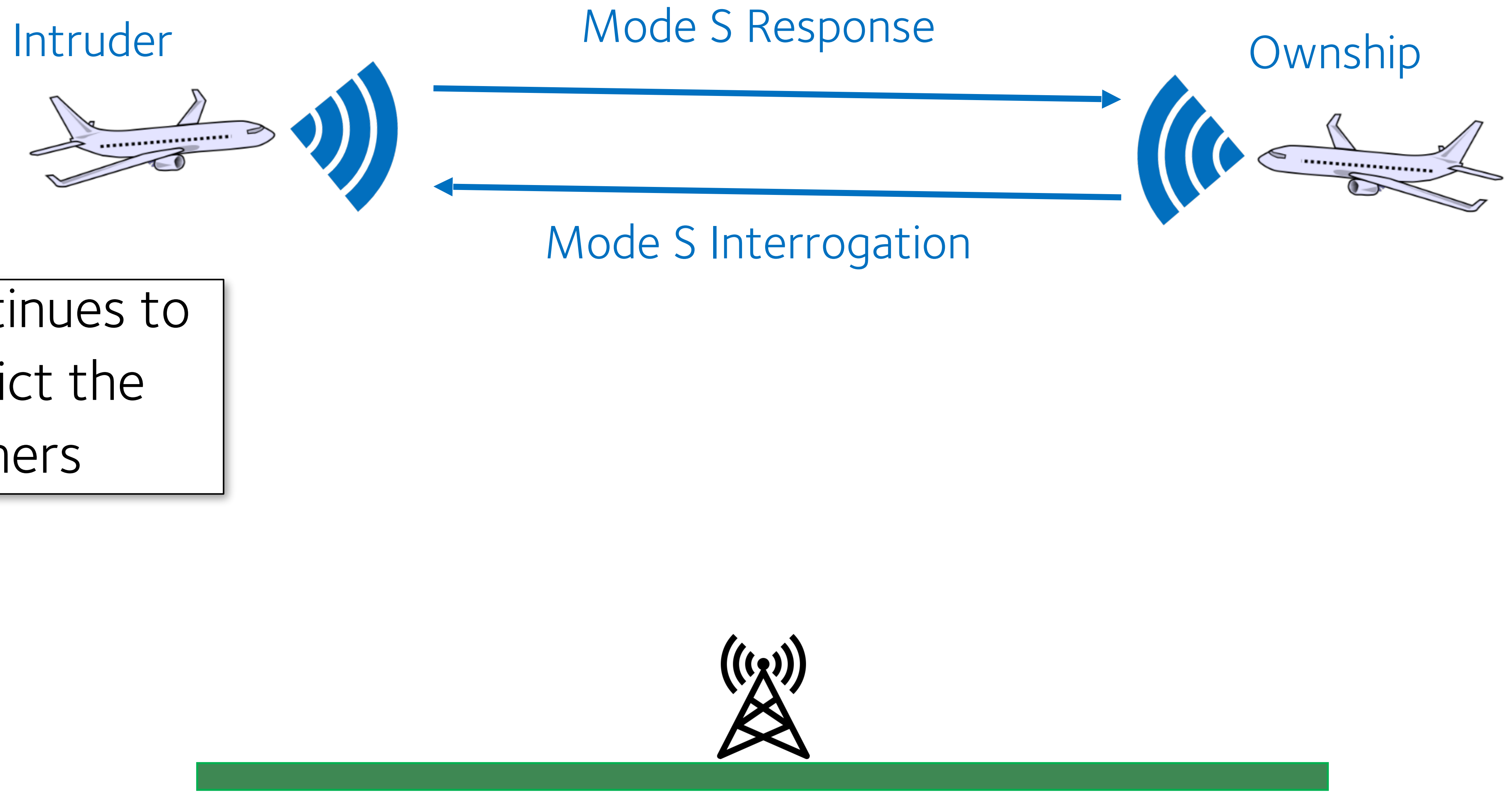

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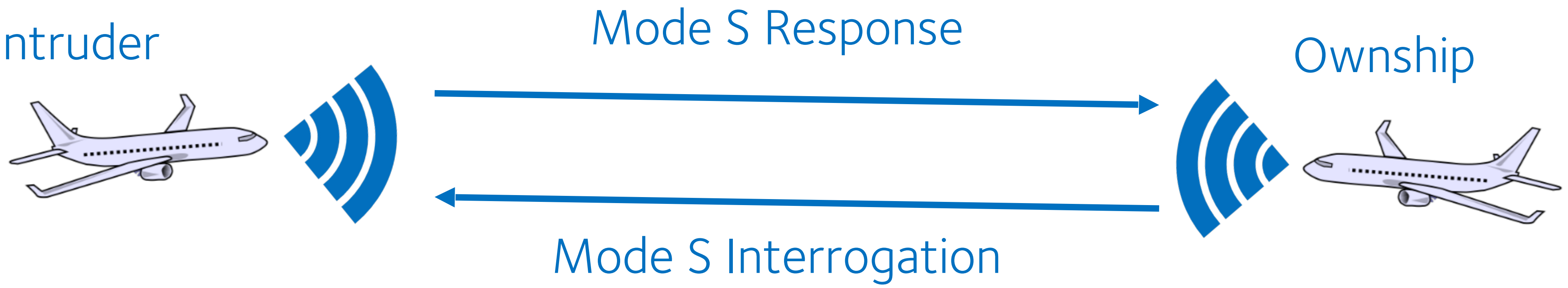

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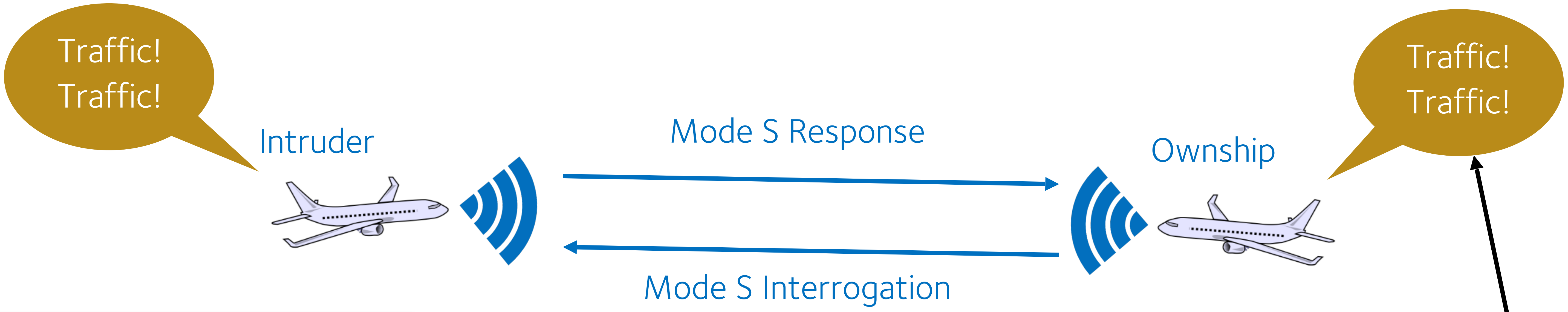

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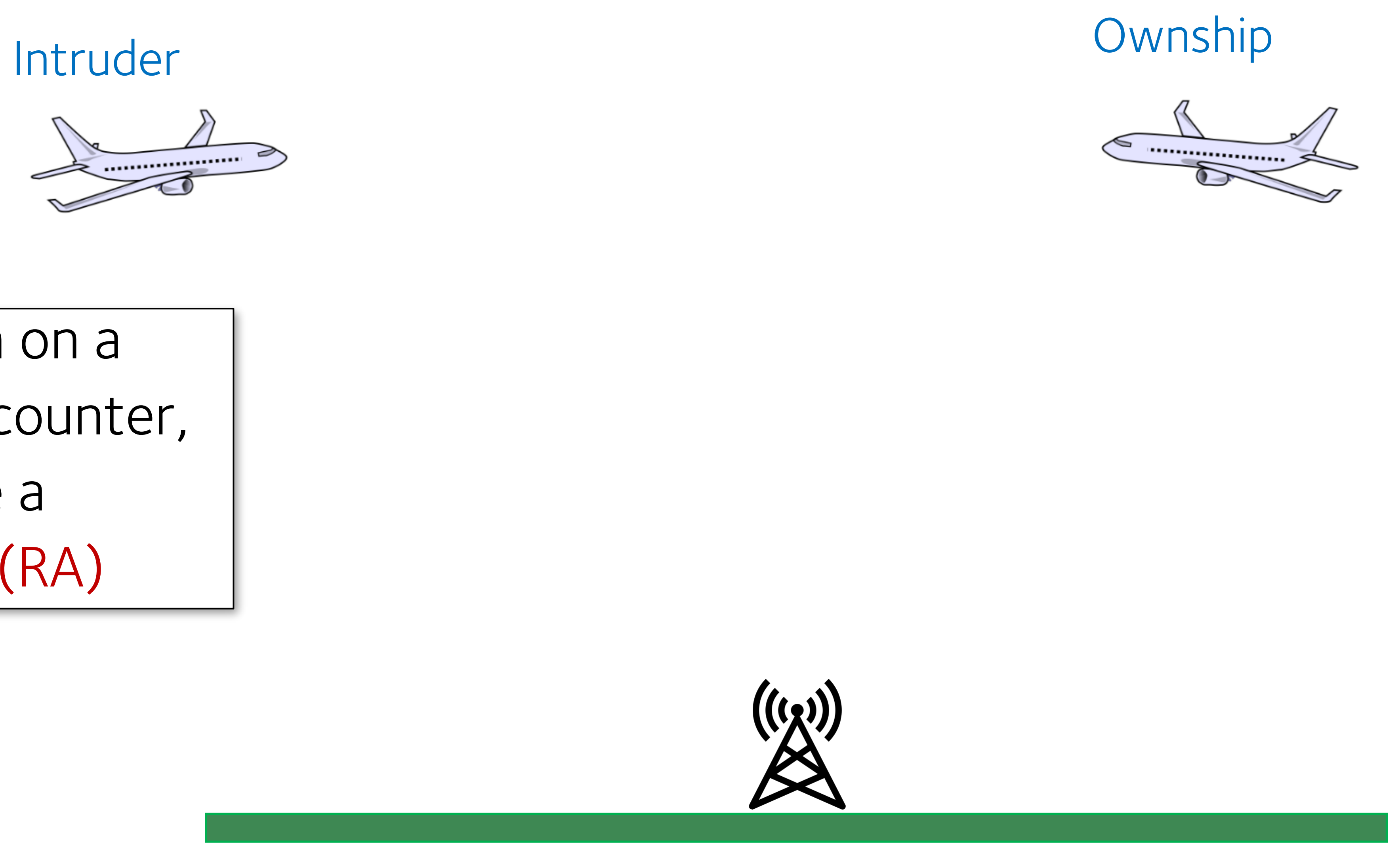

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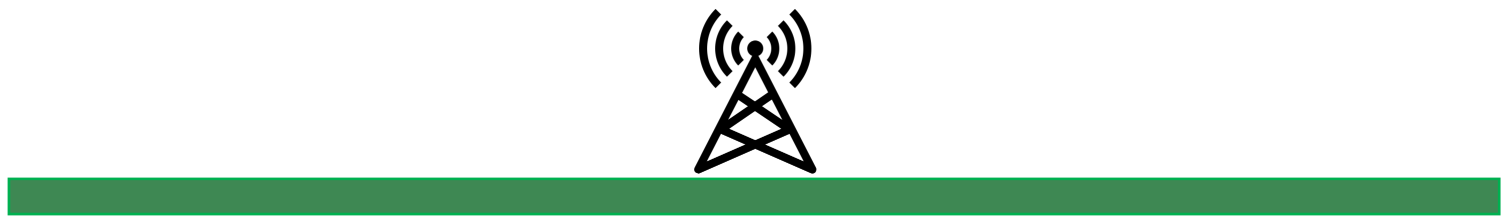

