Wireless Attacks on Aircraft Instrument Landing Systems

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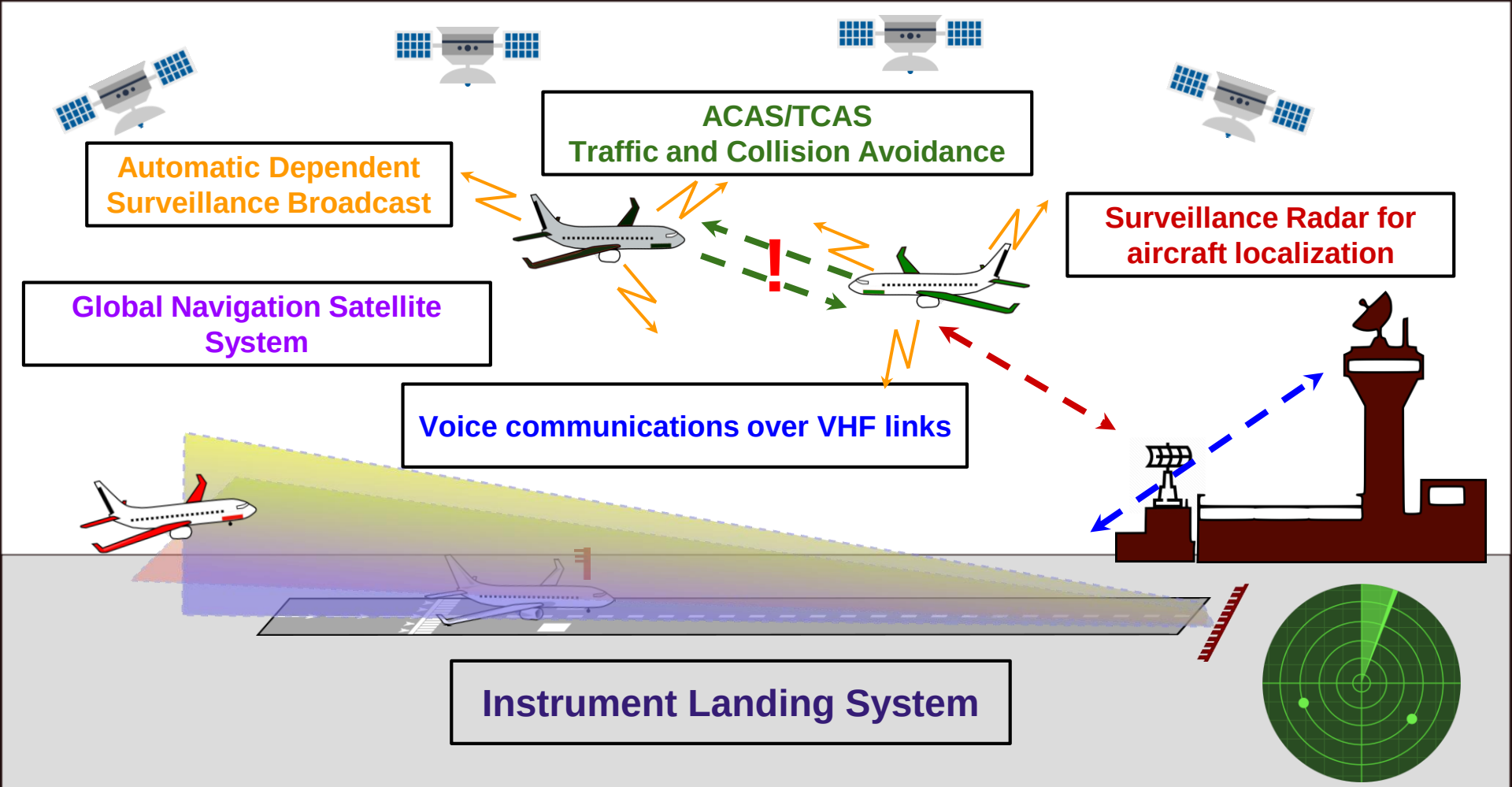
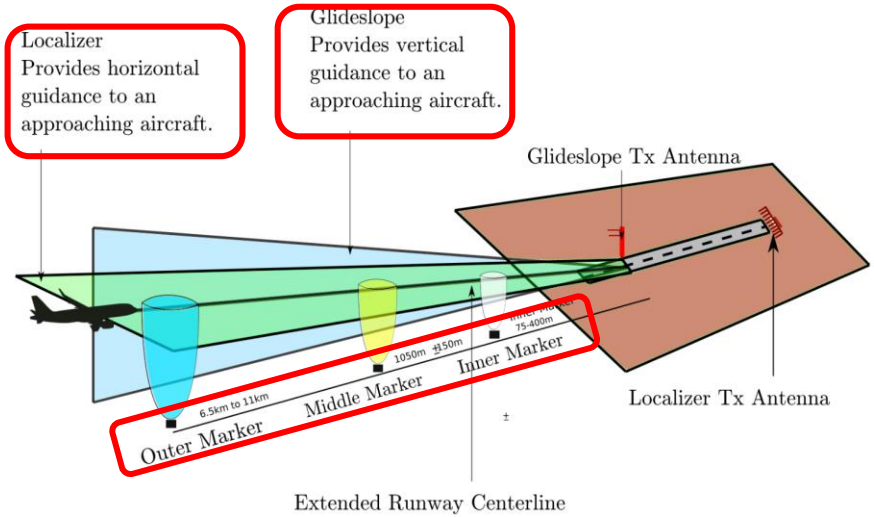
15000 flights!!

https://www.flightradar24.com/1.27,51.96/3


ACAS/TCAS
Traffic and Collision Avoidance
Automatic Dependent Surveillance Broadcast
Surveillance Radar for aircraft localization
Global Navigation Satellite System
Voice communications over VHF links
Instrument Landing System

Aircraft Instrument Landing System (ILS)

- Final approach or landing phase is one of the most critical phases
- According to Boeing 59% of the fatal accidents occur during the final approach phase
- ILS provides precise lateral and vertical guidance even in extreme weather conditions using wireless radio signals



Incident: Singapore B773 at Munich on Nov 3rd 2011, runway excursion

By Simon Hradecky, created Monday, Dec 17th 2018 16:15Z, last updated Monday, Dec 17th 2018 16:15Z

