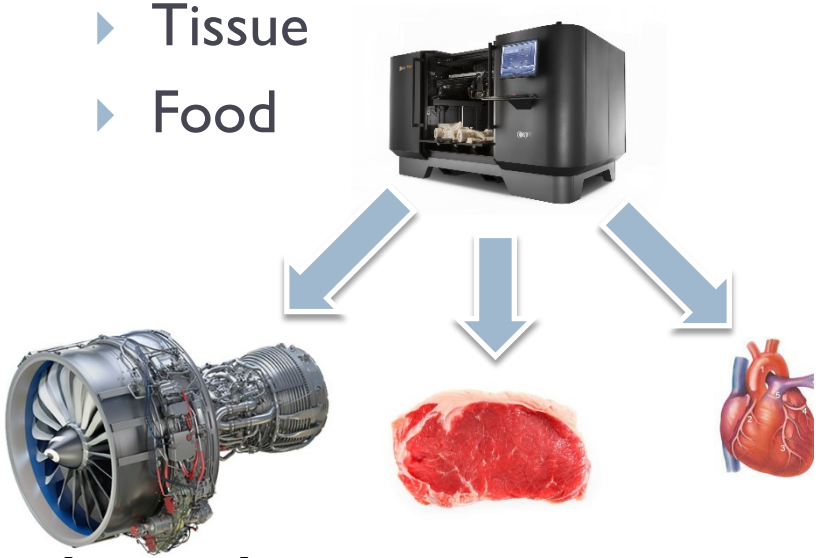
Intellectual Property Protection in Additive Layer Manufacturing: Requirements for Secure Outsourcing

Mark Yampolskiy, William B. Glisson, Alec Yasinsac

Additive [Layer] Manufacturing

- Also Known As
  - Rapid Prototyping
  - 3D Printing
  - …
- Advantages
  - Development Time
  - Manufacturing Costs
  - Necessary Storage
  - On-Demand Production
  - …

- Materials
  - Plastic
  - Metals & Alloys
  - Tissue
  - Food



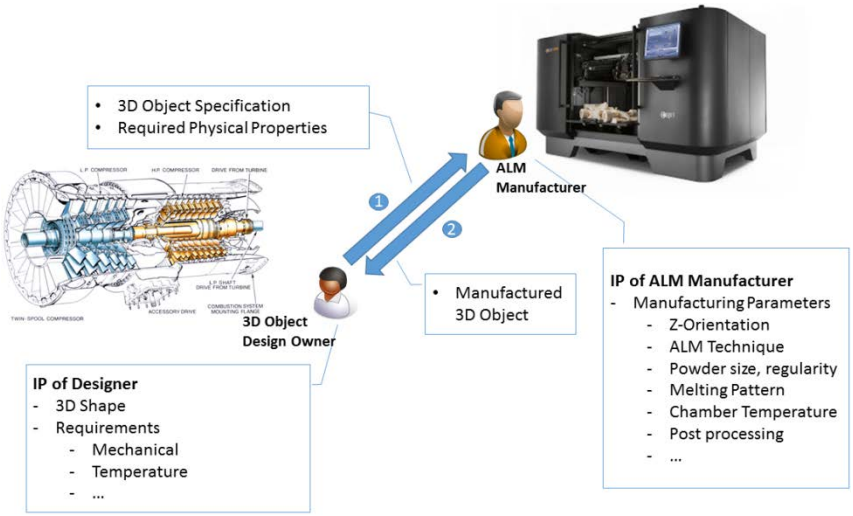
[www.ge.com]

Outsourcing: Why is it needed?

