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Sandia National Laboratories

On Trusting Third-party Satellite Data

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JFK Airport – May 10, 2020

Spot the Difference

Which Image is the Original?

This is a presentation about assuring the authenticity of images created by third-party earth imaging sensors

A third-party is one operated by a commercial company, government agency, or other external organization

Outline

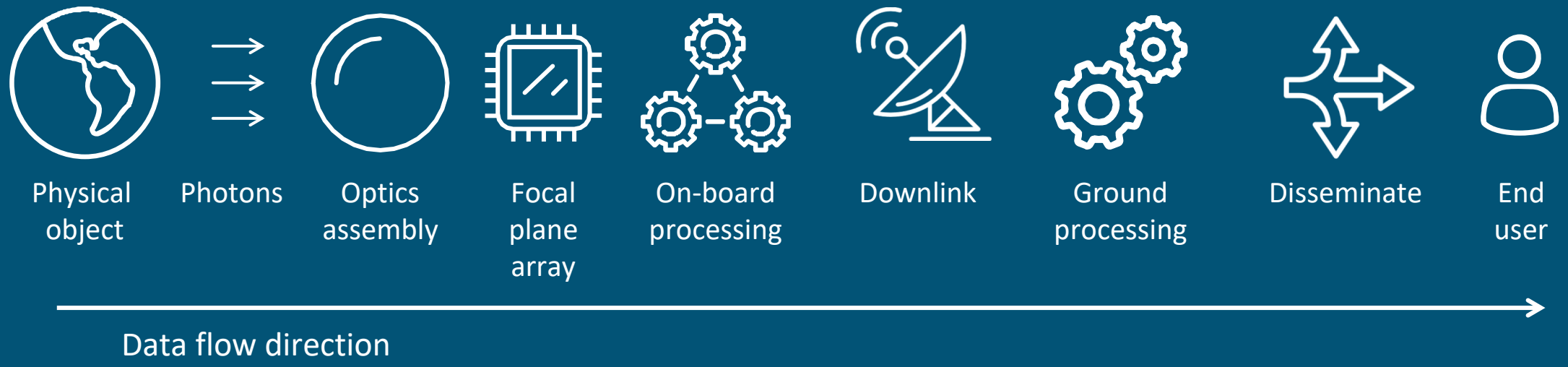
Part 1: Current challenges

Part 2: Requirements for trust

Part 3: Architecture and verification

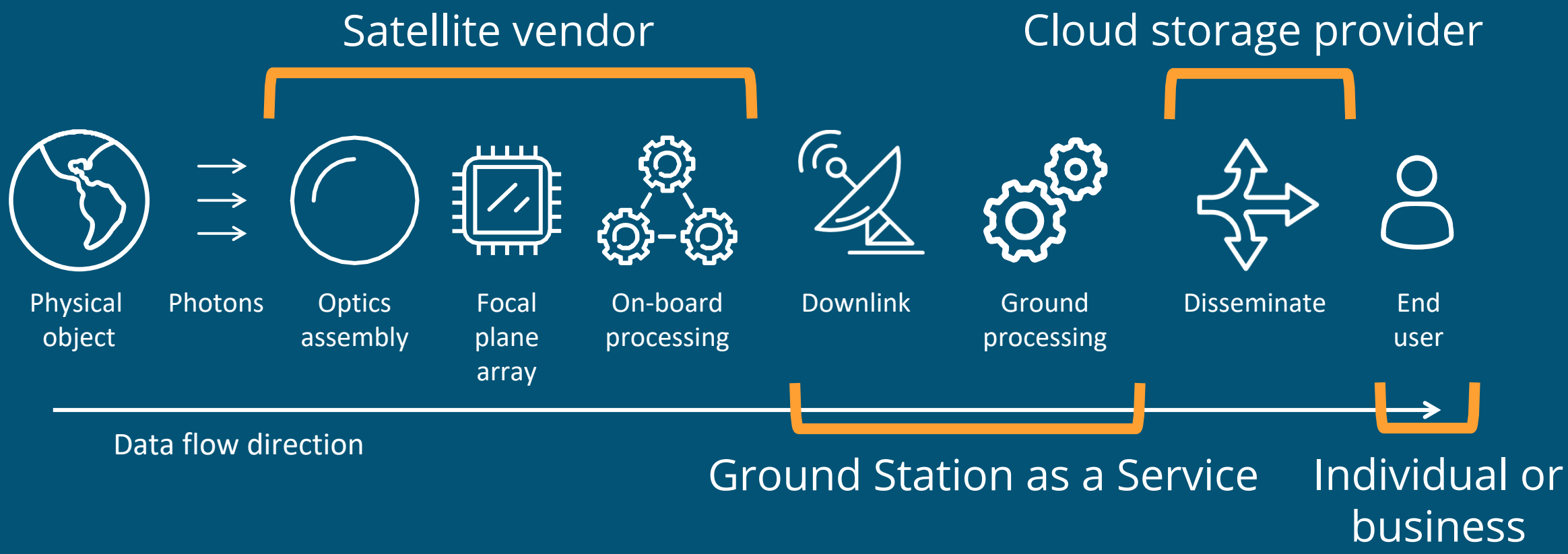
Current Challenges

The Lineage of an Image



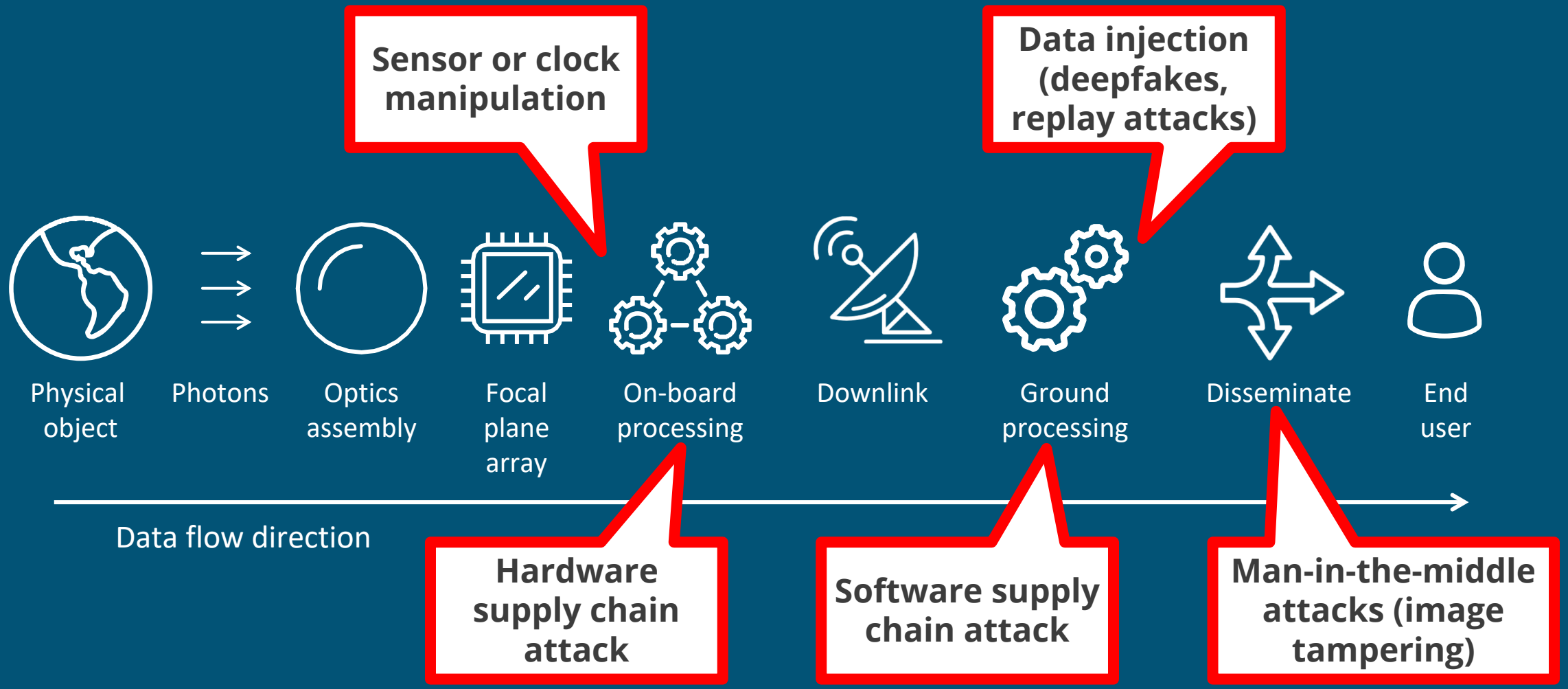
The data flows through several components and systems before reaching the end user

Challenge 1: Trust Segmentation



Trust is segmented as components and systems are built, owned, and operated by a different organizations