On Dec 17th 2018 [illegible] were:

Turkish Airlines – Boeing B737-800 (TC-JGE) flight TK1951

False Localizer Signal

A business jet was in clouds when the pilots initiated a steep descent, following a spurious navigation signal high terrain.

by Mark Lacagnina | October 6, 2010

The flight crew initiated an emergency return to an Irish airport after the Gulfstream IV-SP's windshield crack takeoff in instrument meteorological conditions. The aircraft was outside the localizer coverage area when th armed the autopilot approach mode. As a result, the autopilot captured a false localizer signal. The crew ther deviated from the instructions they had received from air traffic control (ATC) and initiated a rapid descent while

Russian Tu-22M3 crash: Expert says instrument landing system to blame 'hard' landing

Jan 27, 2019 in **Aviation**, **News**

Spectre of false glideslope emerges in Bishkek 747 crash

09 FEBRUARY, 2017 | SOURCE: FLIGHT DASHBOARD | BY: DAVID KAMINSKI-MORROW | LONDON

Preliminary information about the Boeing 747-400F crash at Bishkek appears to indicate that the aircraft encountered a false glideslope before initiating its fatal descent, and that the crew attempted a go-around.

Avionics International — Search Subscribe

ATM Modernization, Commercial, Military

Securing ACARS: Data Link in the Post-9/11 Environment

By Charlotte Adams | June 1, 2006

Send Feedback

Security of ADS-B: State of the Art and Beyond

Martin Strohmeier*, Vincent Lenders+, Ivan Martinovic*
*University of Oxford, United Kingdom
+armasuisse, Switzerland

INDEPENDENT

The Register — Biting the hand that feeds IT

Security

Texas students hijack superyacht with GPS-spoofing luggage

Don't panic, yet

By Iain Thomson in San Francisco 29 Jul 2013 at 18:04 58 SHARE

Enabling Next-Generation Airborne Communications

Realities and Challenges of NextGen Air Traffic Management: The Case of ADS-B

Martin Strohmeier, Matthias Schäfer, Vincent Lenders, and Ivan Martinovic

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

Andrei Costin, Aurélien Francillon
Network and Security Department
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ei.costin@eurecom.fr, aurelien.francillon@eurecom.fr

AINonline

ADS-B Is Insecure and Easily Spoofed, Say Hackers

by Matt Thurber - September 3, 2012, 12:45 AM

ROAD TO NOWHERE —

A $225 GPS spoofer can send sat-nav-guided vehicles into oncoming traffic *

* Some restrictions apply.

DAN GOODIN - 7/18/2018, 7:30 AM

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ADS-B Security Risk Remains Unresolved for US Military

By Woodrow Bellamy III | October 4, 2018

Send Feedback | @WBellamyIIIAC

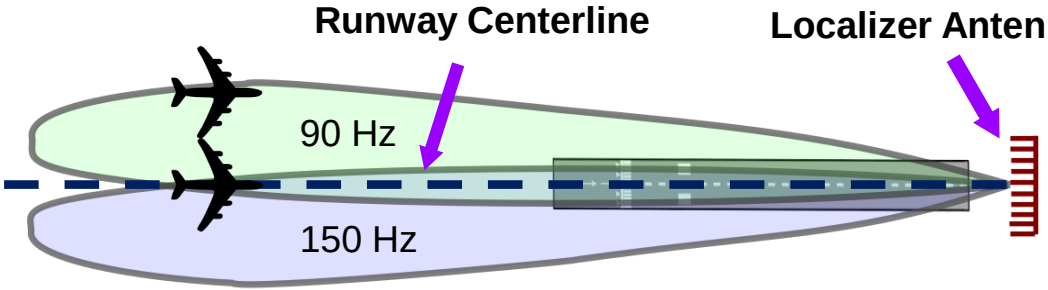
ADS-B, DoD, FAA, security

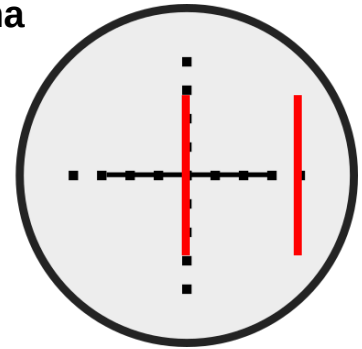
Our contributions

- Demonstrate two types of attacks: 1) Overshadow and 2) Single-tone attack for taking over ILS
- Develop a closed loop tightly controlled ILS spoofer that in real-time adjusts the spoofing signals as a function of aircraft's current location
- Demonstrate the attacks on a flight simulator software which satisfies FAA certification requirements (X-Plane)
- Systematically evaluate the performance of the attack using X-Plane's AI based autoland feature resulting in touchdown offsets of 18 meters to over 50 meters

Localizer

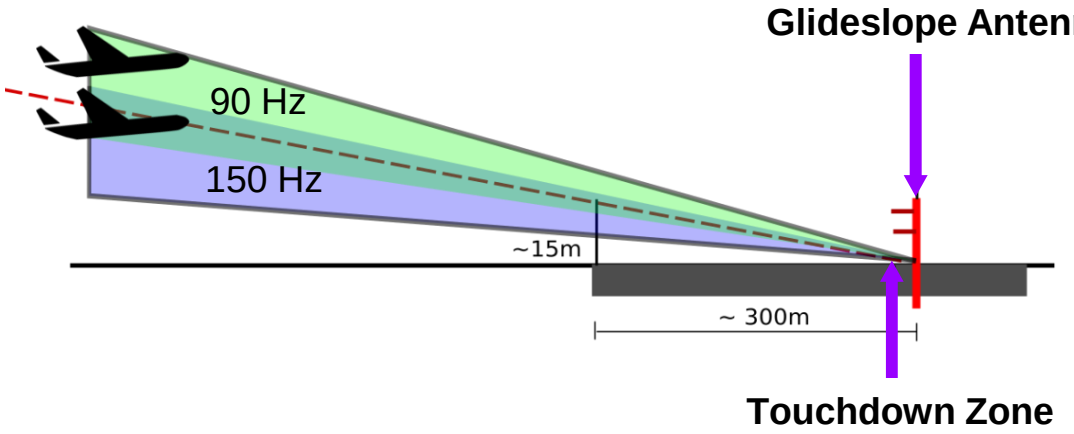
- Enables the receiver to calculate its location with respect to the runway centerline
- The instrument guides the pilot to properly align itself
- Antenna array installed at the end of the runway transmits a 25W signal
- Transmission pattern creates a lobe on each side of the runway centerline:

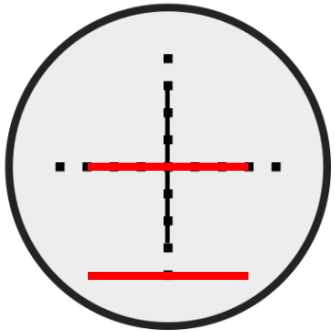




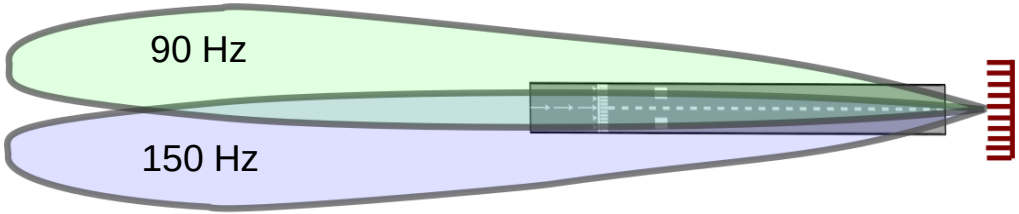
Glideslope

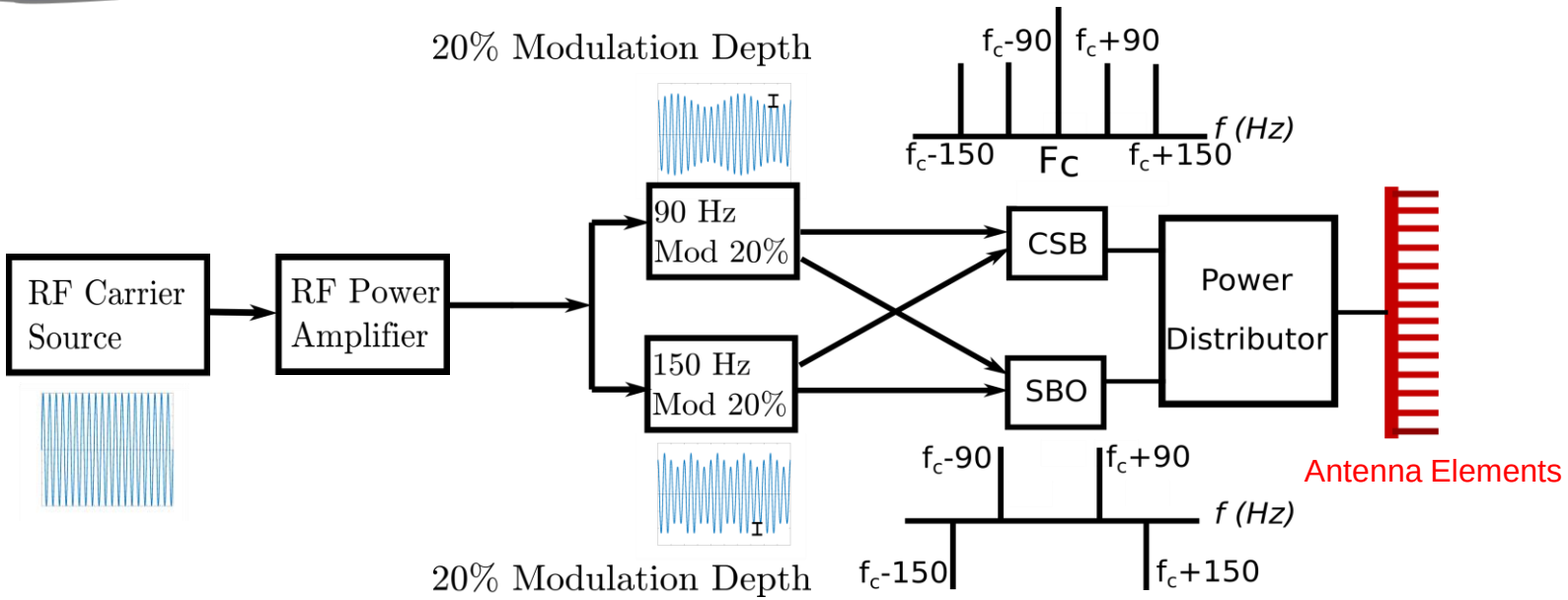
- Enables the receiver to calculate its location with respect to the glidepath
- The instrument guides the pilot to set a perfect glidepath angle
- Antenna installed near the touchdown zone transmits an 8W signal
- Transmission pattern creates a lobe on each side of the glidepath