- Applications
  - Prototyping (LQ sufficient)
    - Models
    - Toys
  - Safety-Critical Devices (HQ needed)
    - Jet Engine
    - Rocket Components
- Quality in ALM
  - Precision
  - Shape Complexity
  - Physical Properties
- Equipment Cost for High-Quality 3D Printers
  - Plastic: $20,000+
  - Metal/Alloys: $100,000+ (often over $500,000)
- Required Know-how
  - Technology-specific Manufacturing Parameters
    - Orientation
    - Temperature
    - Heat Source Pattern
    - …

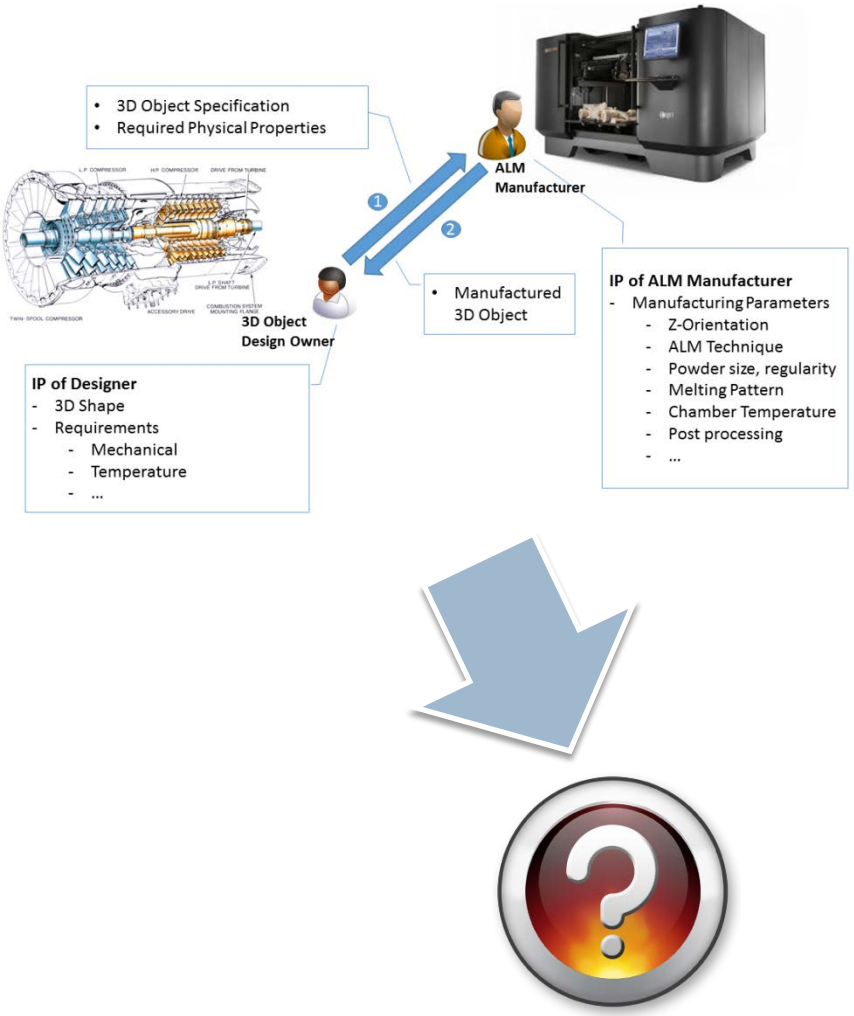
Outsourcing: State of the Art

- Advantages
  - Simplicity
  - Contract- & Reputation-based IP Protection
- Economic Disadvantages
  - Customer Binding
  - Manufacturing Costs
  - Manufacturing Time
  - …