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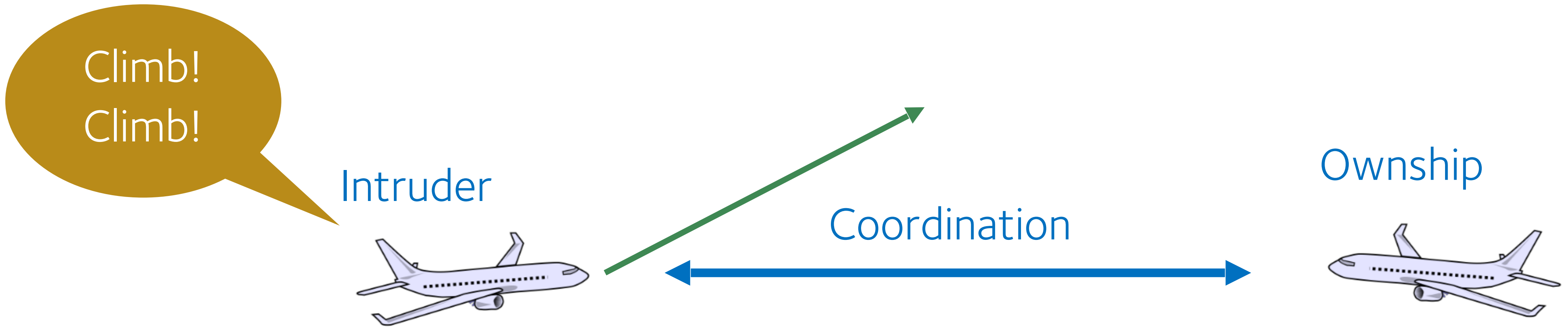

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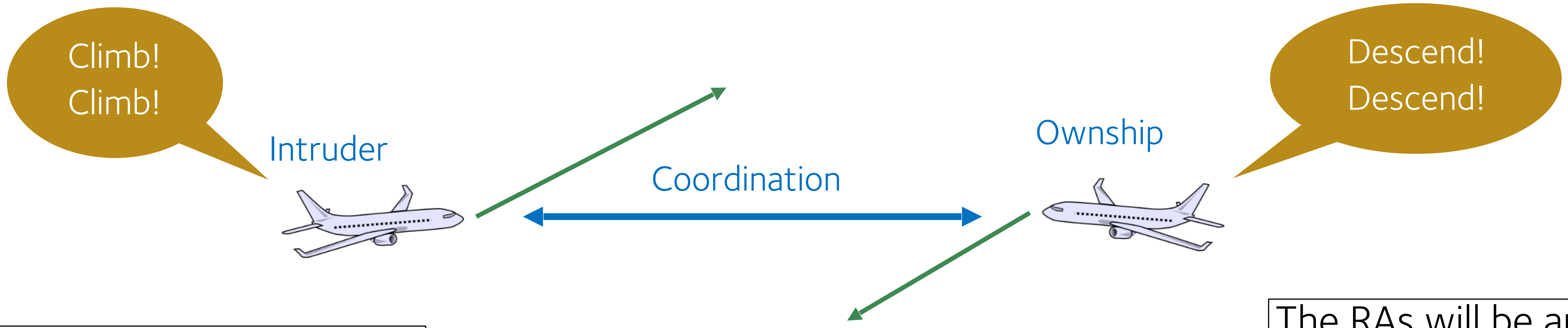

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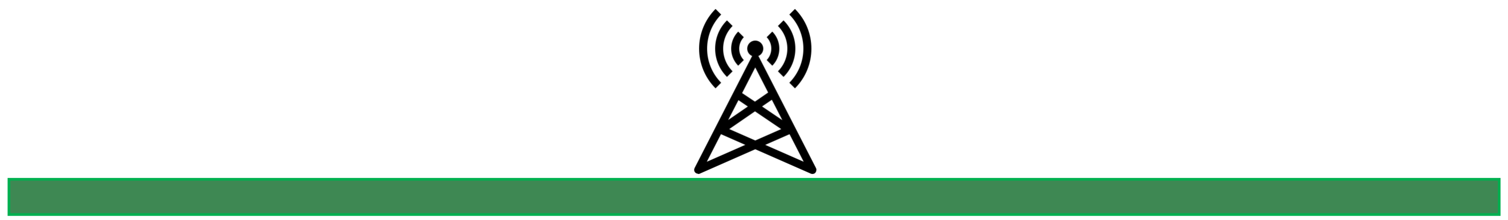

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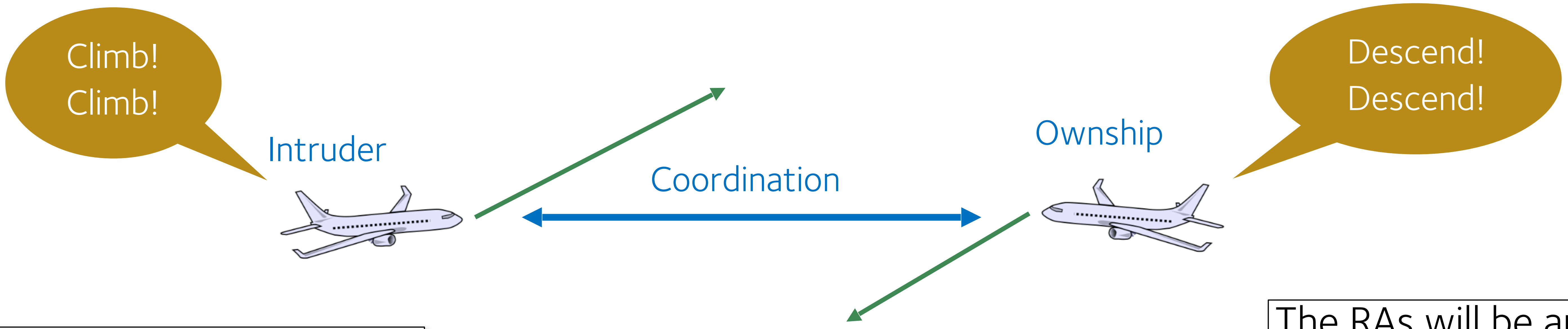

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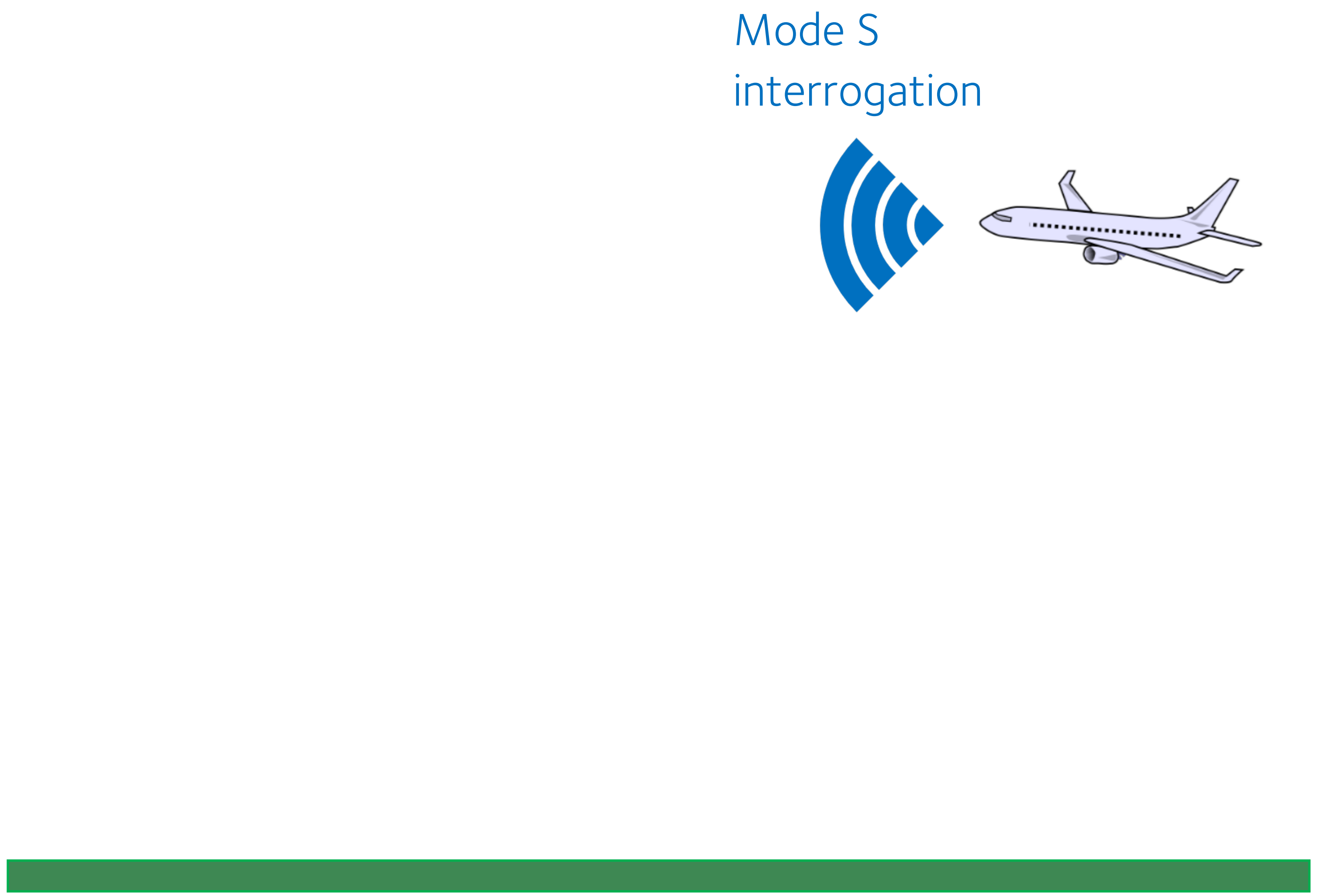
TCAS procedure broadly expects aircraft to be cooperative

TCAS – Attack

- Mode S has been shown to be insecure in previous work by Costin, Schäfer [3]