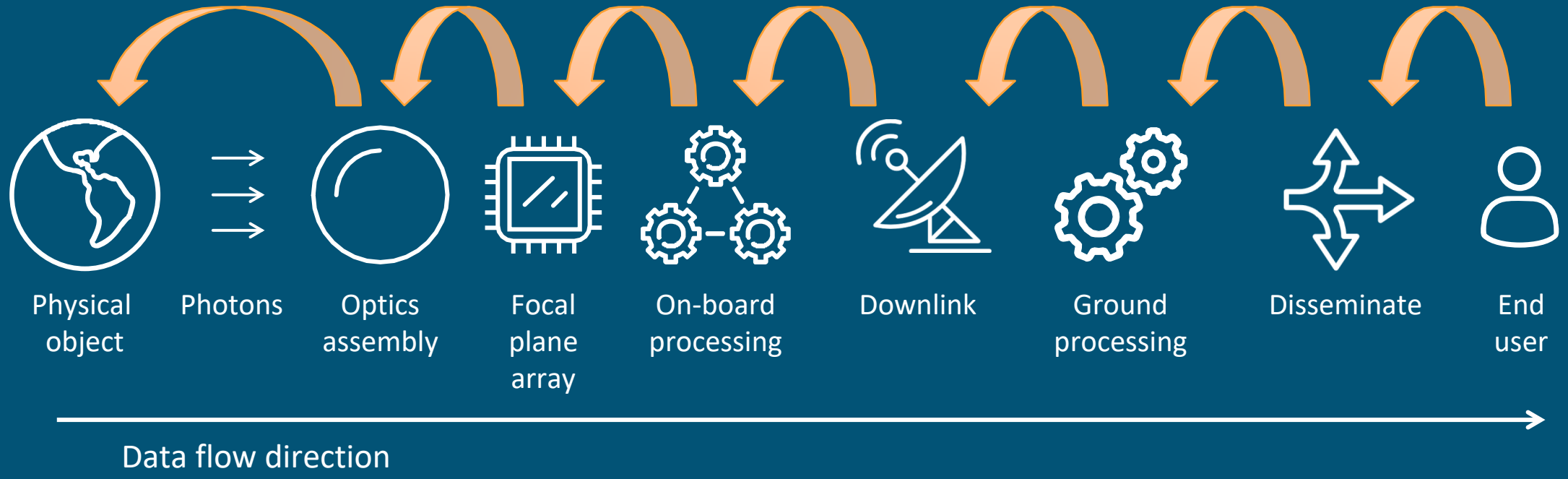
Challenge 2: Broad Attack Surface



These systems and components could be vulnerable to various threats

Challenge 3: A Chain of Unguarded Trust

Each system simply trusts the system that sent the data



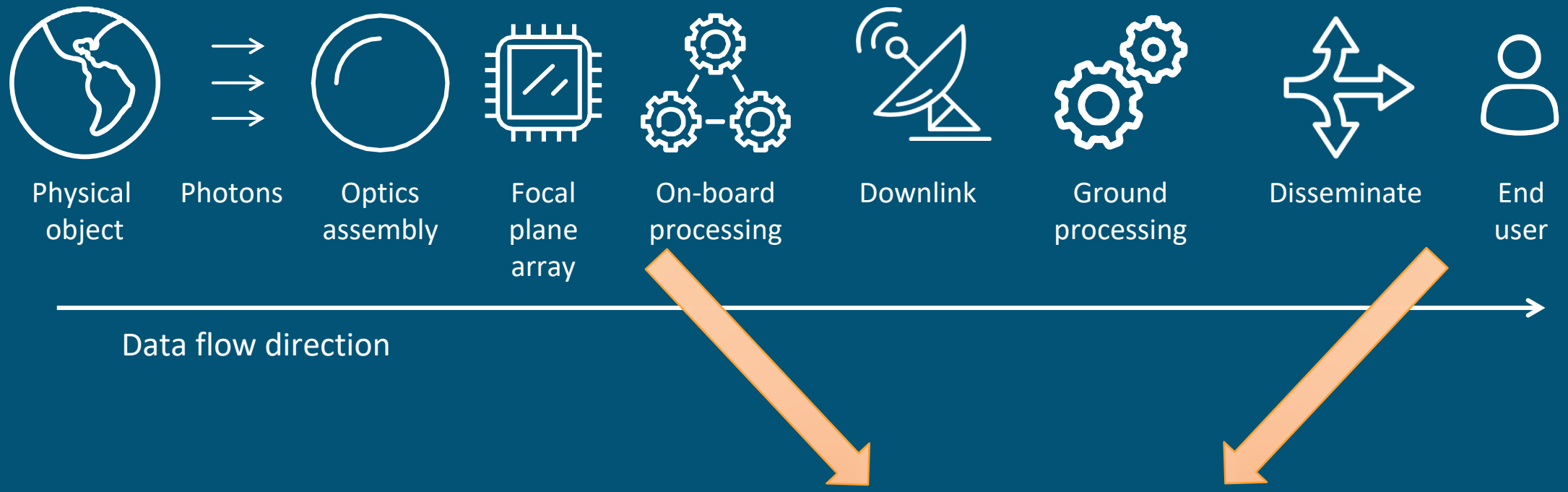
A game of telephone without end-of-round reconciliation!