Outsourcing: New Model Needed

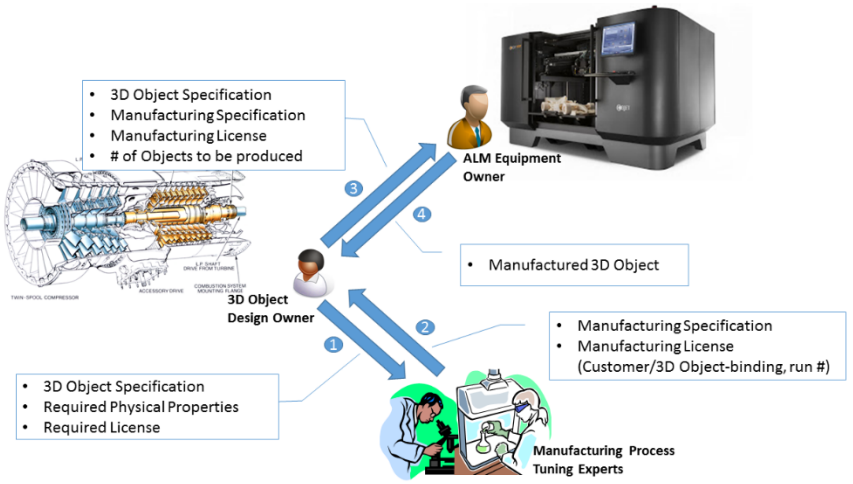
- Business Requirements
  - Outsourcing Flexibility
  - Low Manufacturing Costs
- Require Protection
  - Intellectual Property (IP)
    - 3D Models
    - Manufacturing Parameters
  - Restrictions
    - Licenses



Outsourcing: Proposed Model (1)

Economic Advantages

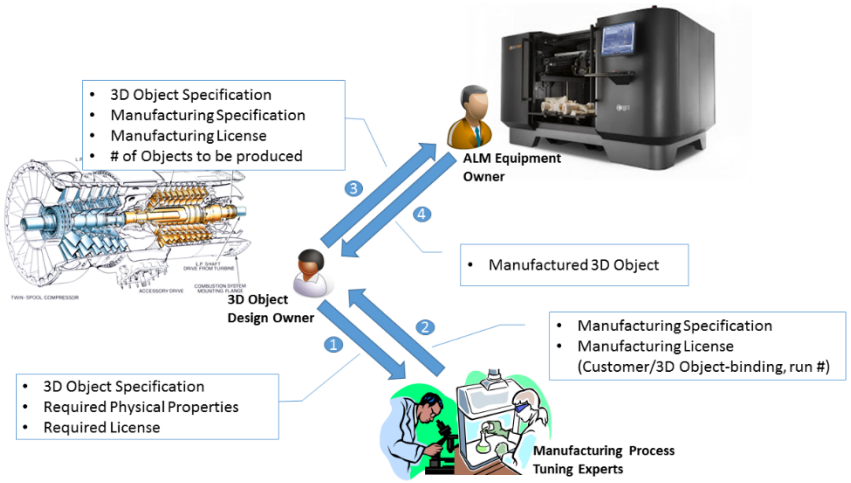
- 3D Object Designer
  - Flexibility
  - Reduced Costs
  - On-demand Scalability
- Tuning Experts
  - New Businesses
- ALM Manufacturer
  - Cost Reduction
  - More Customers



Outsourcing: Proposed Model (2)

Security at Stake

- 3D Object Designer IP
  - 3D Object Specification
  - Physical Requirements
- Tuning Experts IP
  - Manufacturing Parameters
  - Accusation of IP Violation
- ALM Manufacturer Risks
  - Accusation of IP Violation
  - Infection with Malware