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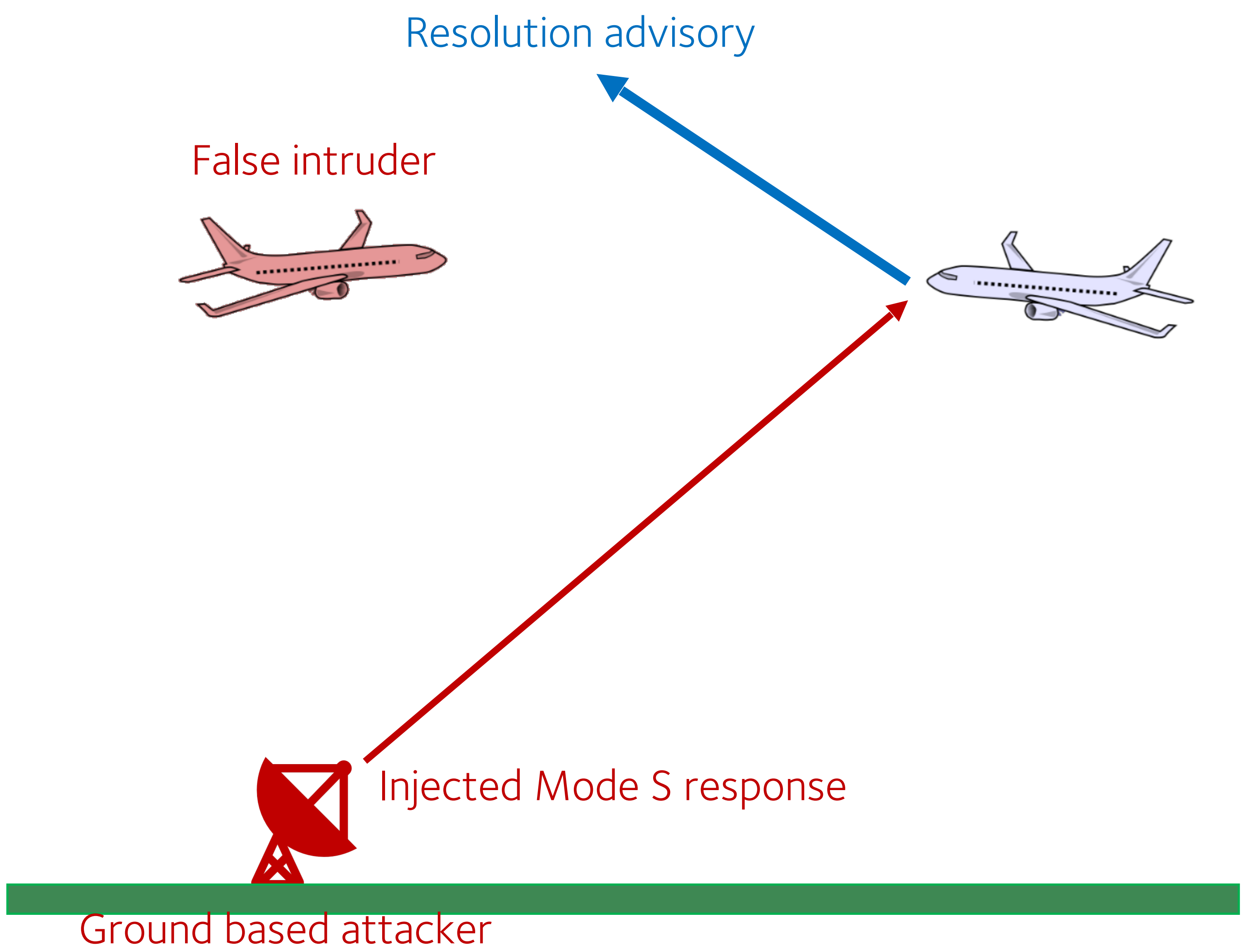

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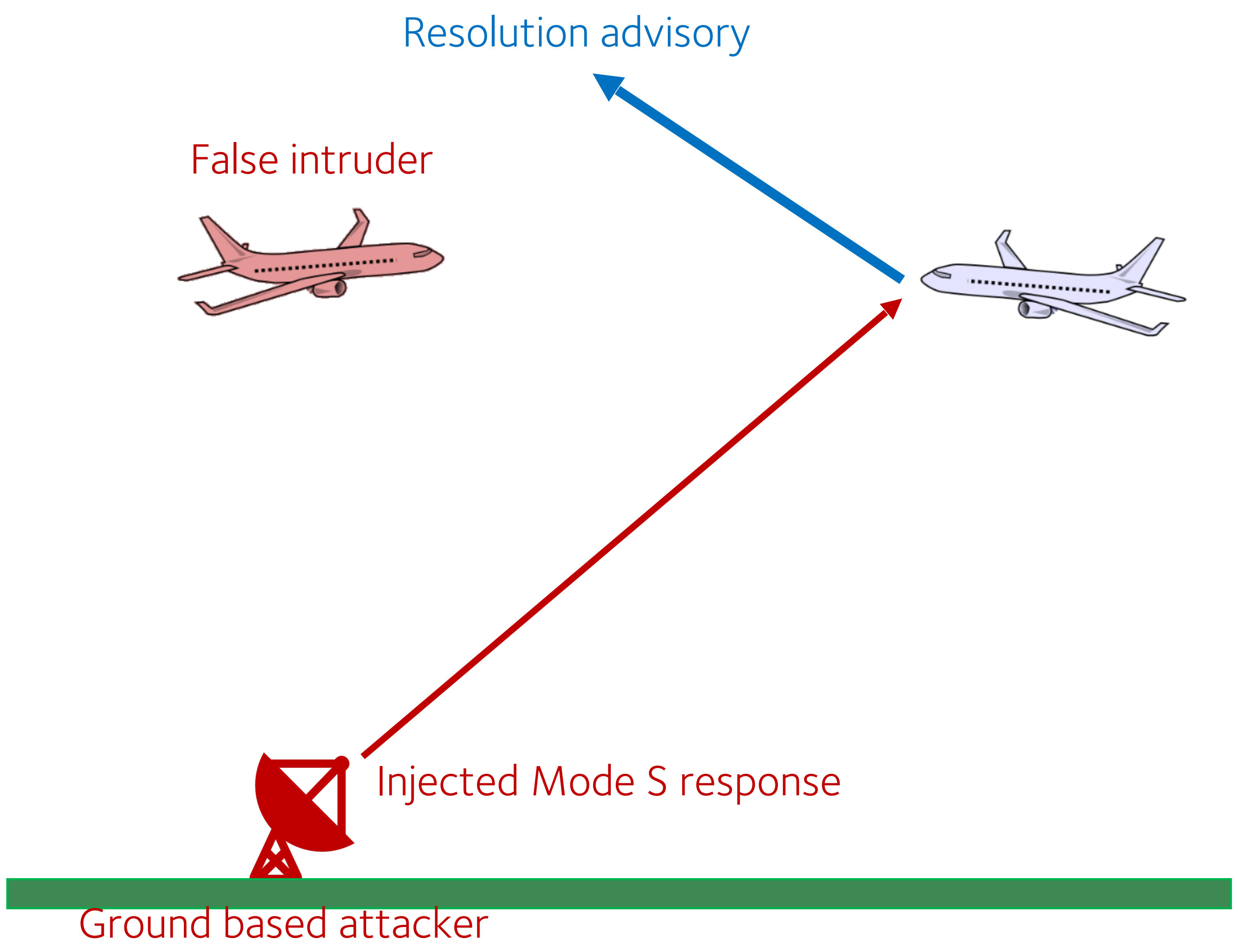

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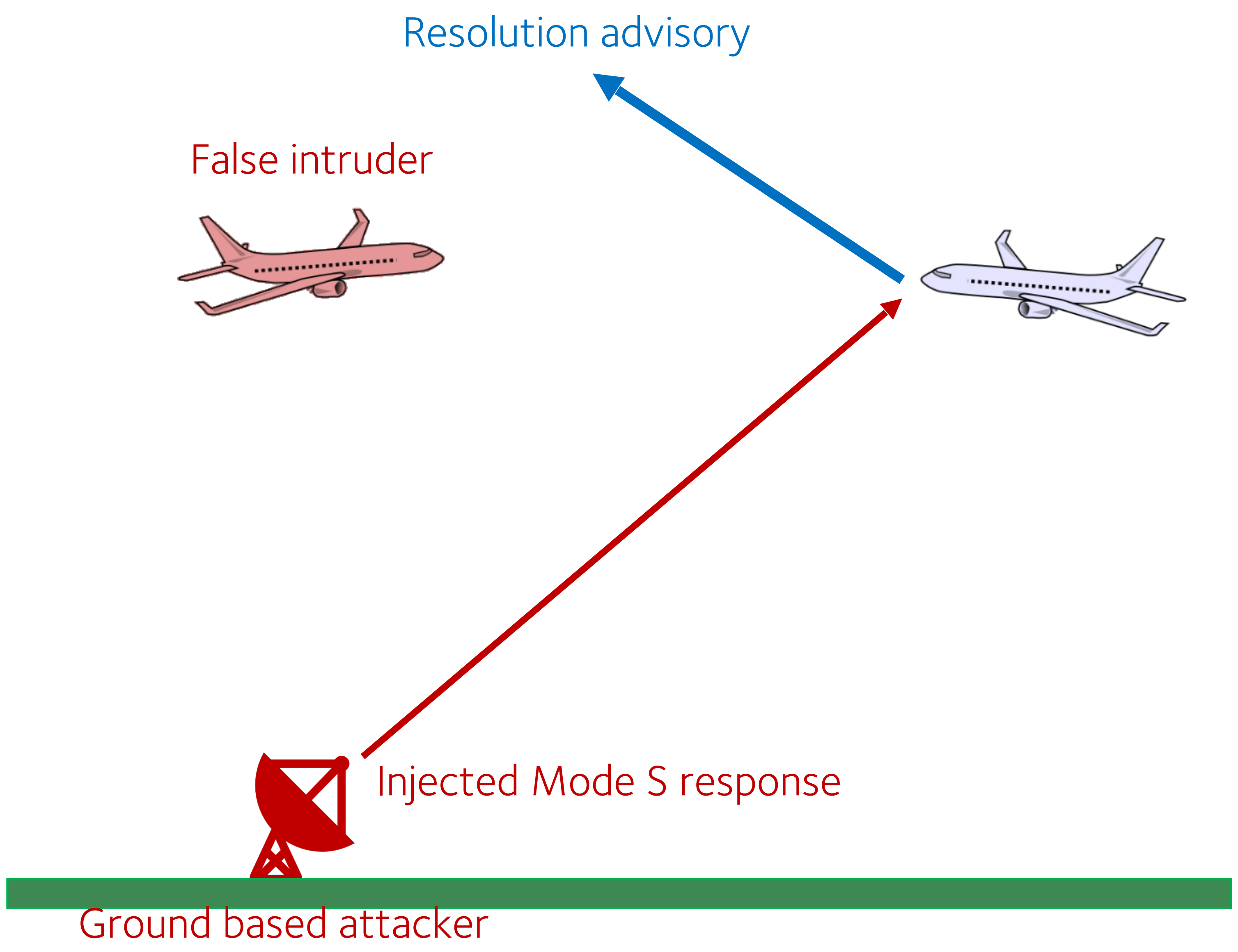

Aim: Force aircraft to repeatedly fly unwarranted Resolution Advisories

TCAS – Results

- Pilots found the repeated RAs so distracting that 26 (87%) pilots reduced the sensitivity of TCAS, with 11 switching to 'Standby'
  - TA-Only after 4.5 RAs, Standby after a further 2.8 RAs

	Final Selected TCAS Mode			Total
	TA/RA	TA-Only	Standby	
Continue on route	4	10	8	22
Avoidance Maneuver	0	3	3	6
Divert to Origin	0	2	0	2
Total	4	15	11	30

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- Attacker can push pilots to fly unnecessary RAs and reduce TCAS sensitivity

