Estimating Security Risk Using Adversary Capability

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Outline

- Problem overview
- Capability-based risk
- Comparison with control effectiveness
- Questions and acknowledgements

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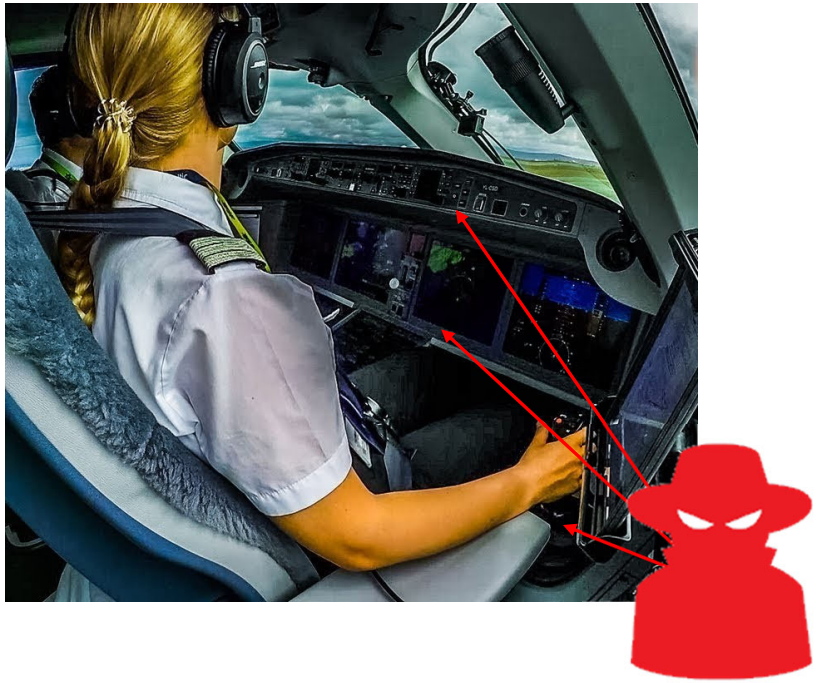
Assessing Safety Risk of Cyber Attack on Aircraft

- **Requested to develop risk assessment methodology for FAA**
  - **Focus: cyber security impact on safety**
  - **Flexible enough to assess a range of subjects including components, systems, systems of systems, and processes**
  - **Can integrate testing as well as analysis**
  - **Risk matrix preferred as overview of risks**
- **STPA/STPA-Sec selected as core**



Traditional Risk Matrix

Likelihood \ Severity	Minimal 5	Minor 4	Major 3	Hazardous 2	Catastrophic 1
Frequent A	[Green]	[Yellow]	[Red]	[Red]	[Red]
Probable B	[Green]	[Yellow]	[Red]	[Red]	[Red]
Remote C	[Green]	[Yellow]	[Yellow]	[Red]	[Red]
Extremely Remote D	[Green]	[Green]	[Yellow]	[Yellow]	[Red]
Extremely Improbable E	[Green]	[Green]	[Green]	[Yellow]	[Red] *

High Risk [Red]
Medium Risk [Yellow]
Low Risk [Green]

* High Risk with Single Cause Failures

- **Useful summary when used properly**
- **Has problems:**
  - **Not very accurate**
  - **Hides useful details**
- **Likelihood has problems**
  - **Historical rates may not be predictive/available**
  - **Adversary intent is not measurable**
  - **Can change rapidly with technology changes/popularity of attack**
  - **Many others [1]**

[1]: http://sunnyday.mit.edu/Risk-Matrix.pdf

Proxies for Likelihood Considered by the Team

Proxy	Problems
• Likelihood of accidents (failure of systems that are cyber-linked)	• Some data available, but accidents are not attacks, historical is not predictive
• SME estimations	• Bias problems, expertise scarce
• Scalability	• Cyber attacks tend to be scalable
• Required adversary capability level	• Detailed data not available, requires modeling each scenario

