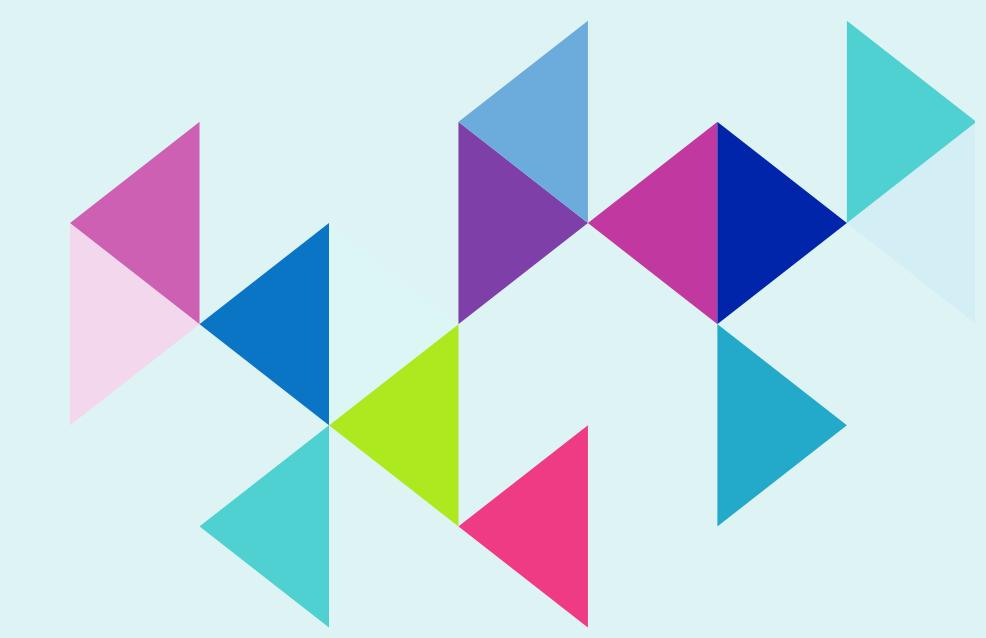
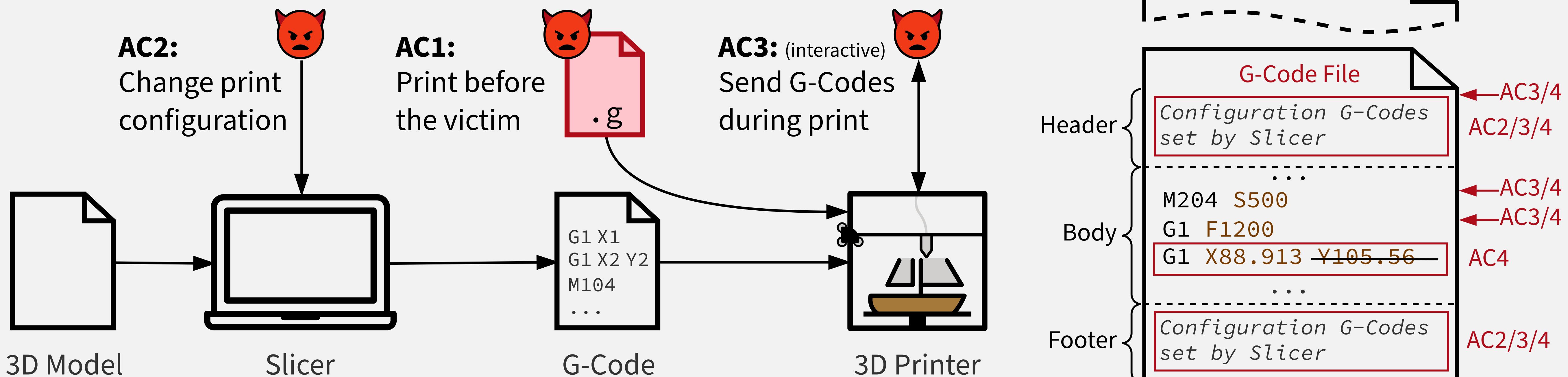


# Security Implications of Malicious G-Codes in 3D Printing



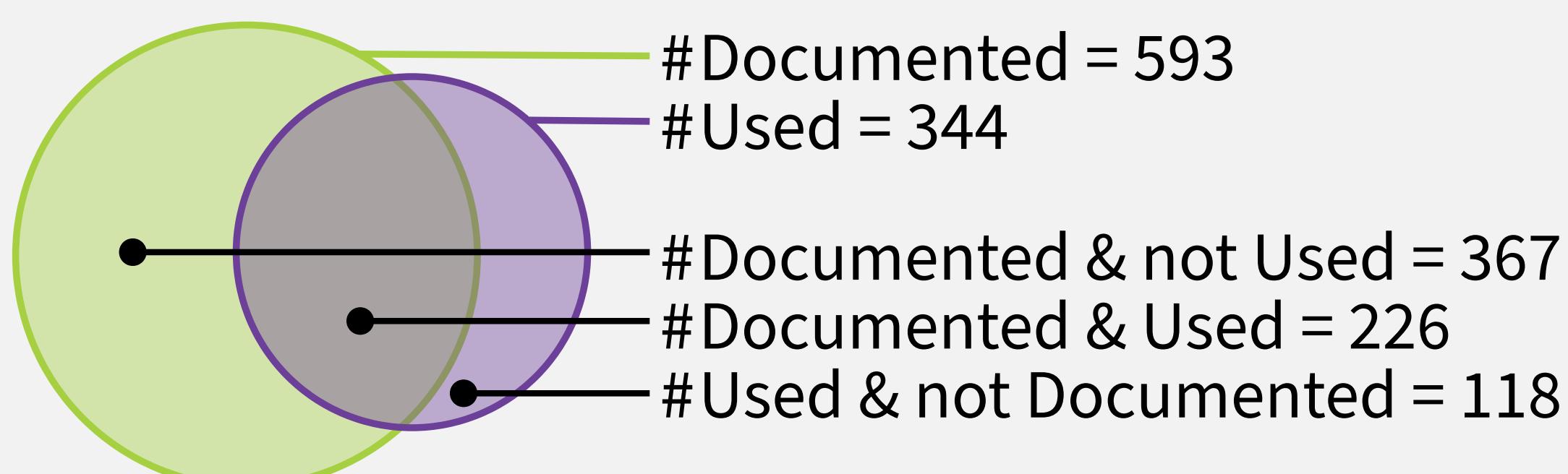
Jost Rossel, Vladislav Mladenov, Nico Wördenweber, Juraj Somorovsky