Without end-to-end checks, nobody knows if the end product is authentic or not

Requirements For Trust

End-to-End Checking

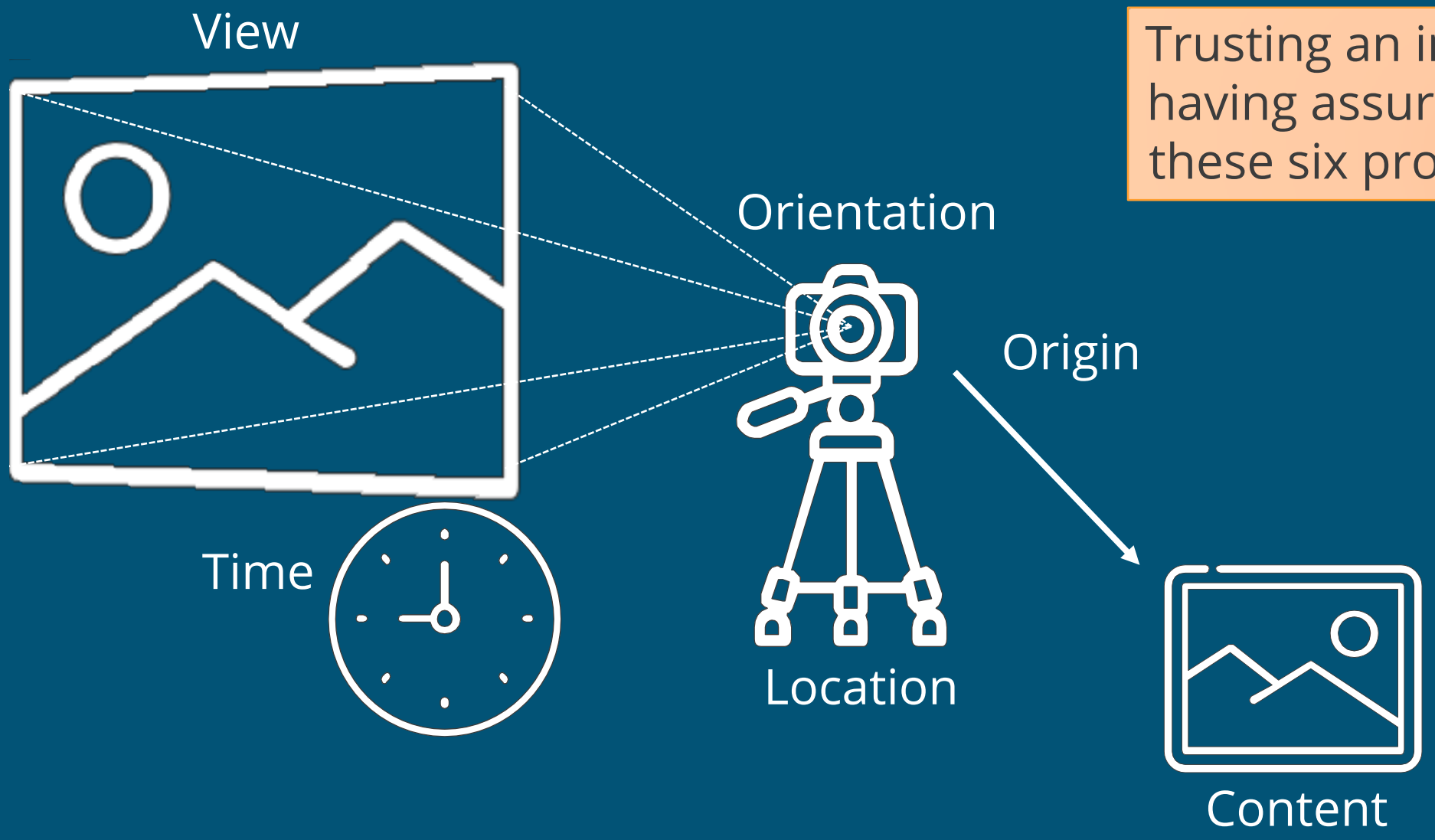
Check authenticity by comparing end products against the image produced by the sensor



$x = y$

- Which properties must be checked?
- How is this done securely?