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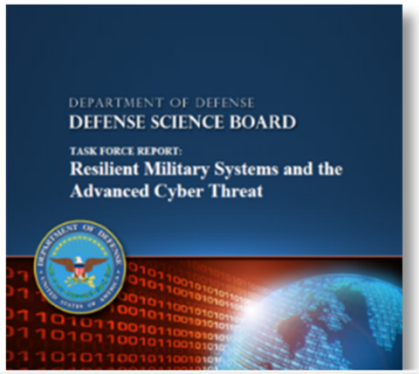
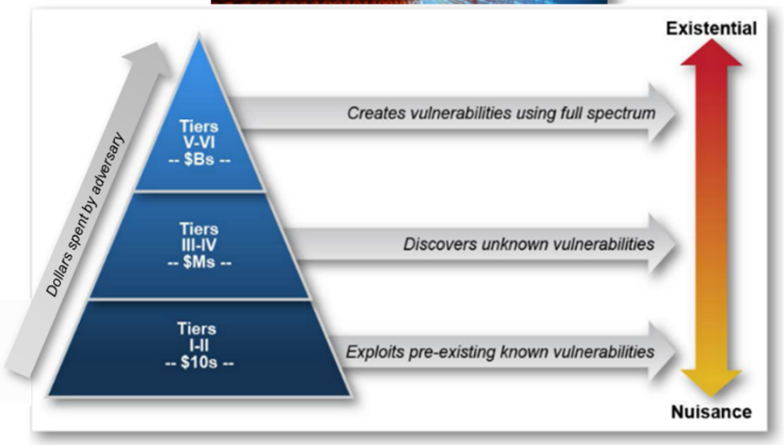
Setting Capability Levels

- **Defense Science Board report "Resilient Military Systems and the Advance Cyber Threat"**
  - **Resource pyramid**
  - **Six tiers of adversary**

- **We derived the following categories**
  - **1: Novice/Intermediate**
  - **2: Proficient**
  - **3: Organized Group**
  - **4: Lesser Nation State**
  - **5: Greater Nation State**





Adversary Cyber Capability Levels

- **Levels are defined by two characteristics**
  - **Resources – rough estimates, can be used to acquire competency (external or internal)**
  - **Competencies – skills necessary to accomplish attacks**
- **In practice, adversaries will have a mix of both**

Level	Name	Description	Resources and Competencies
1	Novice to intermediate	Generally employs capabilities developed by others, with little to no variation.	Resources: <$100K Novice: Download and run preexisting vulnerability discovery and remote administration tools; e.g., Metasploit, Nessus, Wireshark. Intermediate: Limited ability to modify existing tools to desired application. Limited ability to craft tools to employ known vulnerabilities.
2	Proficient	Actors that have advanced understanding of a particular area and can generally develop their own solutions using Commercial Off-The-Shelf (COTS) tools and equipment.	Resources: <$1M Trained and in possession of well–developed skills. Expanded platform expertise and time resources. Ability to discover and exploit vulnerabilities. Buying moderately priced commercial equipment.
3	Organized group	A group of proficient adversaries to leverage individual knowledge of different technical areas. An example would be a terrorist group.	Resources: <$50M Large and heterogeneous capability set, both technical and non-technical such as any of the following: • Can coerce insiders to cooperate • Capable of buying or building custom tools (e.g., aircraft; transmitters)
4	Lesser Nation State	An adversary that can bring national level resources to multiple groups under its direction. They may not have access to the most advanced national-level assets.	Resources: <$1B Create vulnerabilities through influencing design, development, manufacturing or supply chain
5	Greater Nation State	Adversaries at the bleeding edge of development, national resources, and organizational integration.	Resources: $1B+ Boundary pushing technical development in conjunction with effective espionage and military operations.