## Attacker Capabilities

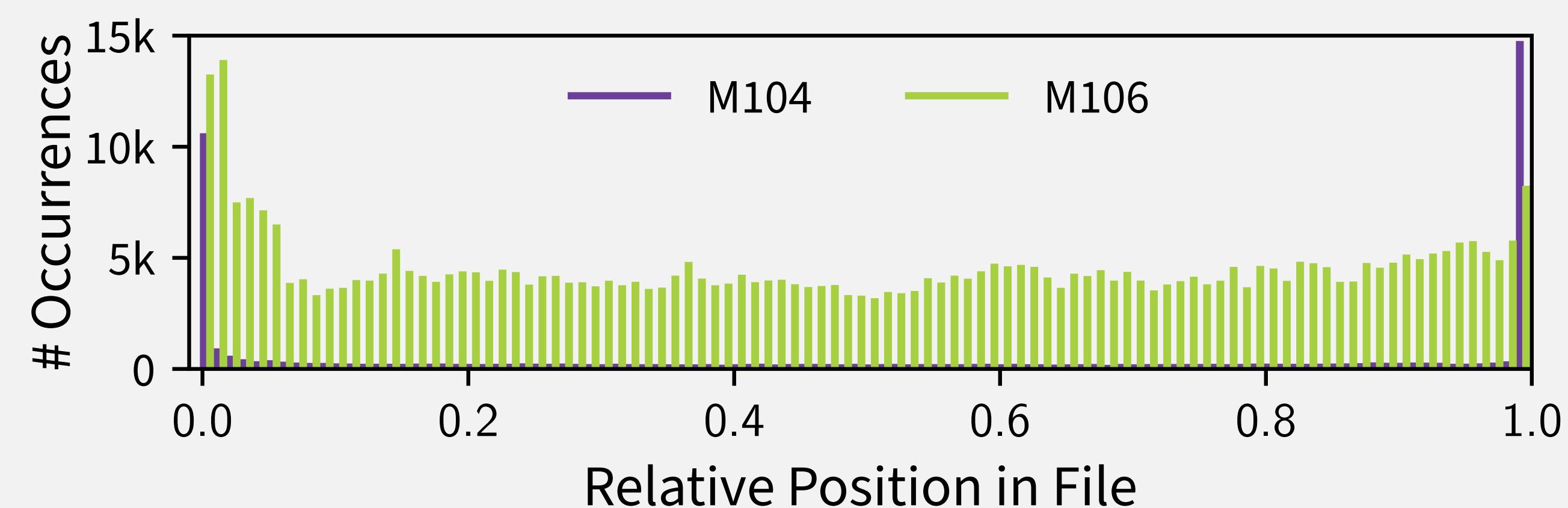


## Understanding G-Code Usage

- 1) Extracting **documented** G-Codes from firmware documentation and scraping **used** G-Codes from Thingiverse.



- 3) Analyzing usage patterns determining which AC can be assigned.



- 2) Manual analysis of **documented** G-Codes and their potential security impact.

## Example Attacks

1 M928 file.g ; write log to file

1 M808 L0 ; set marker to repeat forever  
2 ; execute arbitrary commands (or do nothing)  
3 M808 ; jump to last marker

1 G20 ; set units to inches

1 G1 X1 Y2 E1

2 G1 X2 Y3 E1

3 G1 X3 Y4 E1

G1 X1 Y2 E1

G1 X2 Y3 E1

G1 X3 Y4 E1

Original

"all-powerful" (AC4)

G1 X1 Y2 E1

M28 file.g

G1 X2 Y3 E1

M29

via injection (AC3)

1 M200 D1.75 ; change extrusion mode



Attack Category	# Malicious Codes	% Vulnerable Devices		
		AC1	AC2	AC3
<b>Information Disclosure</b>	92	●	●	●
Intellectual Property Theft	3	●	●	●
Metadata Leakage	90	●	●	●
<b>Denial of Service</b>	140			
Interrupt Printing	123			
Infinite Loop	14	○	●	●
Delay Commands	56			
Ignore Commands / Stop Print	27	○	●	●
Destroy Model / Make Unusable	40	○	●	●
Disable Access / Bricking	30			
Software	18	○	○	○
Hardware	12	○	○	○
<b>Model Manipulation</b>	80			
Toolpath Manipulation	17			
Voids	8			
Surface Anomaly (X/Y Shift)	13			
Layer Height Anomaly (Z Shift)	11			
Faulty Extrusion	44			
Under Extrusion	21	●	●	●
Over Extrusion	19	●	●	●
Material Relocation	6			
Filament Retraction	19			
Printing Speed	18			
Temperature Changes	30			
Bed Temperature	15	○		
Nozzle Temperature	19	○	●	●
Fan Speed	7			