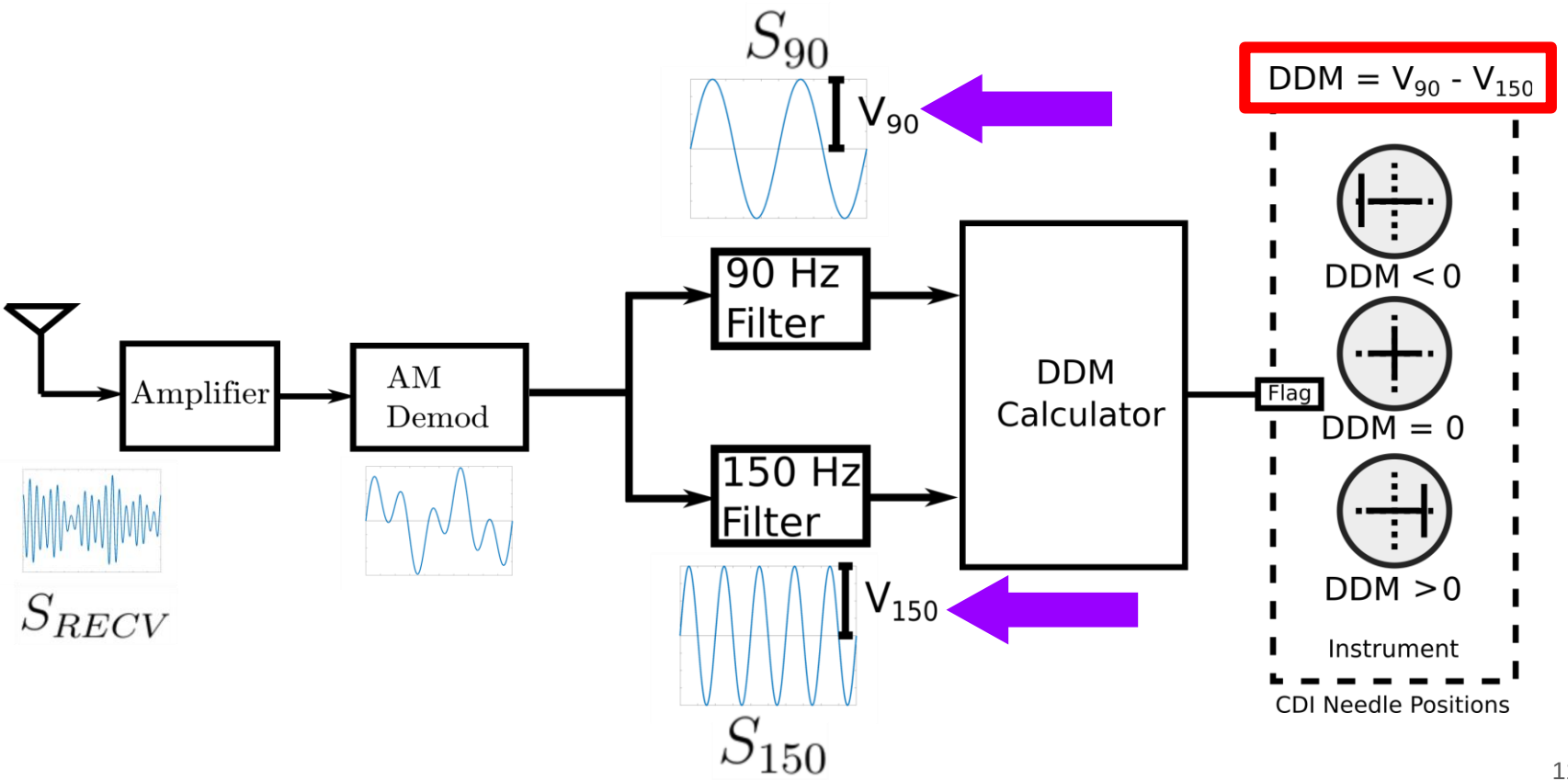


ILS Transmitter





ILS Receiver



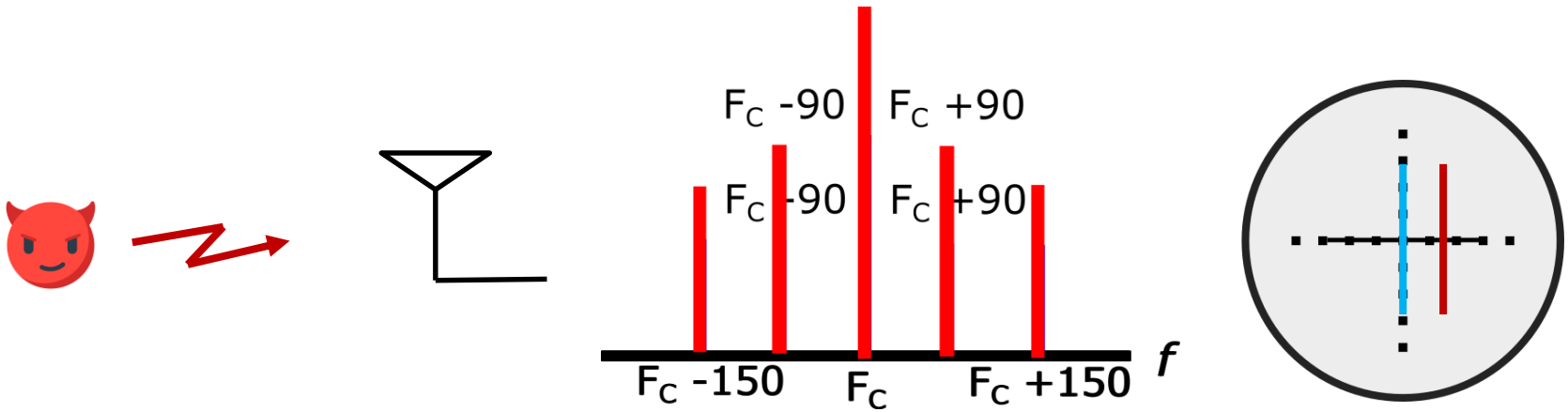
Wireless Attacks

- Needle deflection depends only on the **power of the received 90 Hz and 150 Hz tones!**
- **Objective of the attacker:**
  - Manipulate DDM calculation
  - Force the aircraft to overshoot the runway or completely miss the approach
- We discuss two attacks:
  - Overshadow attack
  - Single-tone attack

With minor changes, the attacks work for both the localizer and the glideslope

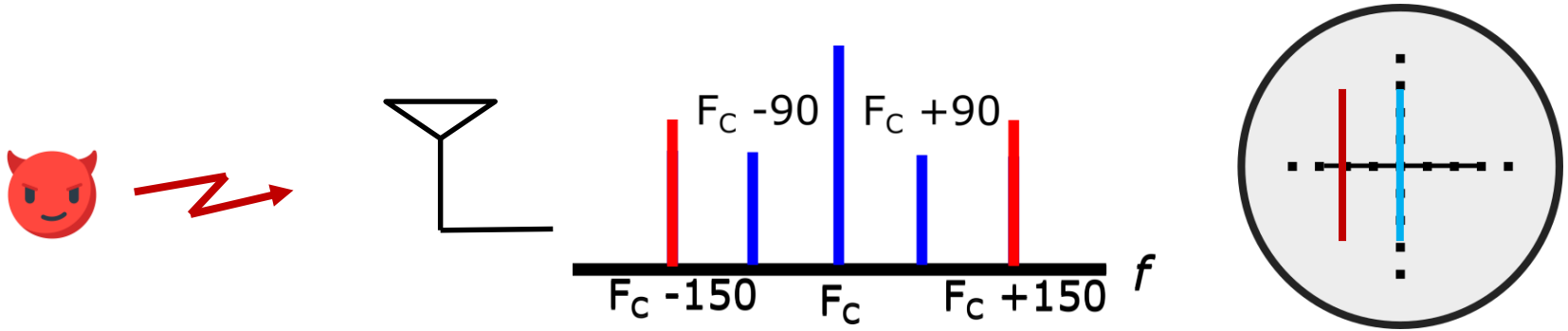
Wireless Attacks: Overshadow Attack

- Attacker transmits a high power pre-crafted ILS signals
- A typical wireless receiver always locks on to the stronger signal
- It is sufficient to generate and transmit signals similar to the received legit ILS signal