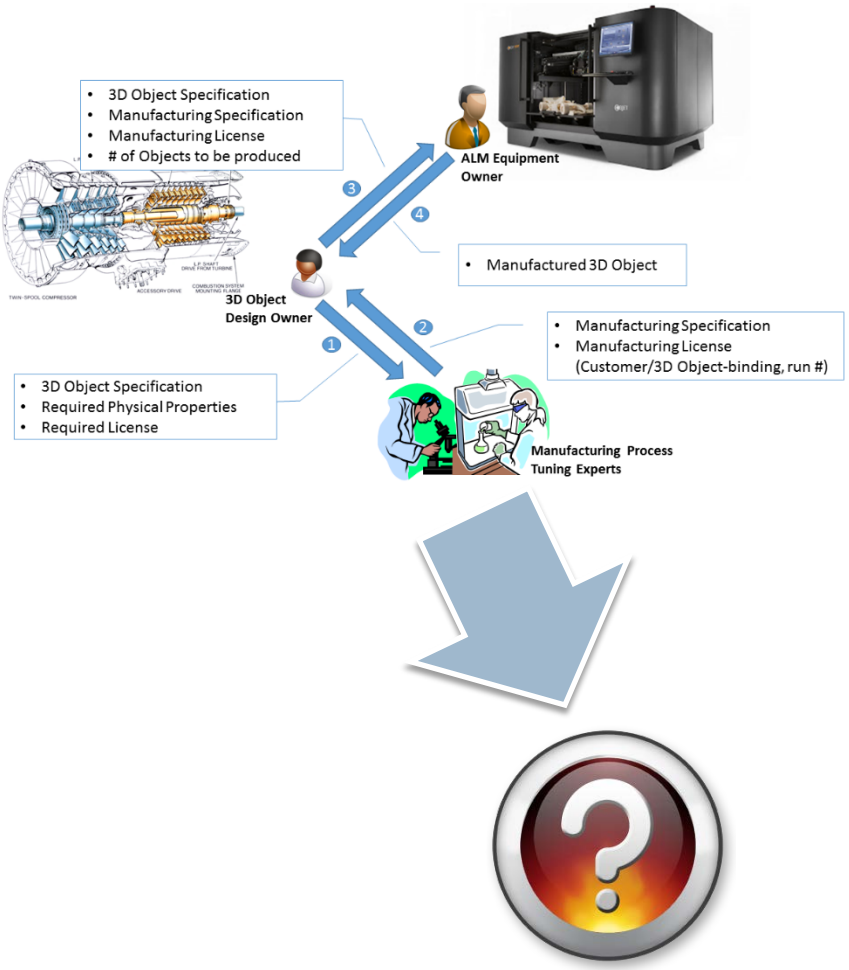


Towards Secure Outsourcing (1)

Needs

- Outsourcing Advantages
  - Flexibility
  - Cost Reduction
  - …
- IP Protection
  - Prevention
  - Detection
  - Attribution

} of IP Violation



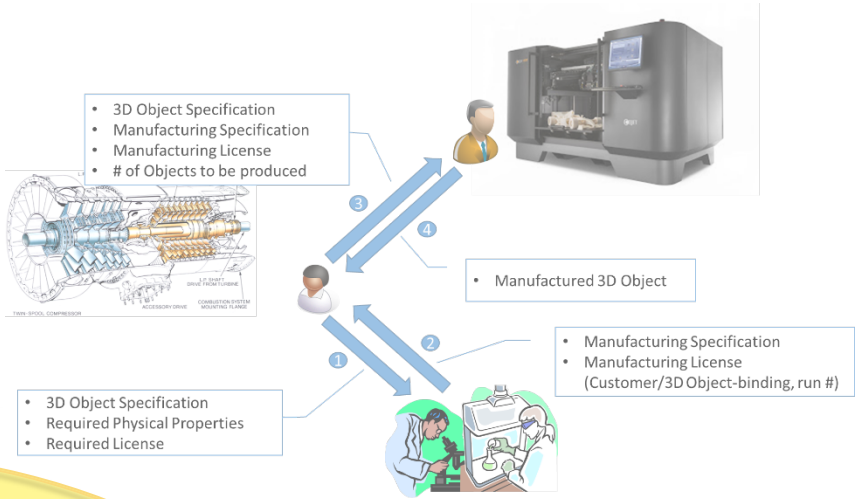
Towards Secure Outsourcing (2)