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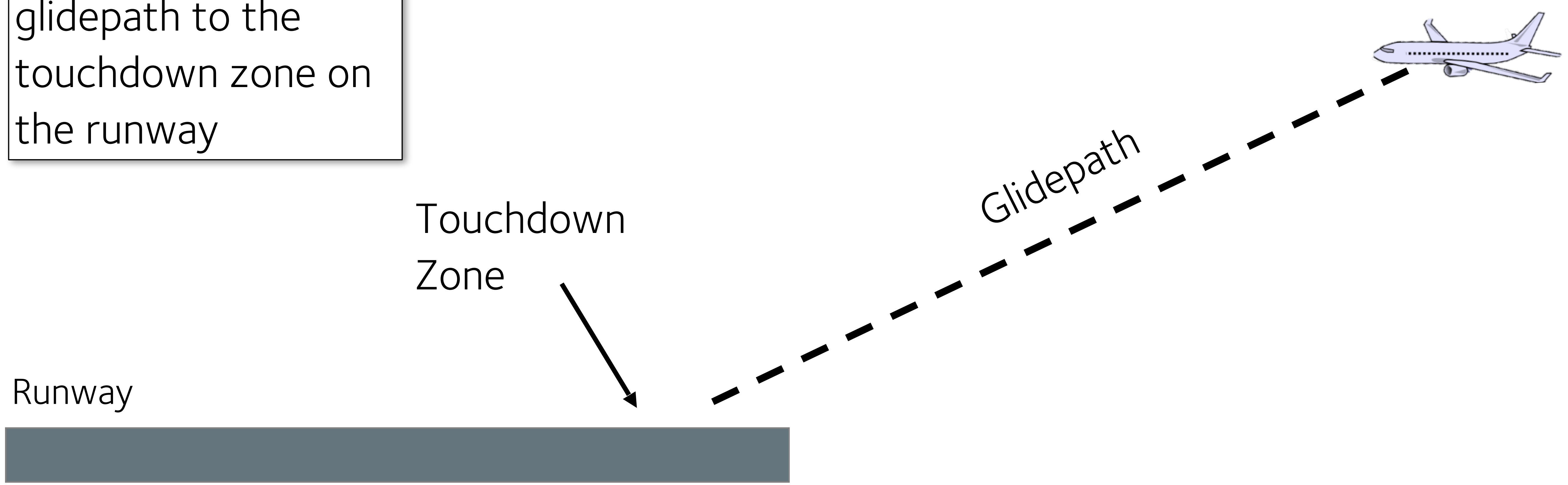
- Pilots forced to reduce sensitivity of key safety system due to distraction

A participant highlighted a 'crying wolf' effect, which might impact future responses to TCAS

Instrument Landing System

Aircraft follow a glidepath to the touchdown zone on the runway



Instrument Landing System

Glideslope – a part of ILS – provides guidance along the ideal glidepath using overlapping lobes

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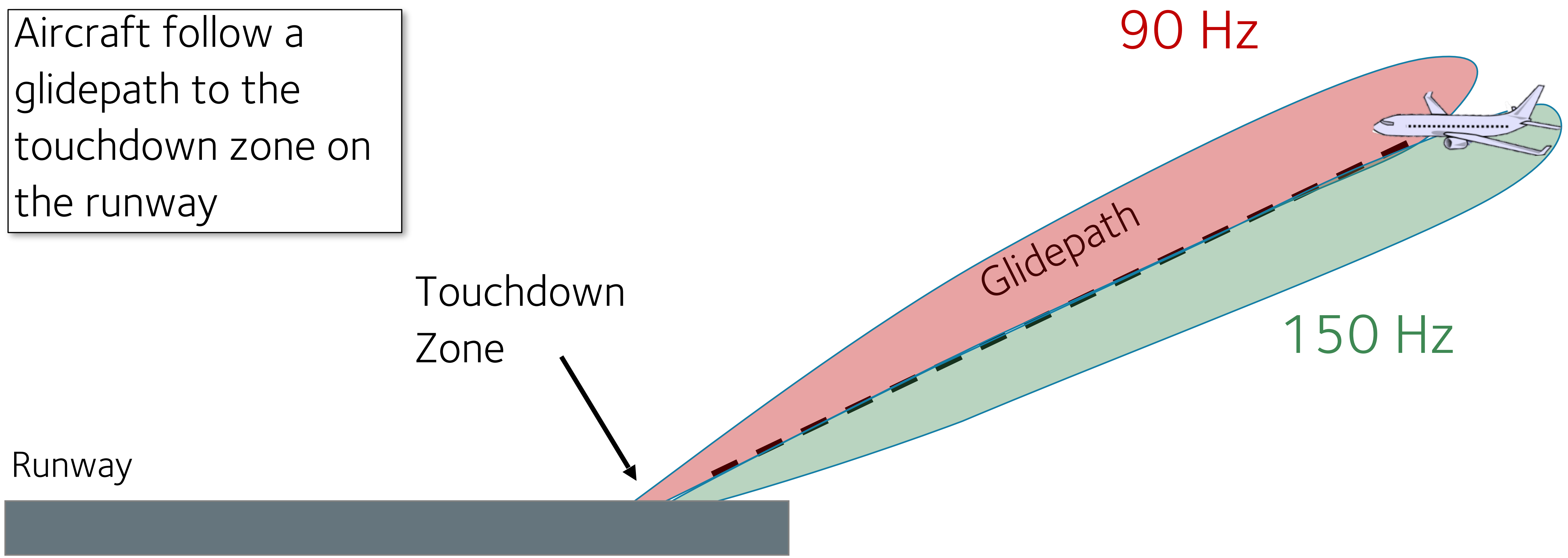
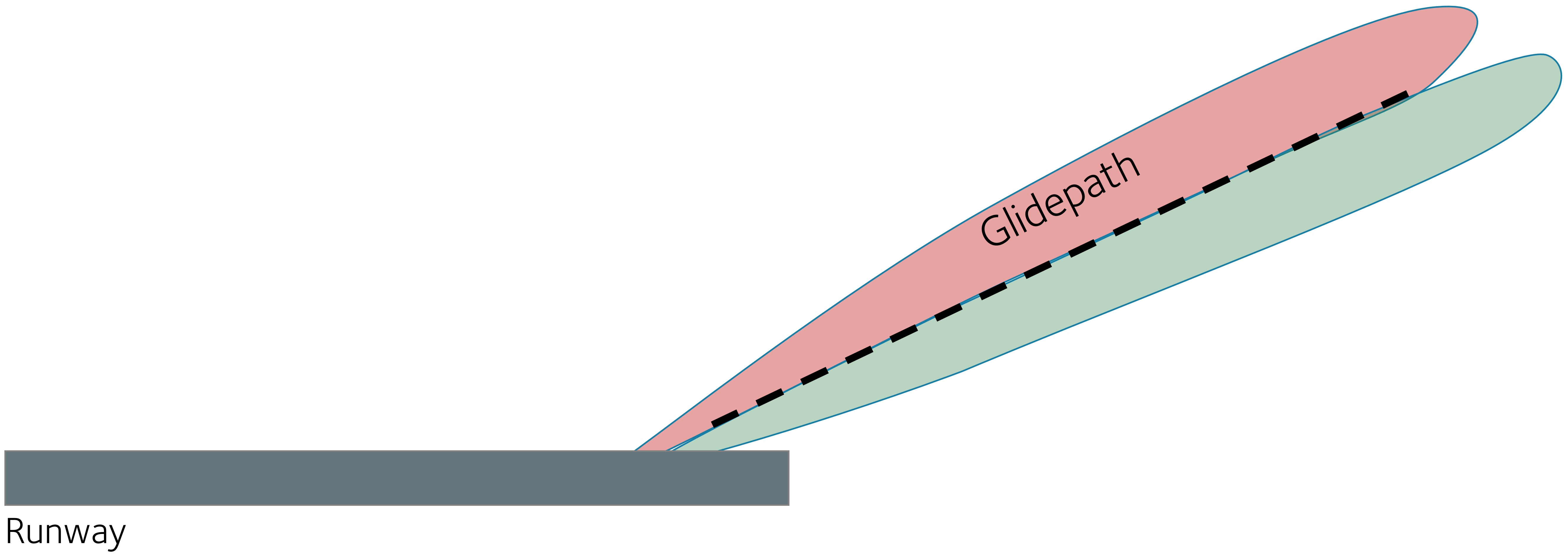
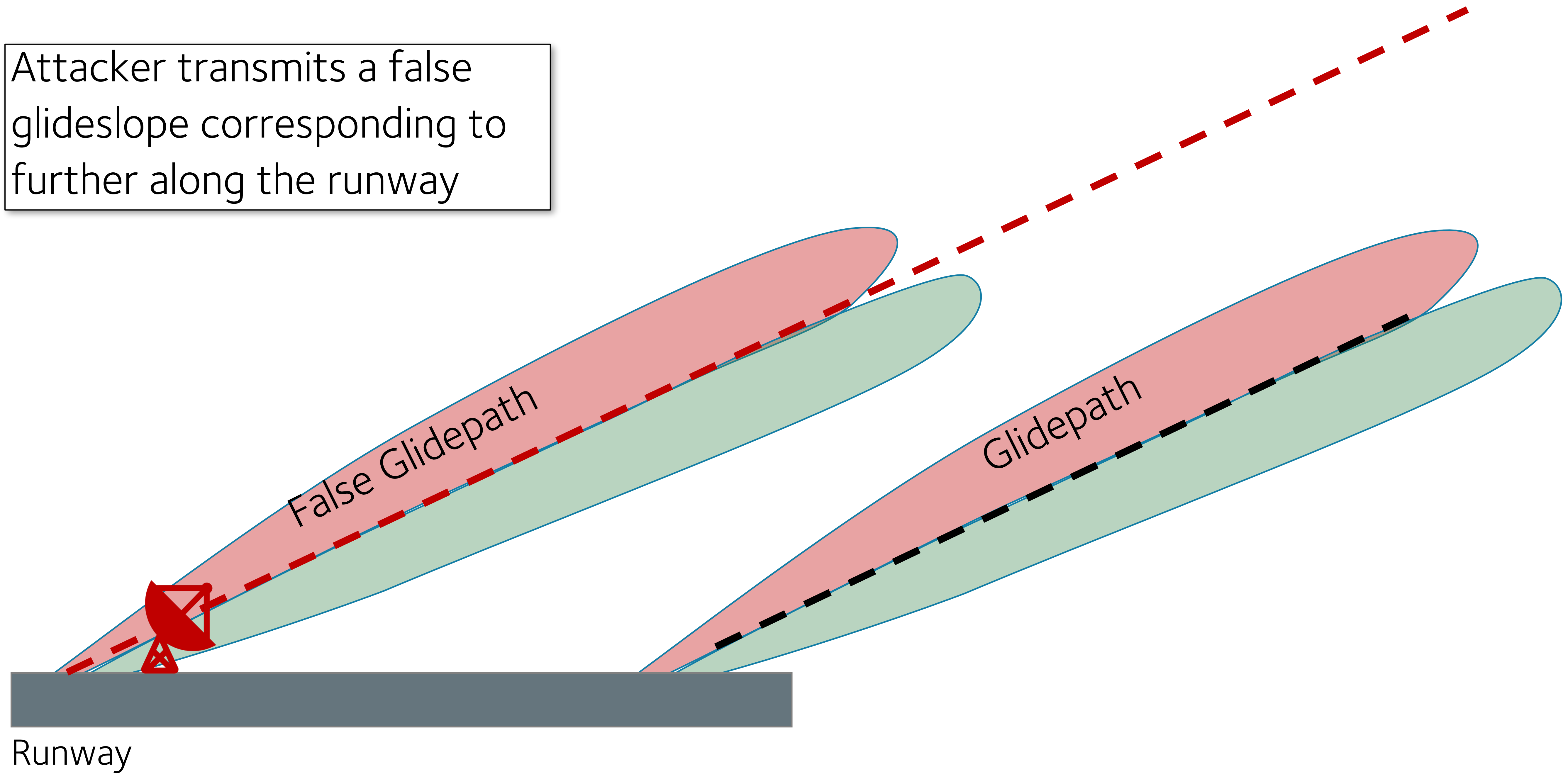