- **Adversary cyber capability levels provide tiers, but not specific capabilities**

Capability Level != Capability

- **Questions to answer:**
  - **Where does one find a list of capabilities?**
  - **How does one determine *which* capabilities matter for a given scenario or set of scenarios?**
  - **How does one determine the necessary capability level if multiple capabilities are required for a scenario?**
- **Answers to questions:**
  - **There was no central list, so we created one that is intended to be a constant work in progress**
  - **Model the scenario in some way – attack trees are a reasonable way to model each individual scenario**
  - **Use the highest capability level required to complete the scenario (the maximum value of all the required capabilities)**

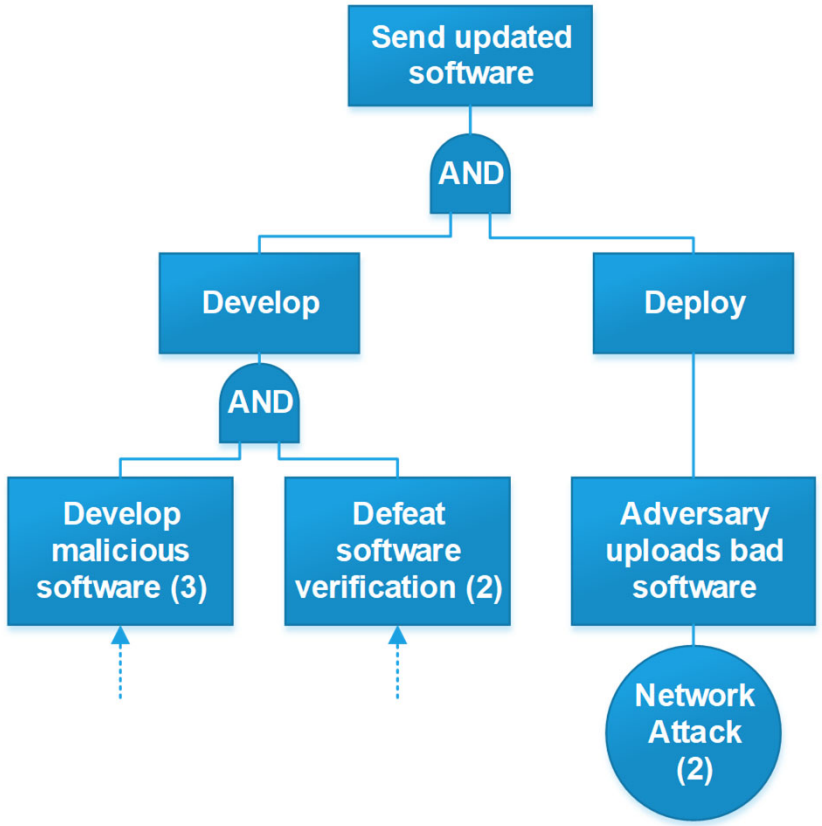
Cyber Capabilities

- **Collaborators from the penetration testing and reverse engineering communities provided the initial list**
- **Added to the list as assessments were completed**
- **Contact FAA ANG-E2 for the current list (sample shown below)**

Capability Type	Title	Description	Required Adversary Level
⋮	⋮	⋮	⋮
Expertise	Avionics testbed development	Development of components and diagnostic tools. High-level assets needed.	3
Expertise	Network attack	Unsecured network	1
Expertise	Network attack	Network deployed with industry standard user authentication and intrusion detection	2
Expertise	Network attack	Network configured to enforce least privilege, service isolation, data isolation, and incidence response	3
Expertise	Cryptanalysis	Deploy commercially available decryption tools	2
⋮	⋮	⋮	⋮