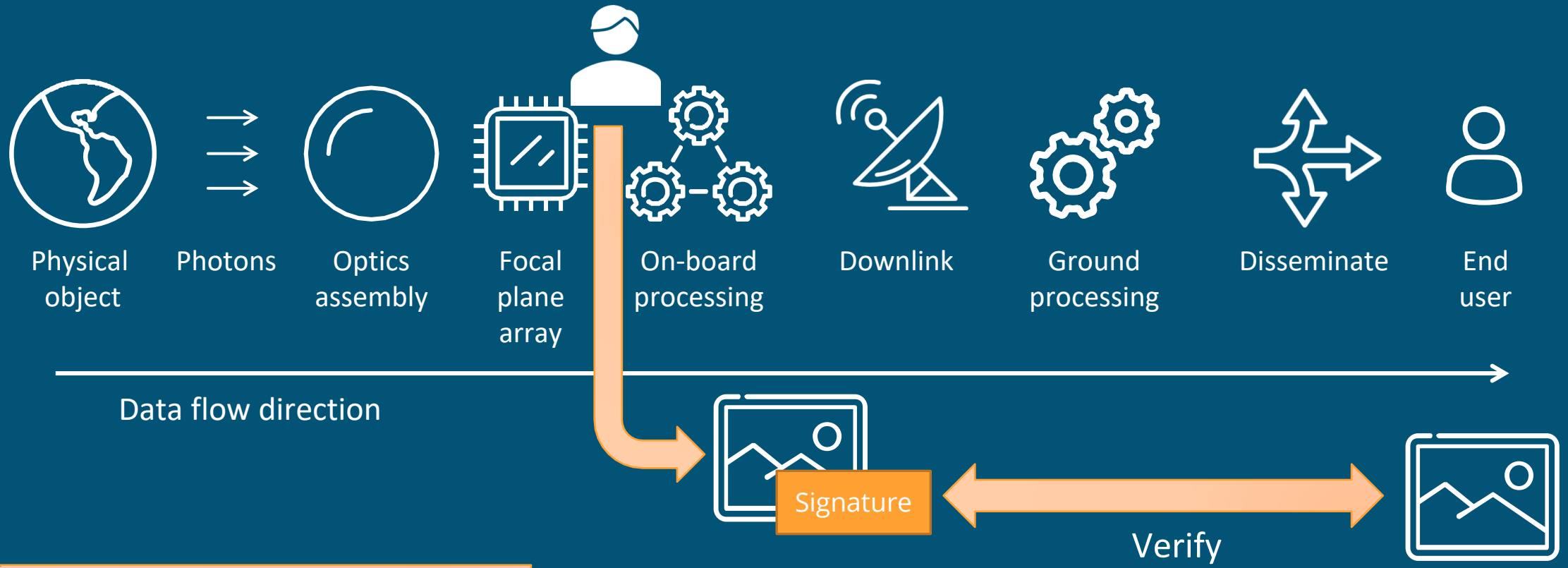
Requirements of Trust of Imagery



Trusting an image is having assurance of these six properties

Assurance of Original Image Properties

A digital “notary public” to sign off on the collection of an image



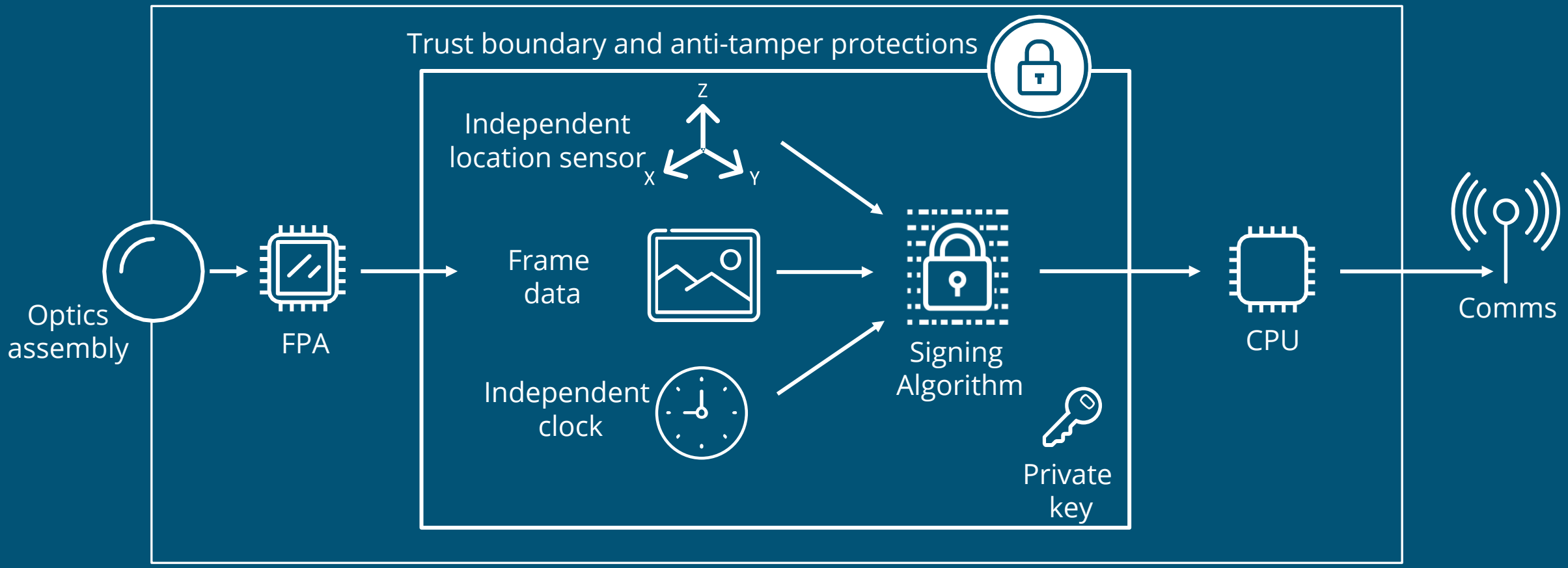
This independent verification bridges the trust gap between the vendor and the end user