Glideslope – Attack



GLIDESLOPE – ATTACK

Attacker transmits a false glideslope corresponding to further along the runway



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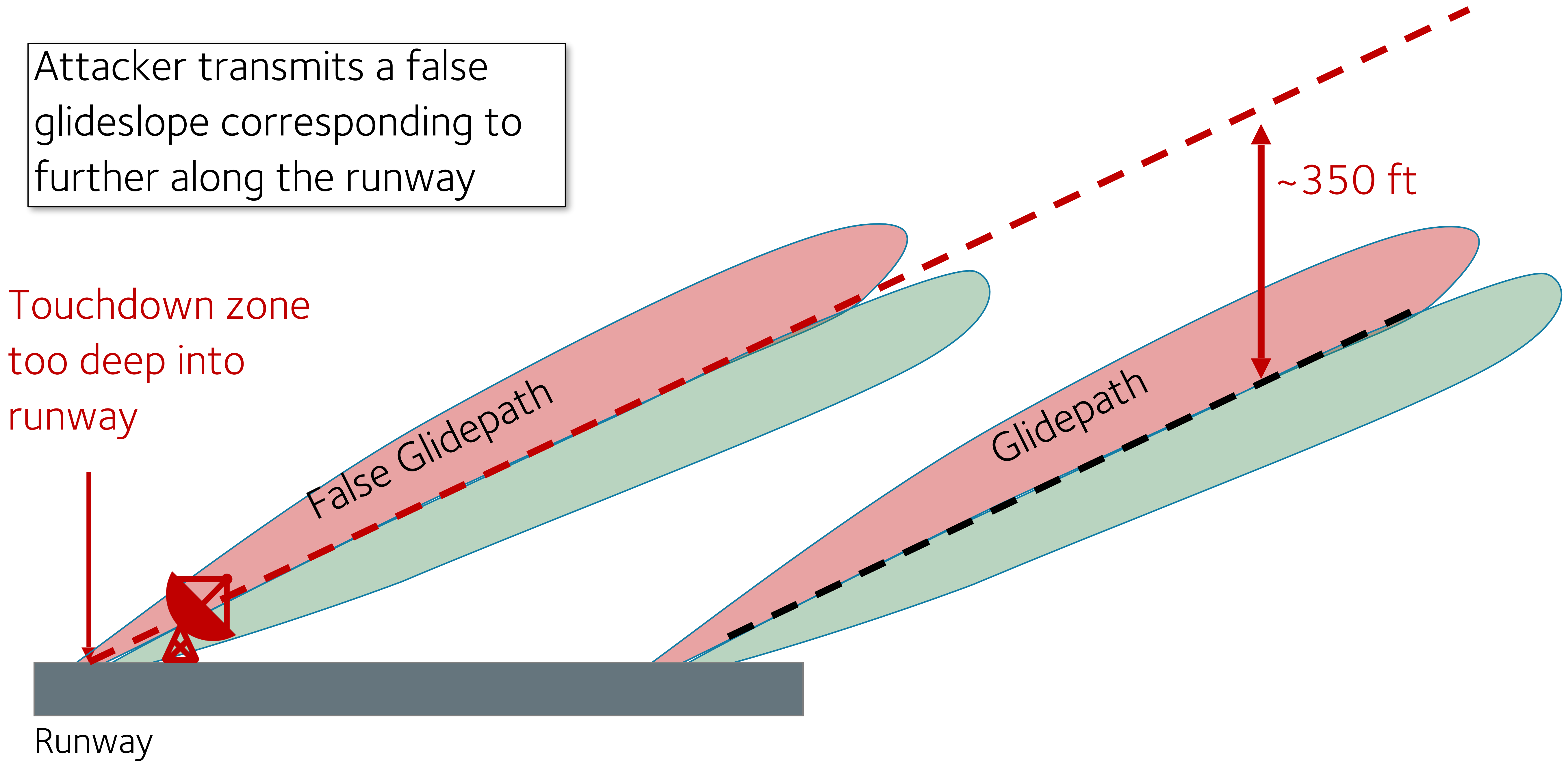

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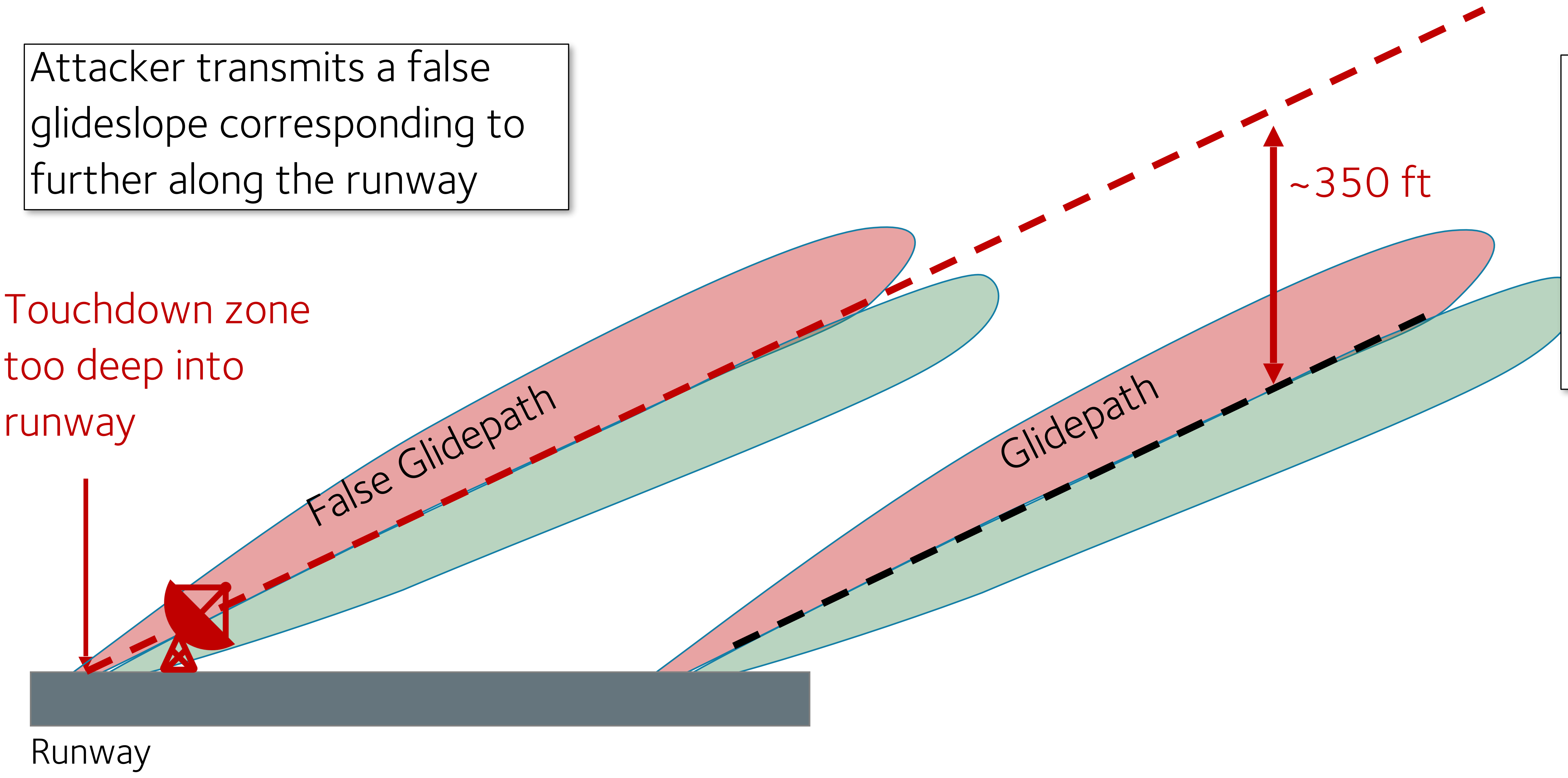

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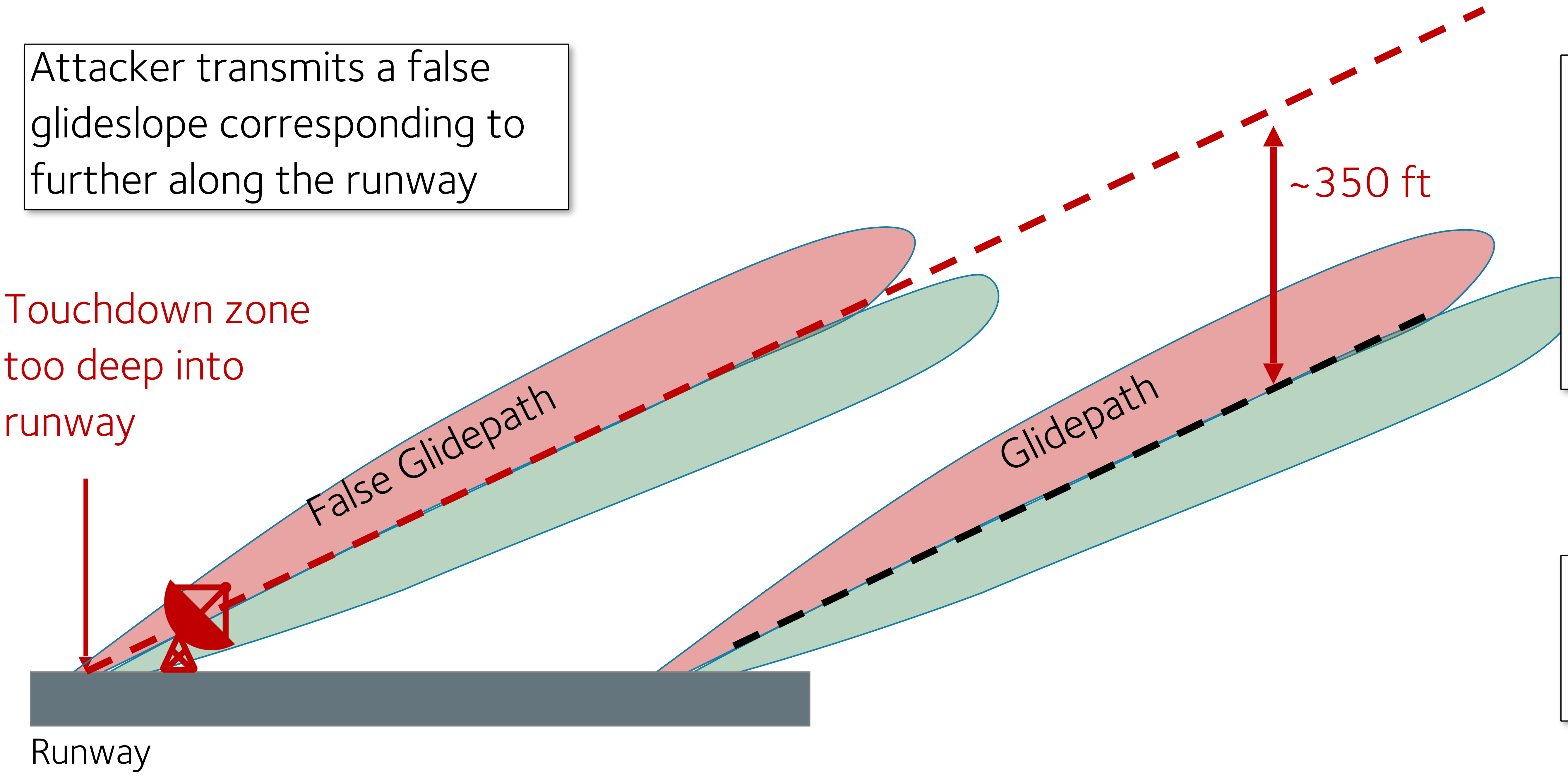