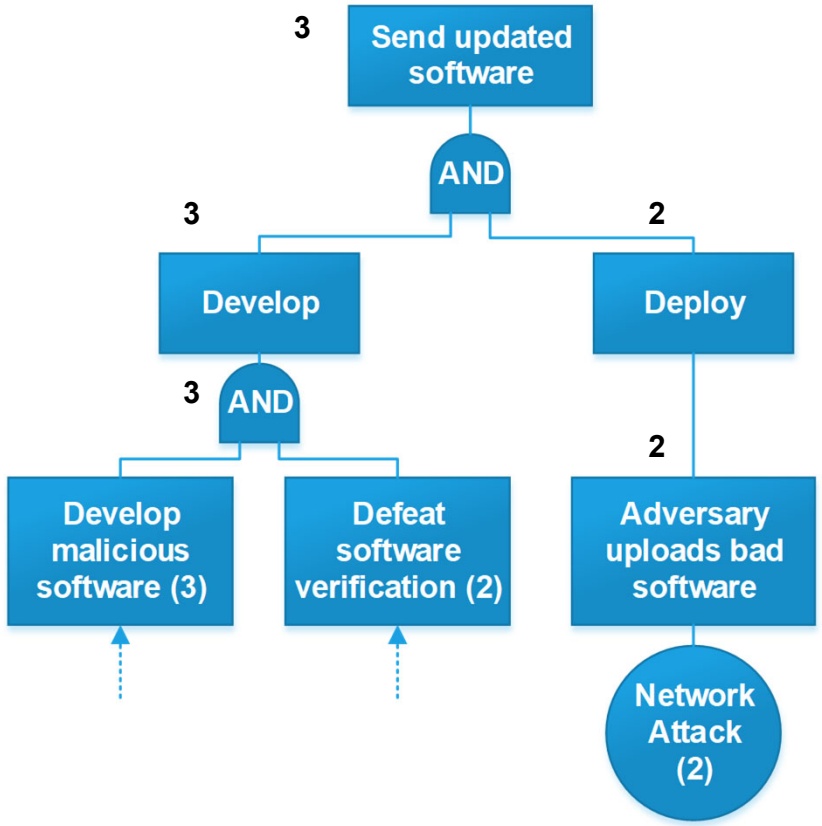
Chosen Capability Level Model – Attack Tree

- **Attack trees**
  - **Successful attack at the root**
  - **Capabilities required to execute the attack at the leaves**
- **Capability levels**
  - **Assigned to each capability**



Chosen Capability Level Model – Attack Tree

- **Adversary level required for this scenario**
  - **Develop malicious software requires an organized group (3)**
  - **Defeat software verification requires a proficient actor (2)**
  - **Network attack requires a proficient actor (2)**
  - **AND = max of the inputs**



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Adversary Level vs. Control Effectiveness

- **Adversary Level**
  - Corresponds to ease with which an adversary can realize hazard
  - Based on capabilities required to accomplish attack
  - Can lead to better understanding of adversarial loss scenarios
  - Only applicable to analyses that address adversarial causal factors
- **Control Effectiveness**
  - Corresponds to the strength of the control used to prevent a loss
  - Based on the level by which the causal factor is affected by the control
  - Can lead to better understanding of loss scenarios
  - Applicable to any analyses that address causal factors using controls

Or Adversary Level with Control Effectiveness?

- Control effectiveness is based on how well the hazard can be controlled
- Adversary level is based on how capable an adversary must be to bypass controls
- Perhaps use both when dealing with analyses accounting for adversarial action?
  - "Control X reduces causal factor B (level 2 control effectiveness), and requires an adversary level 3 (organized group) to be bypassed"

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Questions?

Team Members:

- **MIT Lincoln Laboratory**
  - Rodolfo Cuevas
  - Gabriel Elkin
  - Tom Jagatic
  - Dr. Melva James
  - Dr. Michael McPartland
  - Dr. Eric Quintero
  - David Weller-Fahy
- **Diakon Solutions**
  - Bill Trussell
- **Astronautics Corporation of America**
  - Beau Branback
  - Kathleen Finke
  - Christopher Kerr
  - Elijah Liu
  - Joe Reisinger
- **FAA**
  - John Peace
  - Isidore Venetos

For any questions not answered within this presentation, feel free to contact me at djwf@ll.mit.edu