A digital signature used as a proxy of the original data for comparison

Architecture and Verification

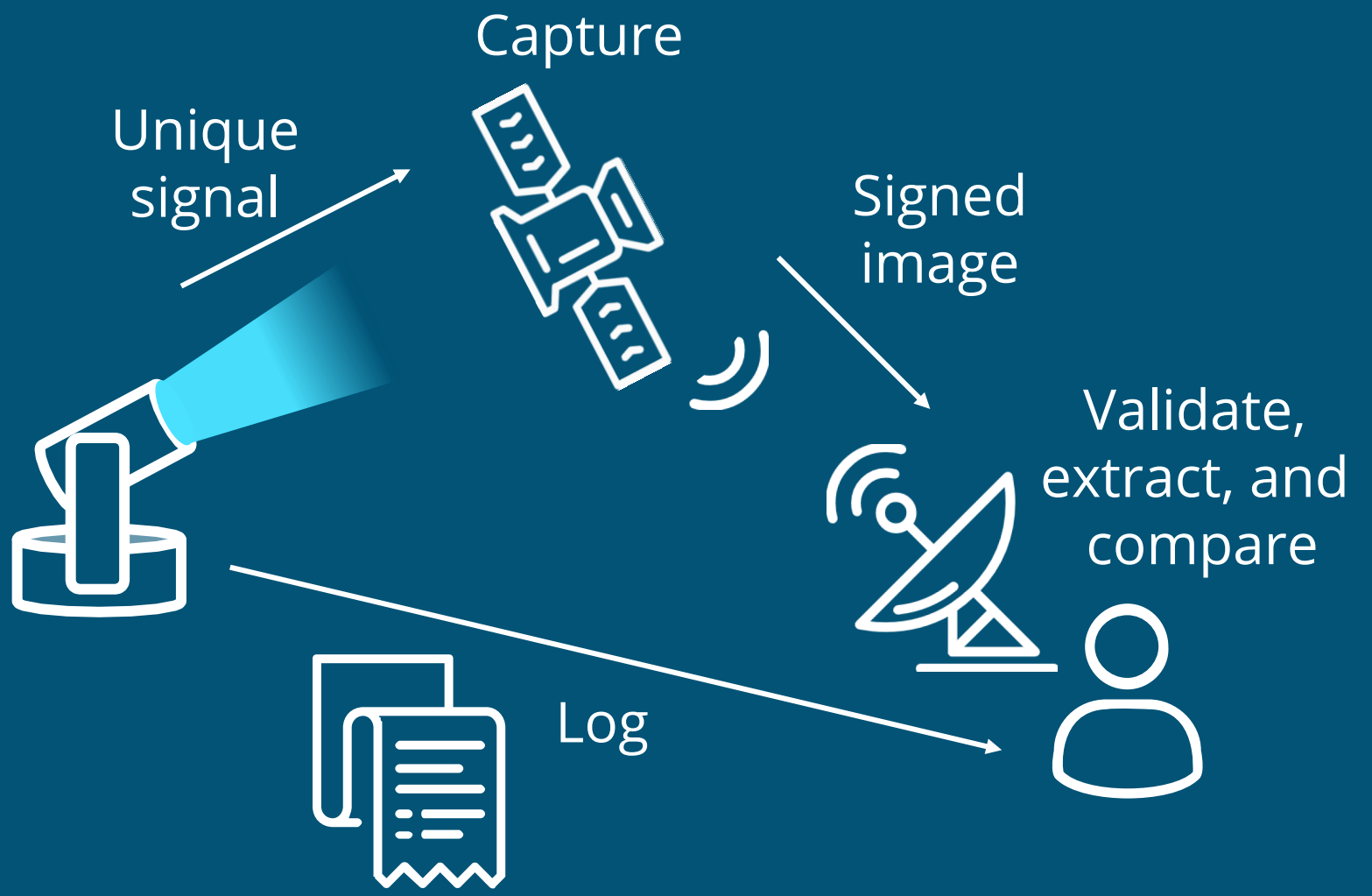
Our architecture and remote verification mechanisms are patent pending