First Step: Requirements

- IP Owner:
  - IP Violations that can inflict financial damage

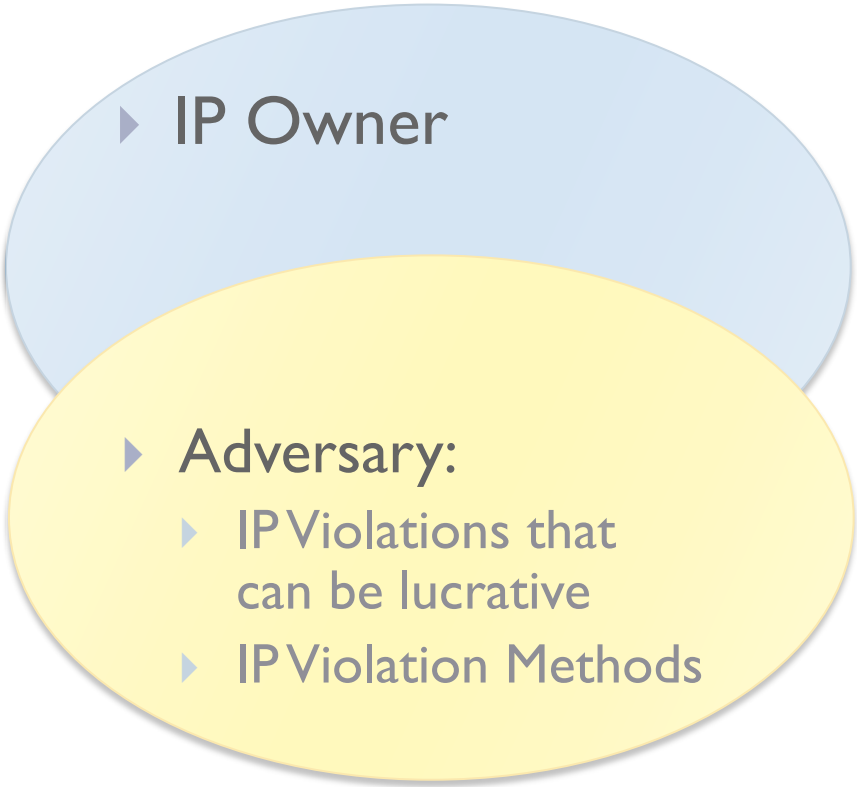
IP Protection Goals

- Adversary:
  - IP Violations that can be lucrative
  - IP Violation Methods



Adversary Goals

- Assumption
  - Every Actor can be Adversary



	Malicious Intents (IP-related only)
3D Object Designer	▪ Remove and/or Modify restrictions on usage of manufacturing parameters specification
Tuning Experts	▪ Copy [parts of] specification of 3D object shape and required physical properties
ALM Manufacturer	▪ Copy [parts of] specification of 3D object shape and required physical properties ▪ Copy and reuse manufacturing parameters specification; remove or modify restrictions associated with the specification
External Adversary	▪ Copy [parts of] specification of 3D object shape and required physical properties ▪ Copy manufacturing properties specification

IP Owner Goals

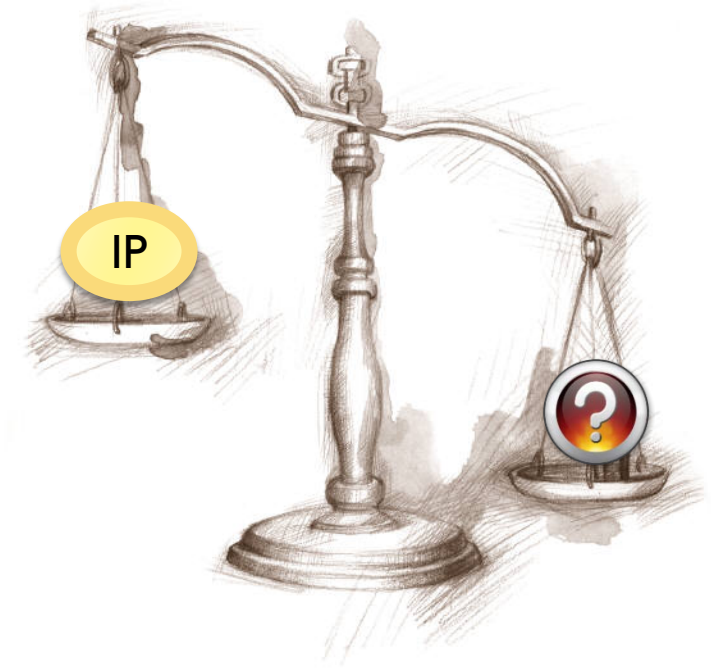
- Assumption
  - Every Actor is a potential Victim