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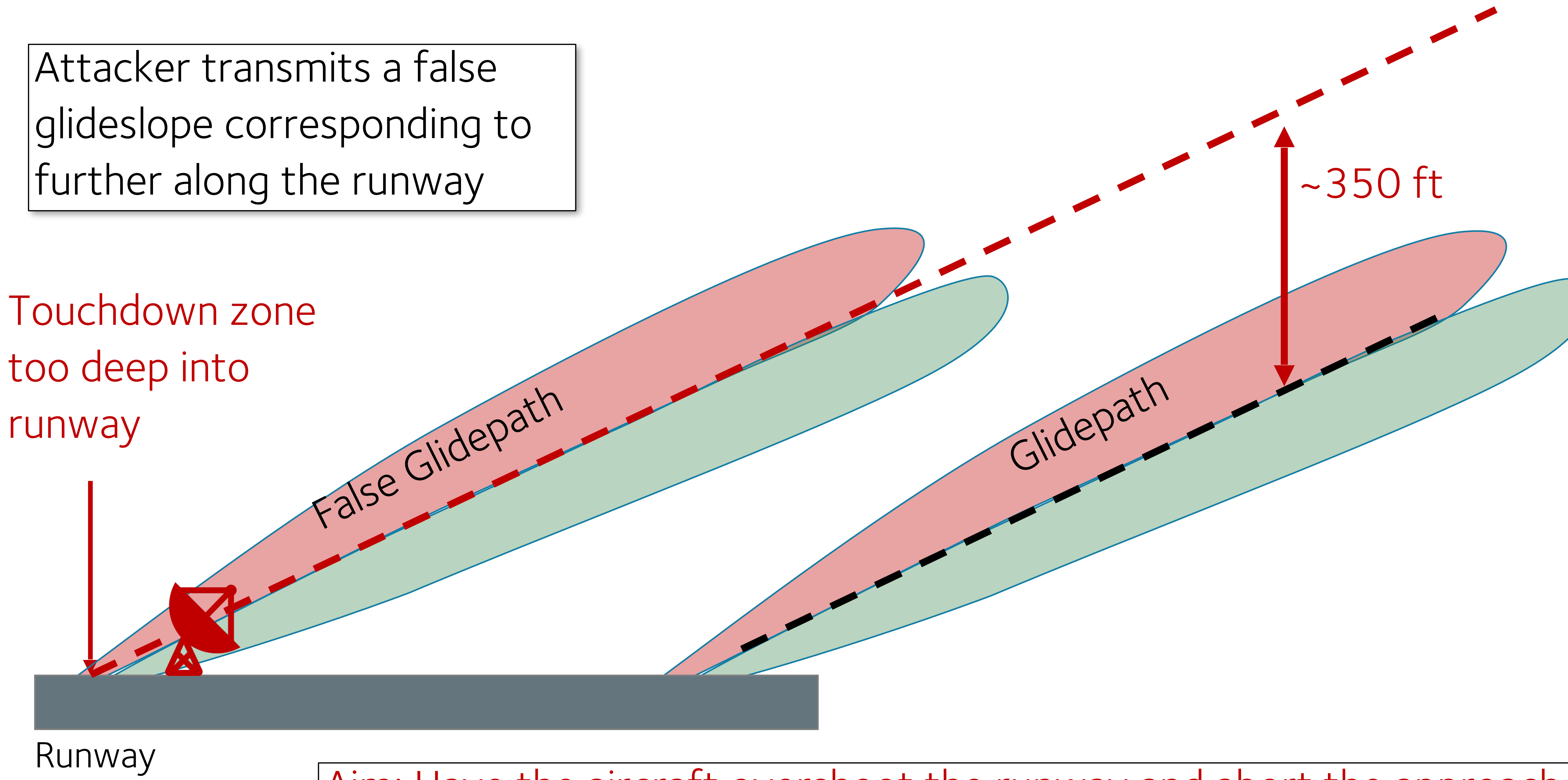

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Aim: Have the aircraft overshoot the runway and abort the approach or land deep

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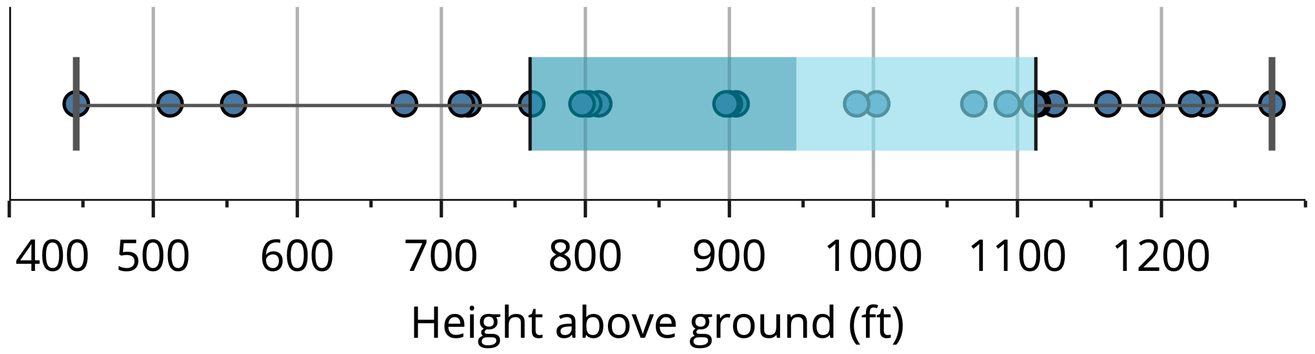
Box plot of heights at the point of deciding to go around on the first approach



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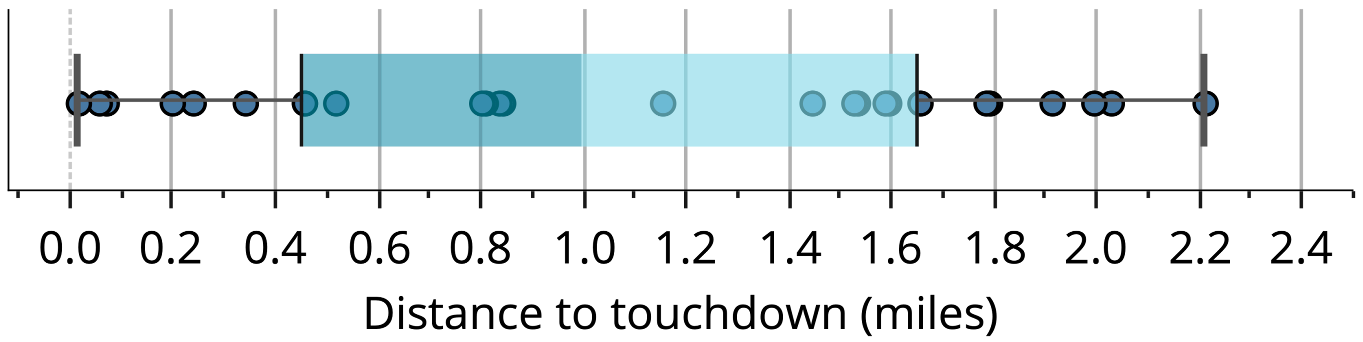

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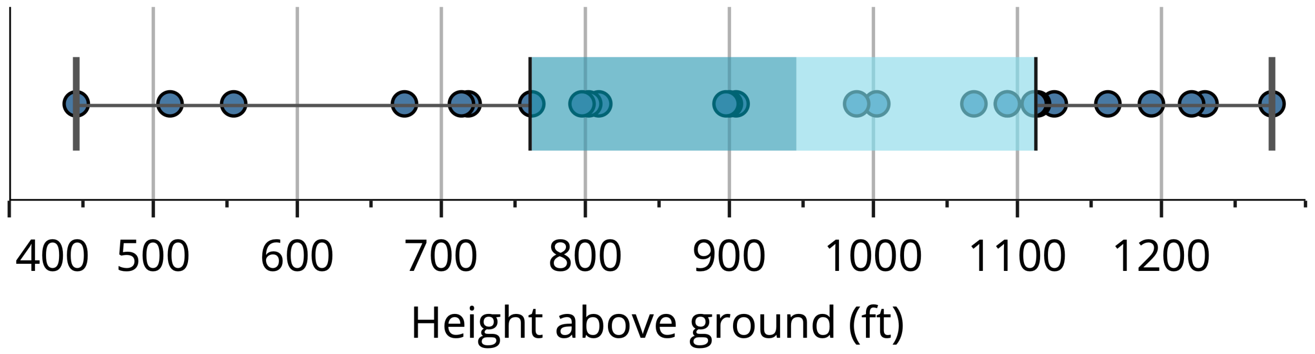

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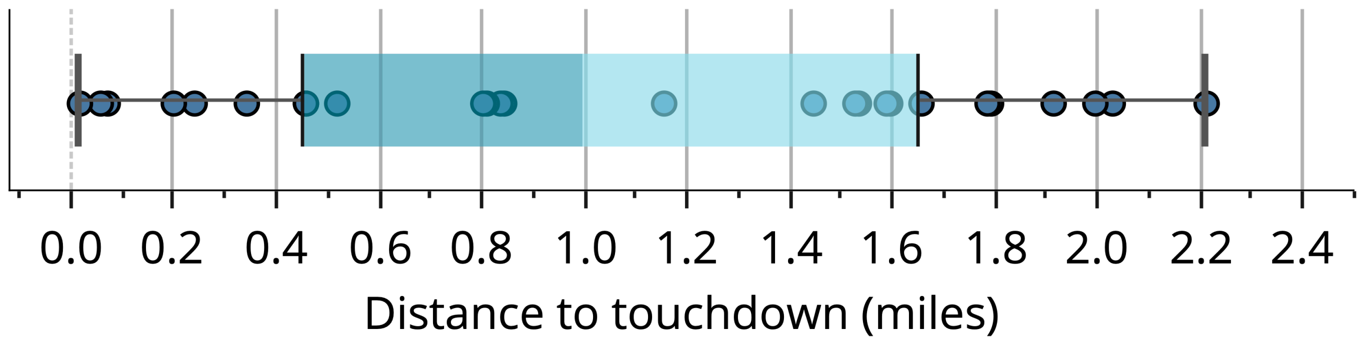