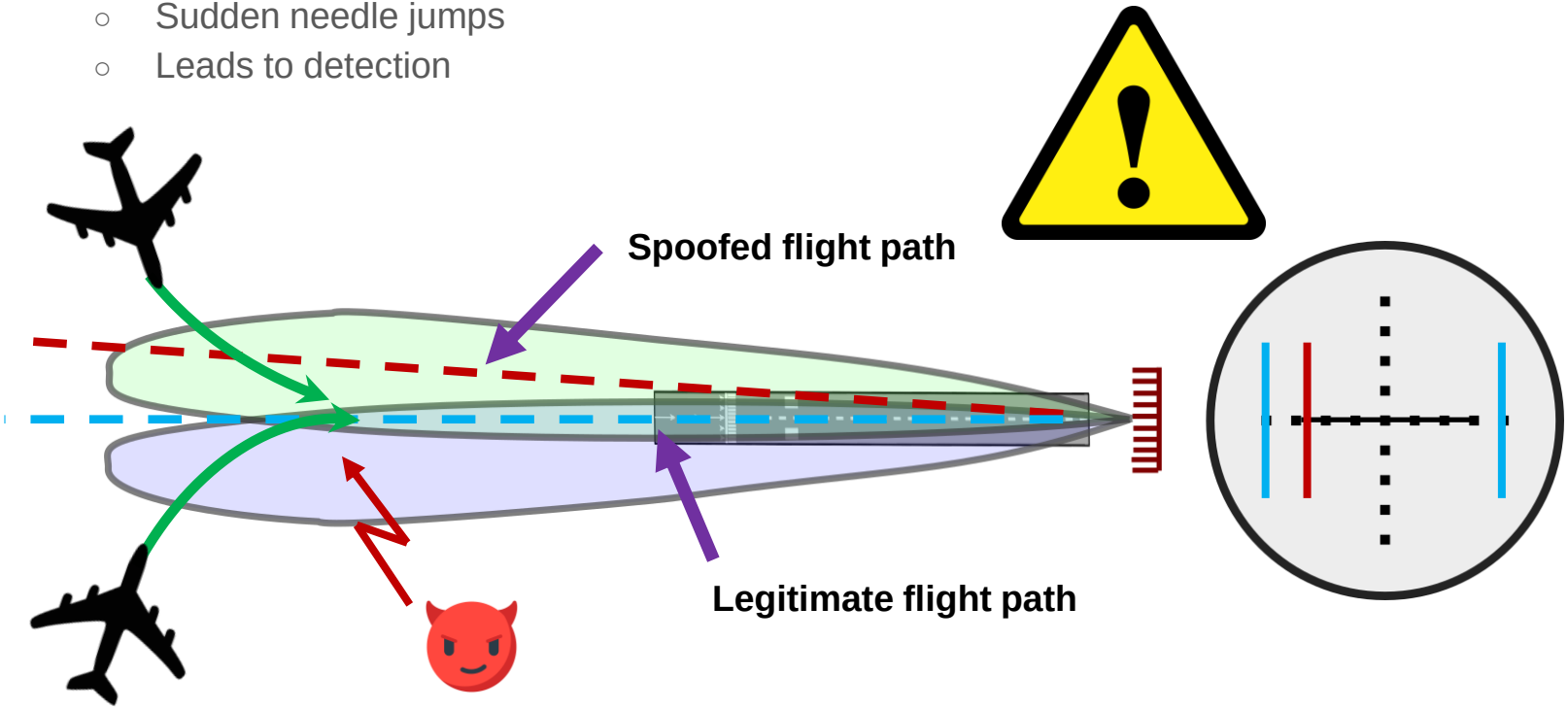
Wireless Attacks: Single-tone Attack

- Attacker transmits only one of the two tones that make up the ILS signal
- Transmitted tone interferes with the existing tones to cause needle deflection
- The attacker signal is similar to a double sideband suppressed carrier signal which is known to be spectrally efficient than a regular AM signal



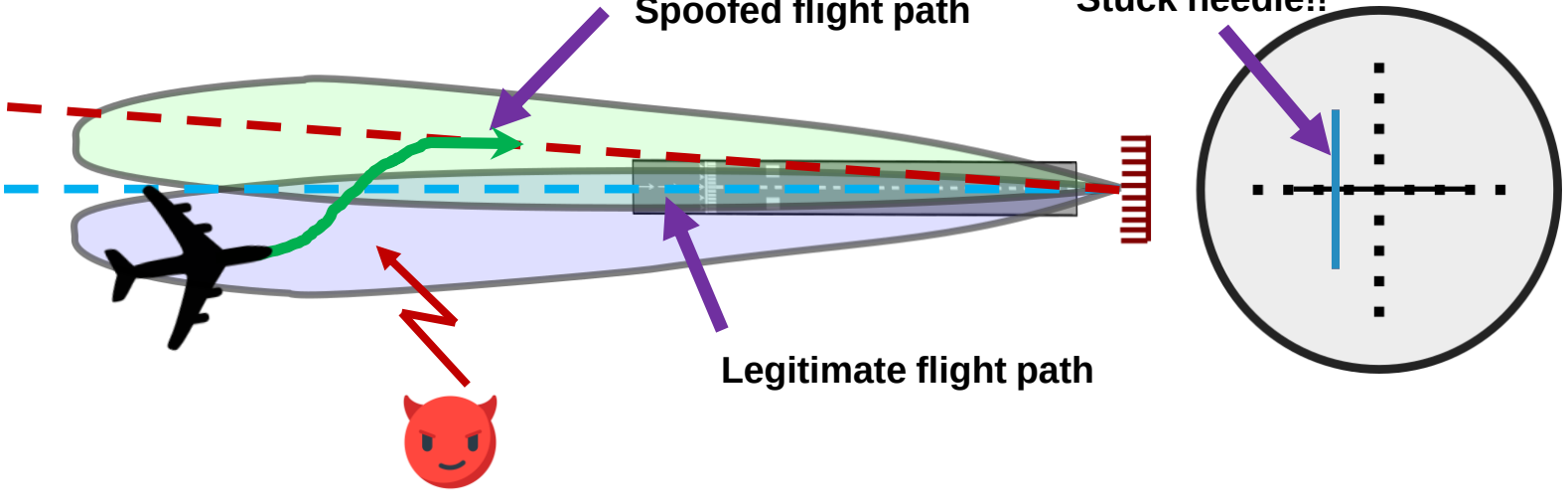
Attacker Challenges

- **Aircraft can intercept the localizer from multiple directions**
  - Sudden needle jumps
  - Leads to detection