	Prevention	Detection
3D Object Designer	▪ Copying ▪ Modification of Restrictions	▪ Identification of used IP ▪ Liability
Tuning Experts	▪ Copying	▪ Identification of used IP ▪ Liability
ALM Manufacturer	▪ Copying ▪ Modification of Restrictions ▪ Side-Channel Analysis ▪ Reverse Engineering	▪ Identification of used IP ▪ Liability
External Adversary	▪ Interception of Communication ▪ Reverse Engineering	▪ Distinction between internal/ external adversaries

Next Steps

- Modelling of Outsourcing
  - Support of hierarchical Outsourcing
  - Outsourcing Negotiation and IP Exchange Protocols
  - Data Models
  - IP Flow
- Validation and Limitations Identification
  - IP Protection in Printers, Scanners, CD/DVD, mp3, …
  - IP Watermarking (3D Models, Manufacturing Specification)
  - TPM-based Protection
  - Side-Channel Attacks Prevention Methods
- Interplay with another Aspect of ALM Security

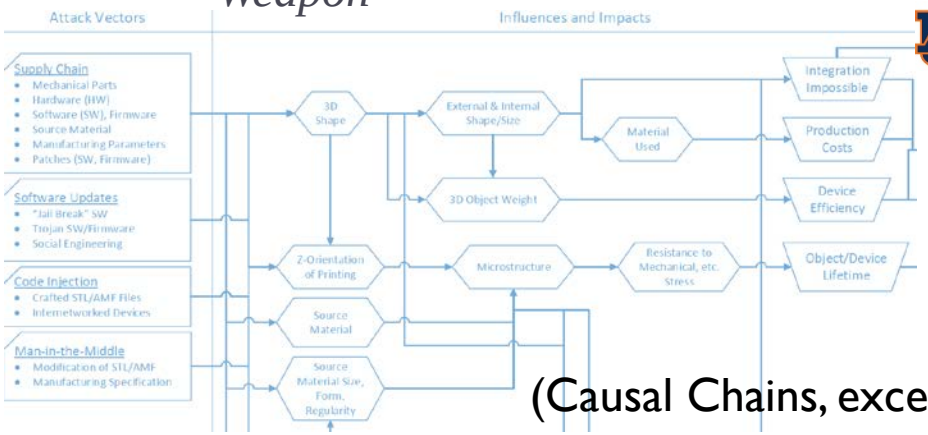
ALM Security



Parallel Thrust: Cyber-Physical Attacks

- Cyber Manipulations
  - 3D Object Specification
  - Manufacturing Properties
- Physical Consequences
  - Size/Shape
  - Weight
  - Physical Properties
- Broader Impacts
  - Physical Destruction
  - Economical Damage
  - Changed Public Opinion

- Under Review:
  - Mark Yampolskiy, Lena Schuetzle, Uday Vaidya, Alec Yasinsac, *Additive Layer Manufacturing with Metallic Alloys: Security Challenges*
  - Mark Yampolskiy, Jana Ivanidze, Anthony Skjellum, Ruel Overfelt, Alec Yasinsac, *3D Printer as a Weapon*



(Causal Chains, excerpt)

Looking for Research Partners