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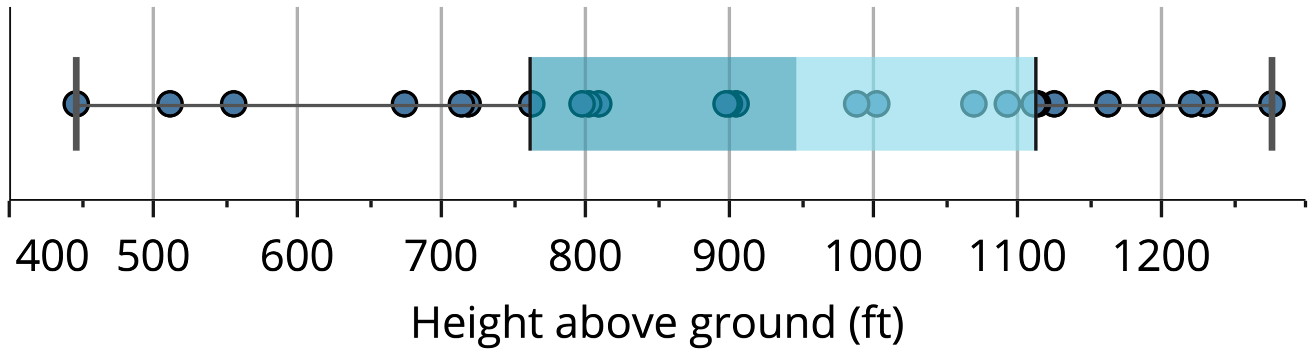

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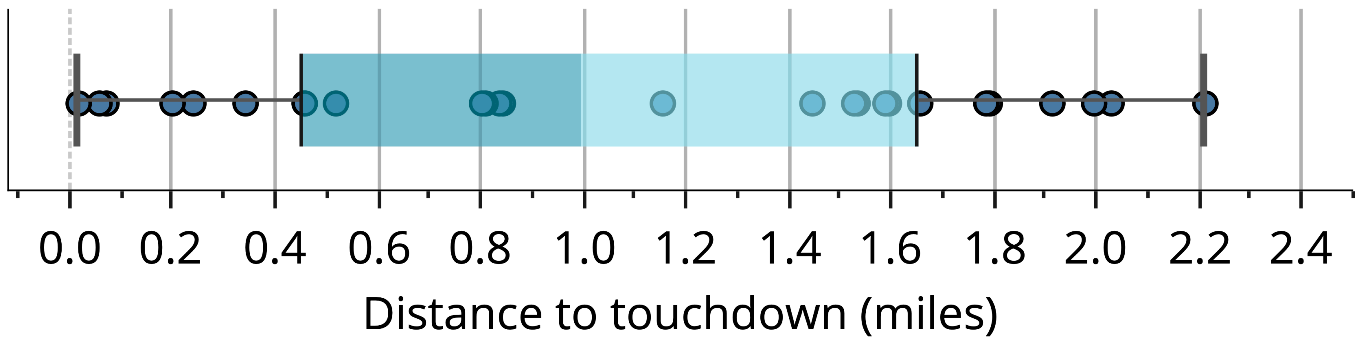

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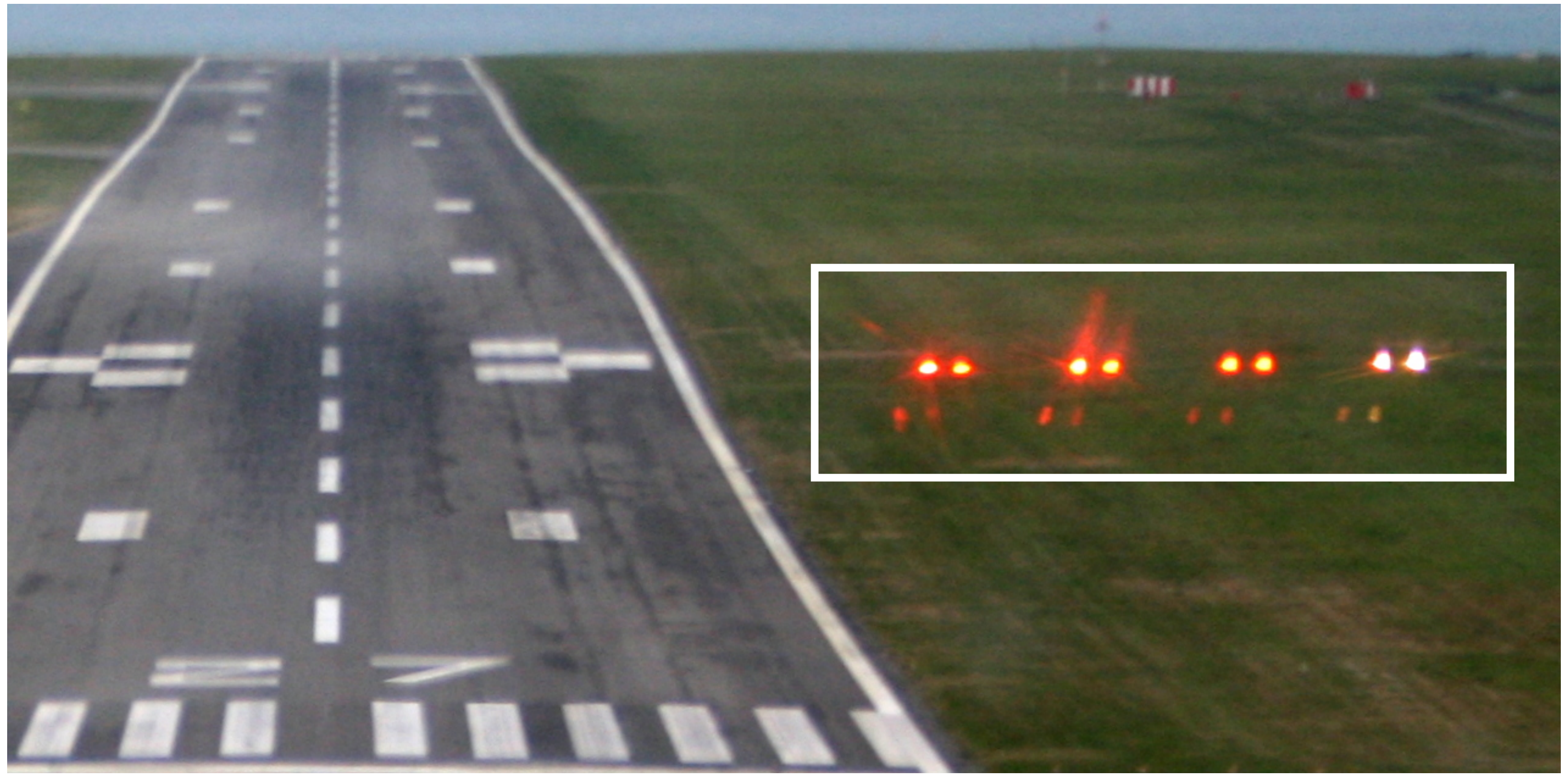

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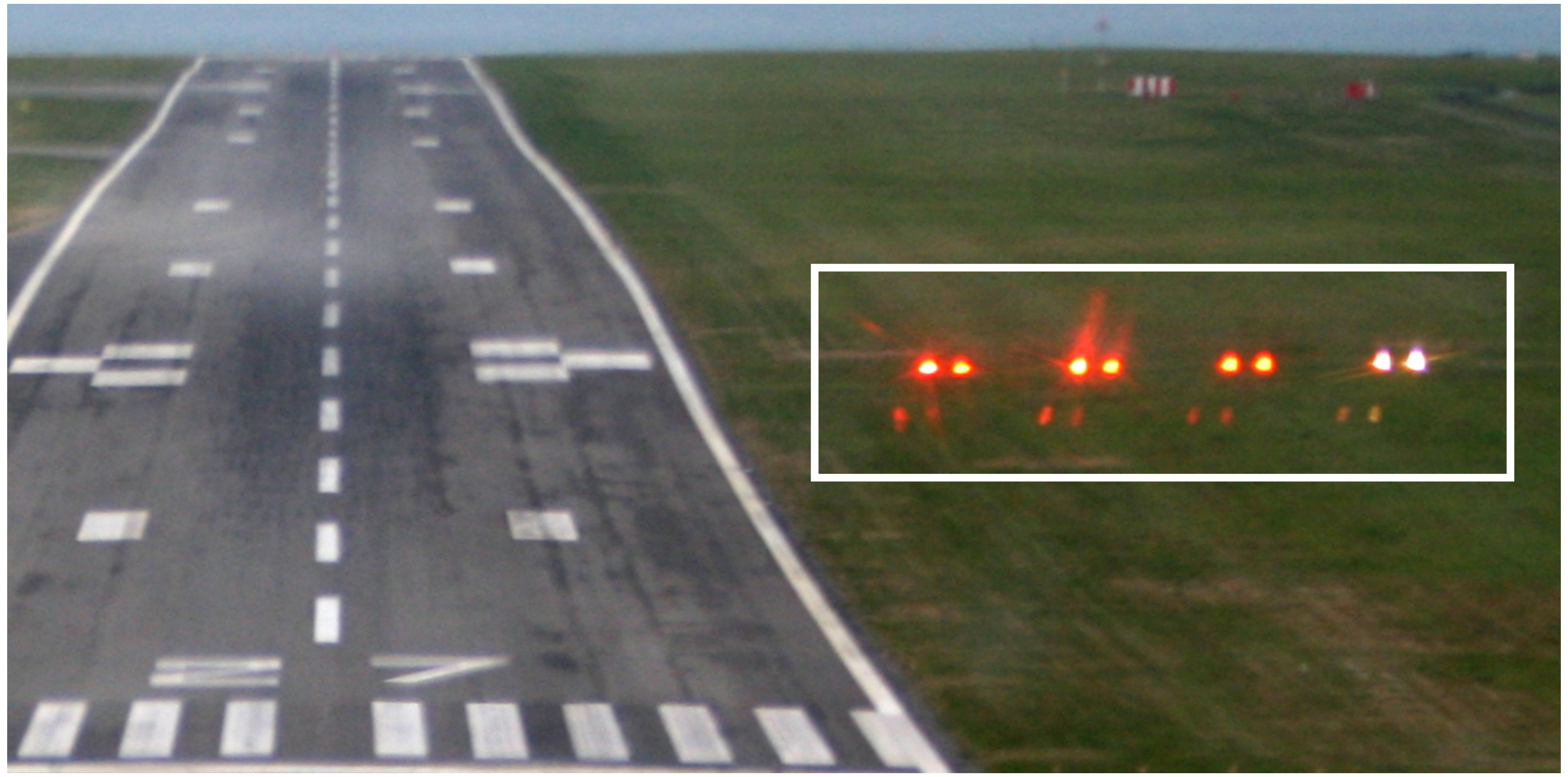