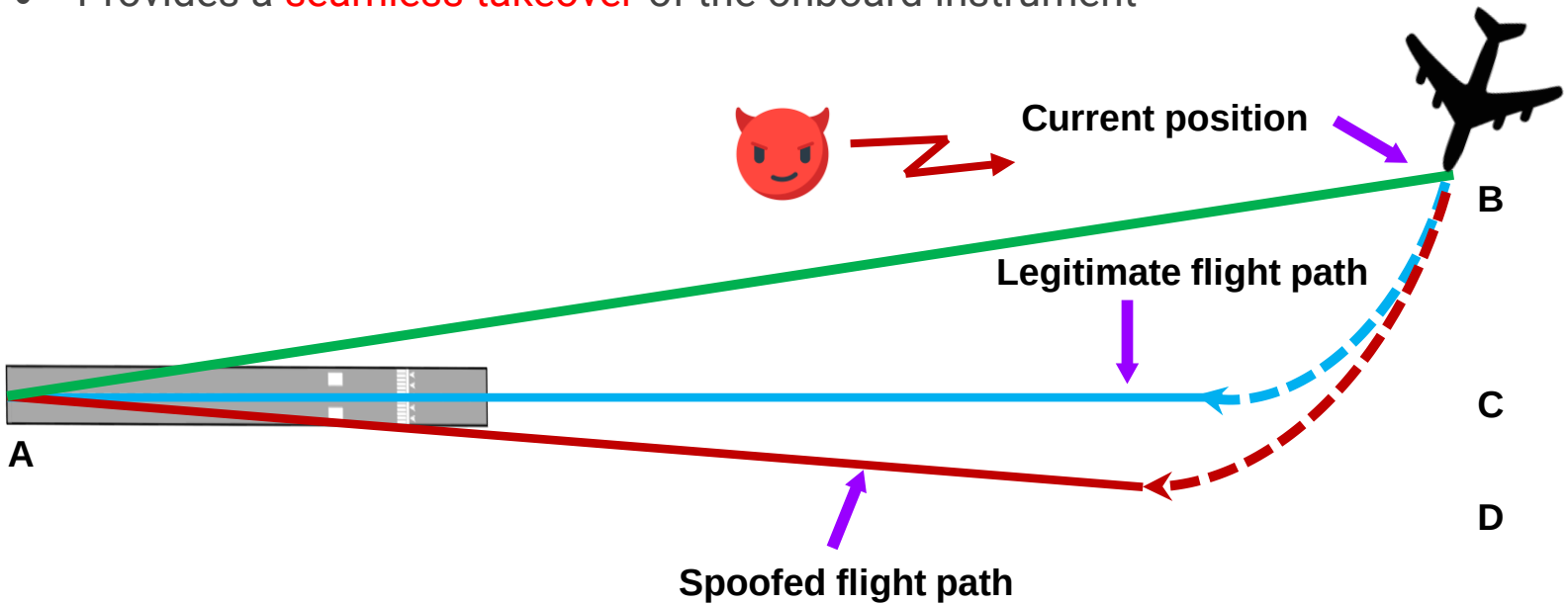
Attacker Challenges

- **Naïve overshadow attack results in fixed unreactive offset**
  - Easy detection
  - Attack never succeeds