Payload Architecture



Our architecture provides independent assurance of a satellite collection by signing the data, collect time, location information

Remote Verification: Emitter Test

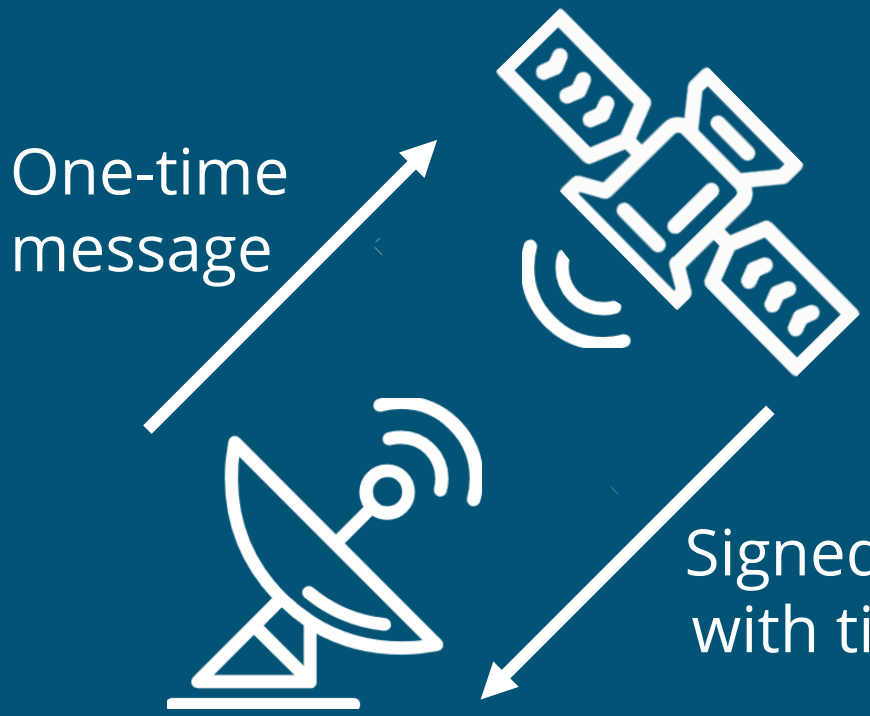


Trust requirements verified:

1. View
2. Orientation
3. Location
4. Origin
5. Content

This test exercises the full end-to-end data path: physical object to end user

Remote Verification: Challenge/Response Test

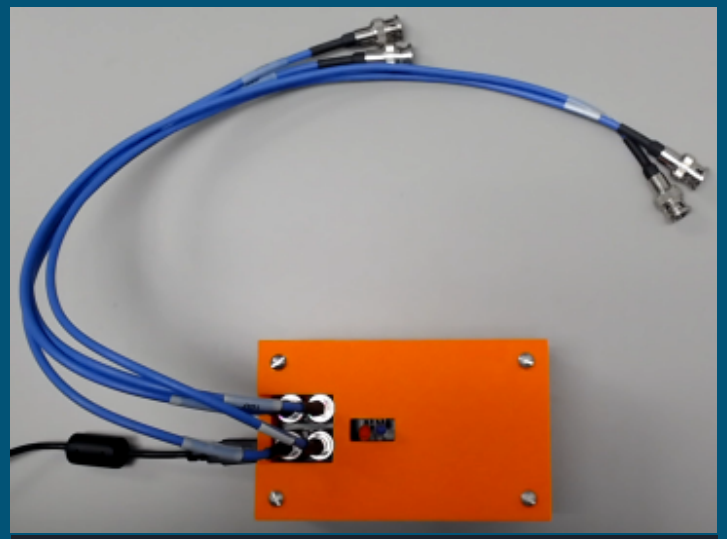


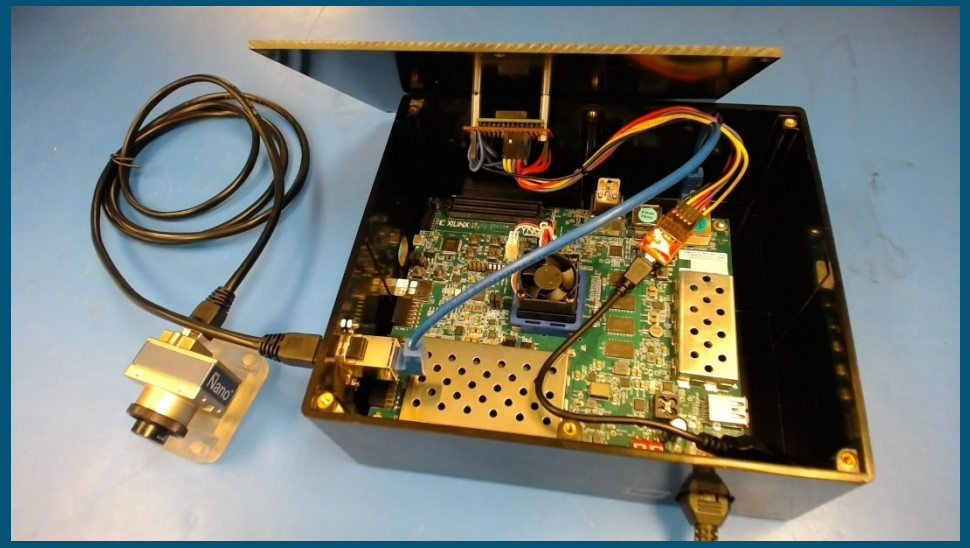
This test over RF commanding channels checks the trusted clock

Trust requirements verified:
1. Location
2. Origin
3. Time

This bounded time test checks the trusted clock and confirms that the private signing key is on orbit

End-to-end Prototype (Lab Test)





Prototype Trusted Hardware

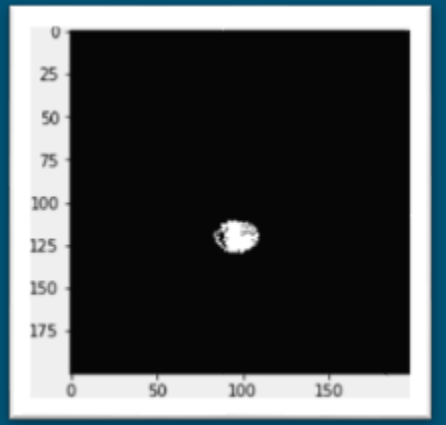
End-user Verification

PC_TIME,LAT,LON,NONCE,RED,BLUE,SUCCESS
2022-08-02T20:16:54.644Z, 35.08, -106.65, 1, MEDIUM, OFF, False

Signal Generator

	A	B	C	D	E	F	G
1	PC_TIME	LAT	LON	NONCE	RED	BLUE	SUCCESS
2	2022-08-02T20:16:54.644Z	35.08	-106.65	1	MEDIUM	OFF	False
3	2022-08-02T20:16:55.692Z	35.08	-106.65	1	MEDIUM	OFF	True
4	2022-08-02T20:16:56.729Z	35.08	-106.65	1	MEDIUM	OFF	True
5	2022-08-02T20:16:57.769Z	35.08	-106.65	8	LOW	MEDIUM	True
6	2022-08-02T20:16:58.824Z	35.08	-106.65	3	OFF	LOW	True
7	2022-08-02T20:16:59.848Z	35.08	-106.65	6	HIGH	LOW	True
8	2022-08-02T20:17:00.905Z	35.08	-106.65	11	OFF	HIGH	True
9	2022-08-02T20:17:01.946Z	35.08	-106.65	12	LOW	HIGH	True
10	2022-08-02T20:17:03.002Z	35.08	-106.65	7	OFF	MEDIUM	True
11	2022-08-02T20:17:04.042Z	35.08	-106.65	0	LOW	OFF	True
12	2022-08-02T20:17:05.076Z	35.08	-106.65	3	OFF	LOW	True
13	2022-08-02T20:17:06.129Z	35.08	-106.65	7	OFF	MEDIUM	True
14	2022-08-02T20:17:07.178Z	35.08	-106.65	7	OFF	MEDIUM	True
15	2022-08-02T20:17:08.200Z	35.08	-106.65	6	HIGH	LOW	True
16	2022-08-02T20:17:09.244Z	35.08	-106.65	0	LOW	OFF	True
17	2022-08-02T20:17:10.285Z	35.08	-106.65	4	LOW	LOW	True

Signal Log



Signal Extractor

Pass/fail

Consider how you can integrate these principles of data authenticity into your satellite architectures

Thank you!

"The book is always better"

See our full paper for additional detail, including:

- Threats
- Architecture description
- Size, weight, and power constraints
- Post processing restrictions
- Inspection plans