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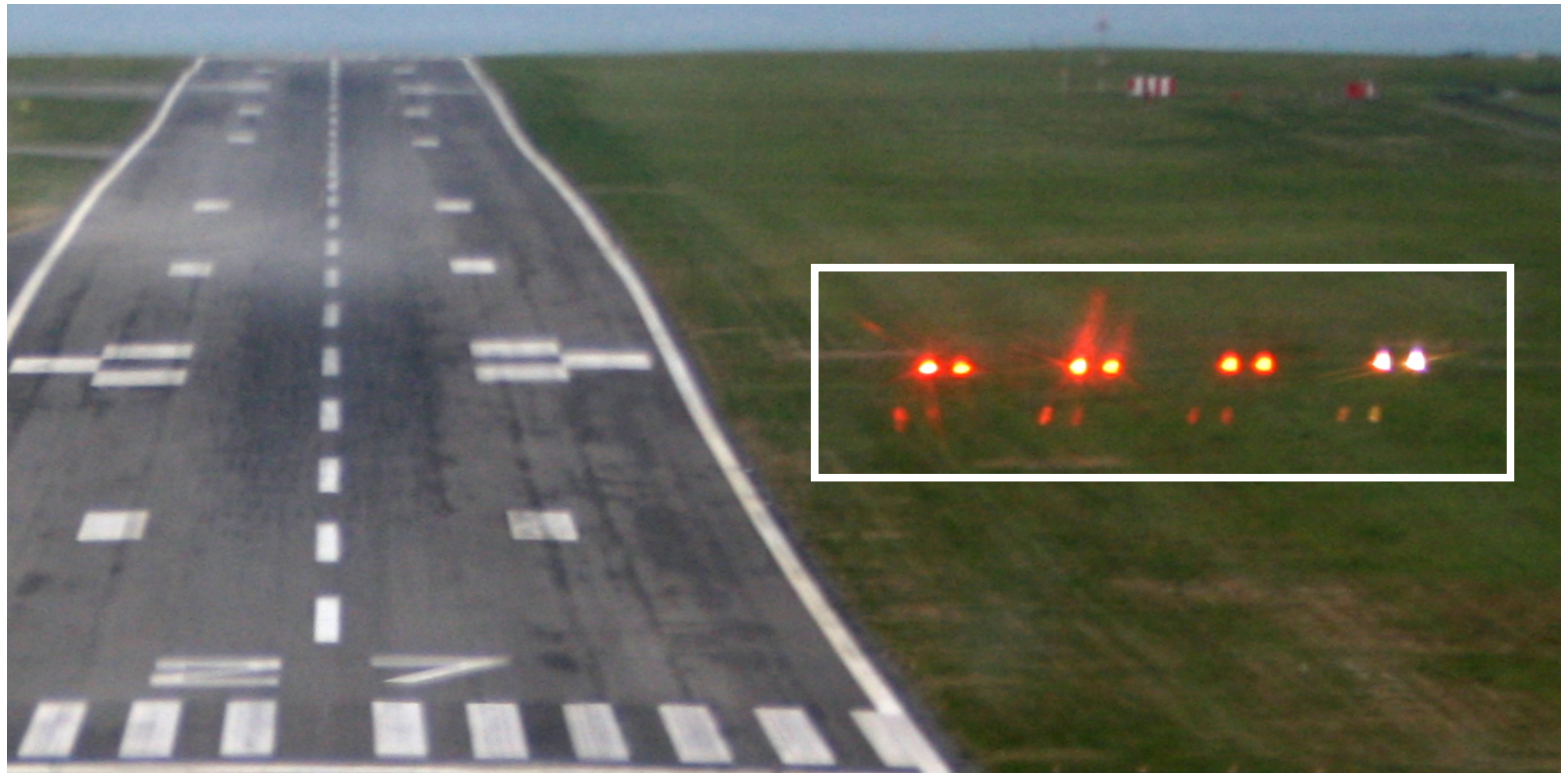

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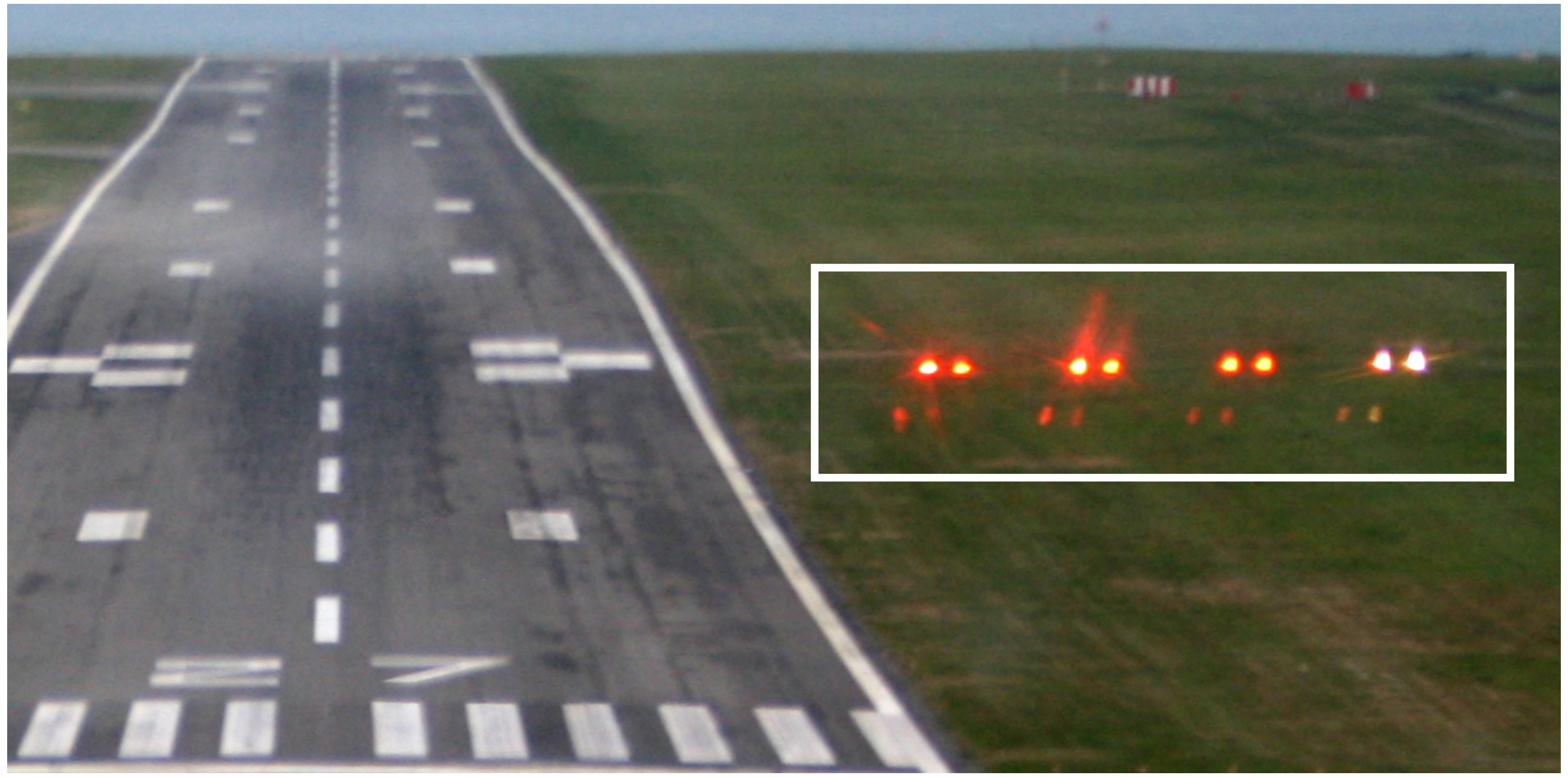

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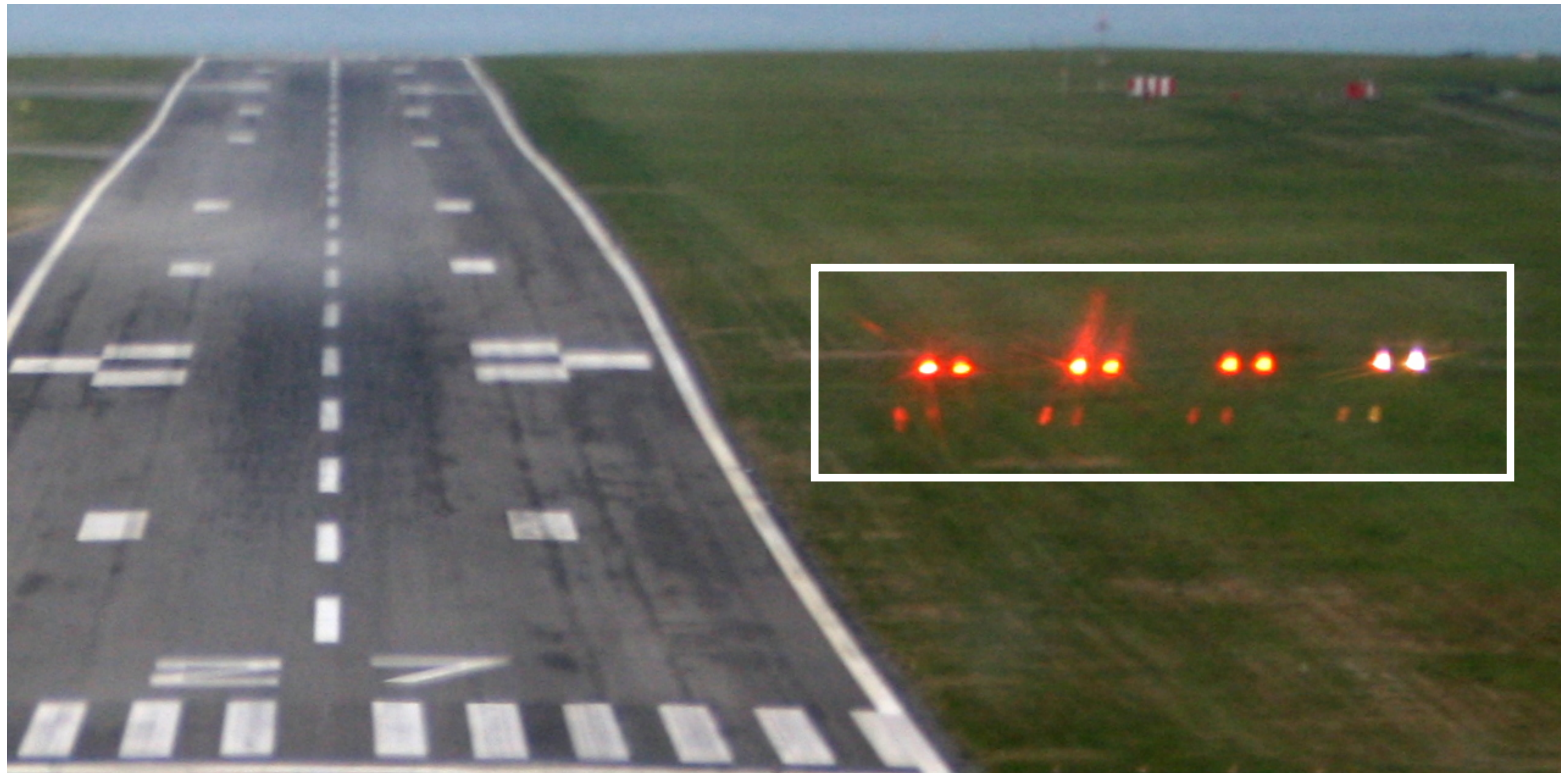

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3. ## Real usage matters

   Understanding how and why humans in the loop of safety critical systems act like they do is important in security analysis

Summary

- Attacks cause disruption, even when pilots can mitigate part of the effect of the attack
- Responses take a variety of forms, leading to attacks causing unpredictability
- In many cases, attacks push pilots to disable safety-related systems
- Existing procedure provides an ideal starting point for new steps to handle attacks

Questions

A View from the Cockpit: Exploring Pilot Reactions to Attacks on Avionic Systems

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- [4] - Original uploader Tswgb. Edit by Abuk SABUK https://commons.wikimedia.org/wiki/File:PAPI_Jersey_Airport.JPG
- [5] - https://commons.wikimedia.org/wiki/File:Baltic_Aviation_Academy_Airbus_B737_Full_Flight_Simulator_(FFS).jpg
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