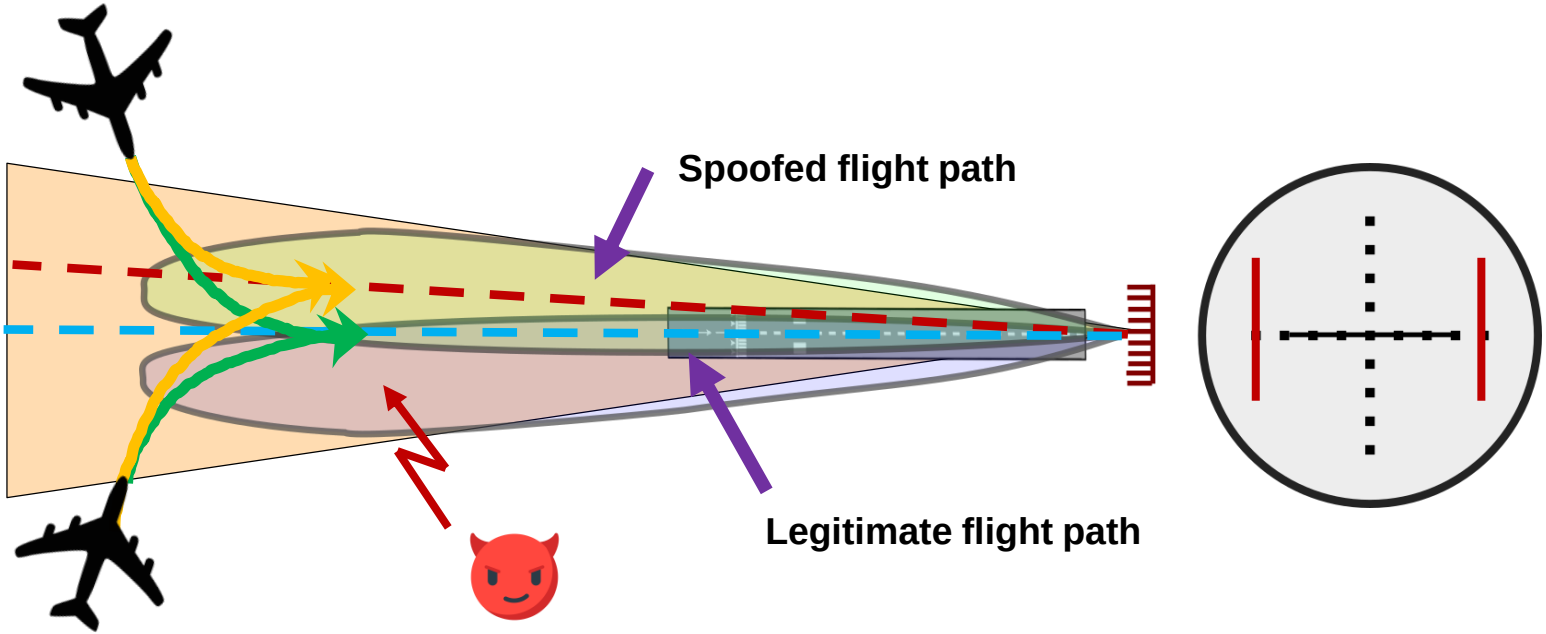
Offset Correction Algorithm

- Real time offset calculation and signal generation
- Adjusts attacker's signal as a function of aircraft's GPS location
- Provides a seamless takeover of the onboard instrument

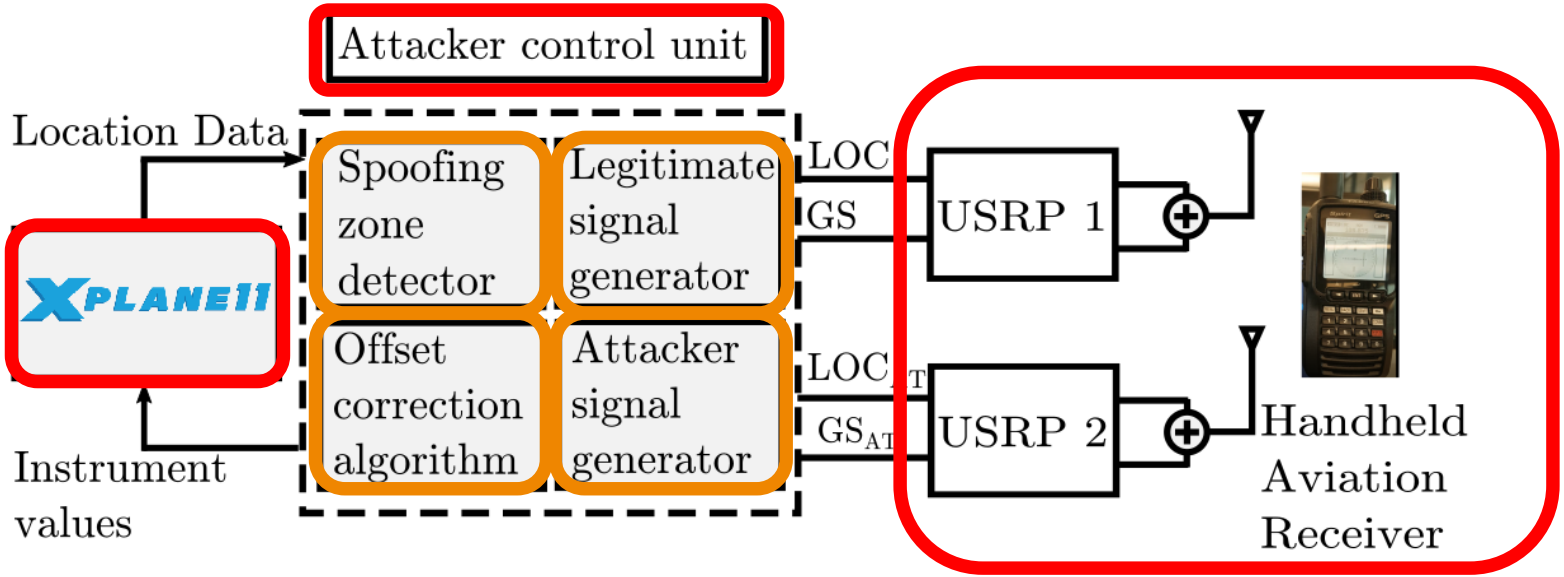


Spoofing Zone Detector

- Enables timely and automated triggering of the attack
- Detects if the target aircraft has entered the area of final approach
- Avoid sudden needle jumps



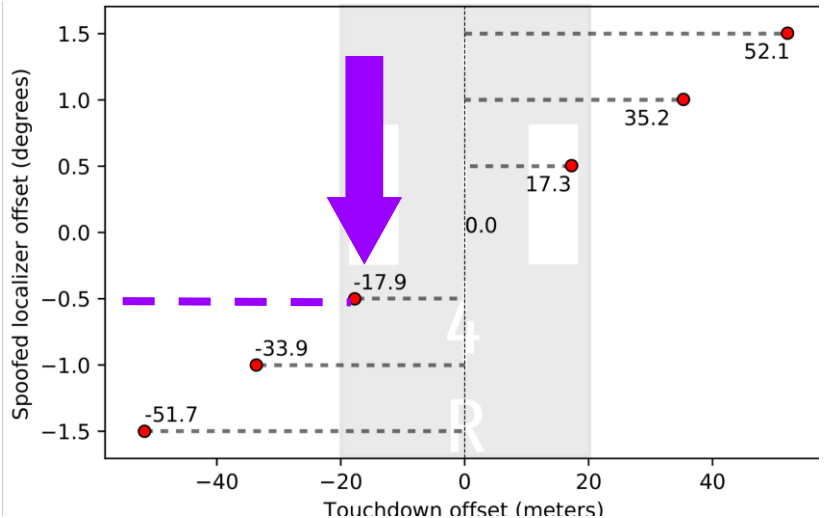
Experimental Setup

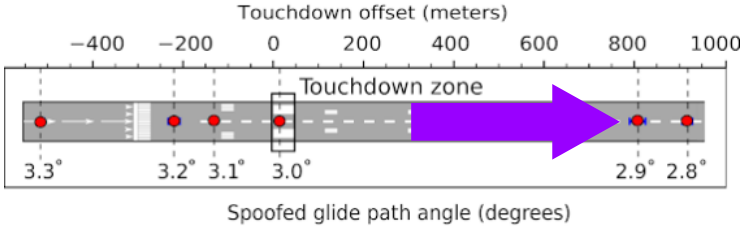



Attacker control unit
X-Plane flight Simulator
Handheld
Rx
USRP 1
USRP 2

Evaluation of Overshadow Attack

- 5 test flights with AI based automated landing were flown for each spoofed offset
- Even minute offsets have significant effects
- A certified pilot was called in to test the setup and fly the approach with and without spoofing

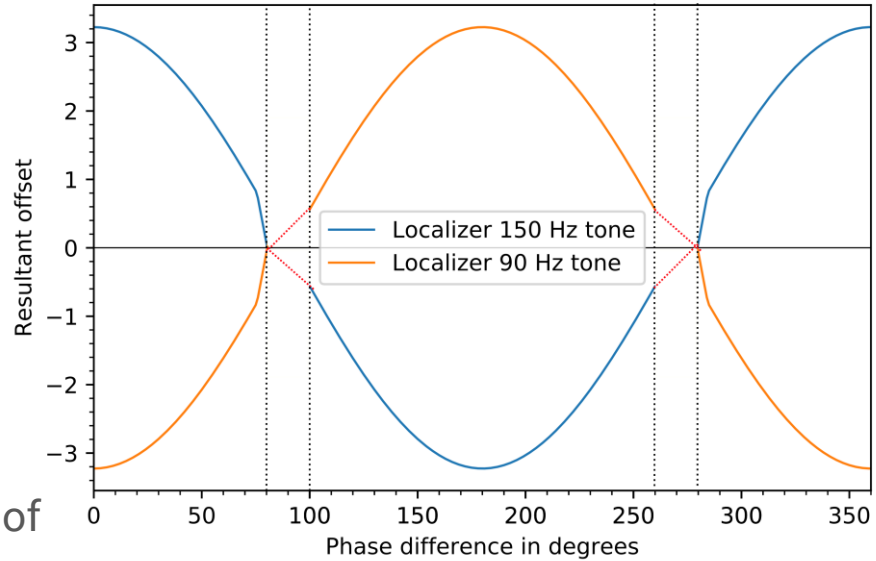




Evaluation of Single-tone Attack

- Single-tone attack is susceptible to phase changes
- Effect was less severe on the handheld receiver:

  It depends on:
  - **Speed of the approaching aircraft**
  - **Refresh rate of the instrument**
- Amplitude scaling for countering the effect of phase
- Unpredictable needle deflections can be used as a low power last minute DoS attack



Summary

- **ILS is vulnerable to spoofing attack**
- The attacks were successfully demonstrated on flight simulator software which satisfies FAA certification requirements
- Pure analog nature makes it fundamentally challenging to secure these critical navigation systems
- Pilots have multiple other systems which they can rely on for recovery if the attack is detected in time

Thank you!

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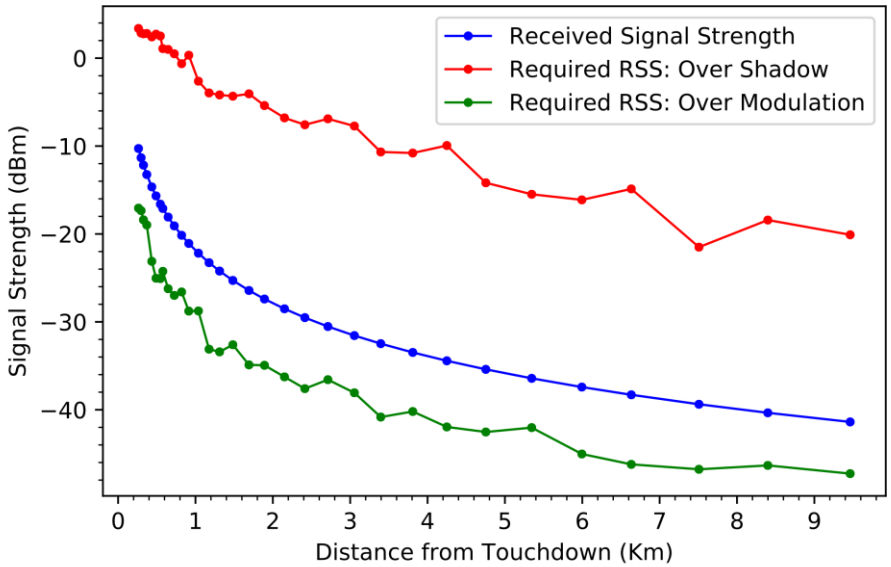
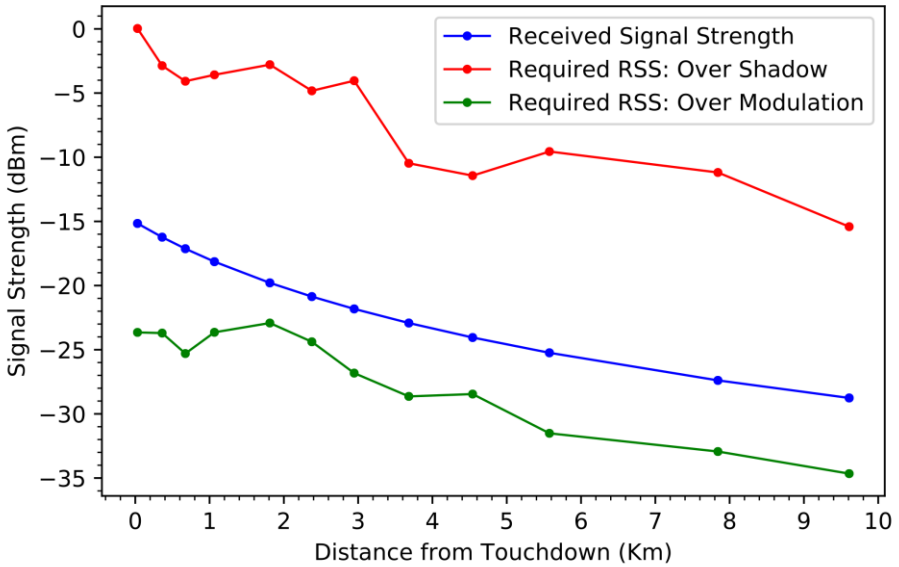
Potential Countermeasures

- Introduction of GPS based landing systems which uses ground based augmentation
- Secure localization technology
- Signal strength monitoring for overshadow attack detection
- Transmitter detection inside the cabin to detect malicious activity
- Non-technical countermeasure: effective pilot training

Comparison of Power Requirements



Localizer



Glideslope