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Siemens Corporate Technology, IT Security

Secure Software Distribution in Aviation Context

Dr. David von Oheimb and Dr. Rainer Falk
Siemens Corporate Technology, *IT Security*

Aviation Cyber-Physical Security - Safety and Security
Workshop, SAE AeroTech, 2011-Oct-21 in Toulouse, France
http://www.sae.org/events/atc/

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Overview

- **Software Distribution Systems**
- Technical Challenges
- Security Mechanisms
- Conclusion

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Motivation for software distribution

- In aircraft and other mobile systems, more and more software is used.
  - BMW estimation of 2007: 25+% of the value of a modern car is software
  - “An airplane is a supercomputer with wings”
- Specific software and increasingly standard components are employed.
  - For example, proprietary device controller and generic network stacks
- Software needs to be updated more and more often:
  - Bug fixes, both self-induced and inherited ones
  - Enhancements/Updates due to evolving requirements
- Software controls critical parts of mobile systems w.r.t. safety and business.
  - For instance: velocity control, emergency modes, maintenance utilities
- Consequently, software distribution in the field is essential and critical.

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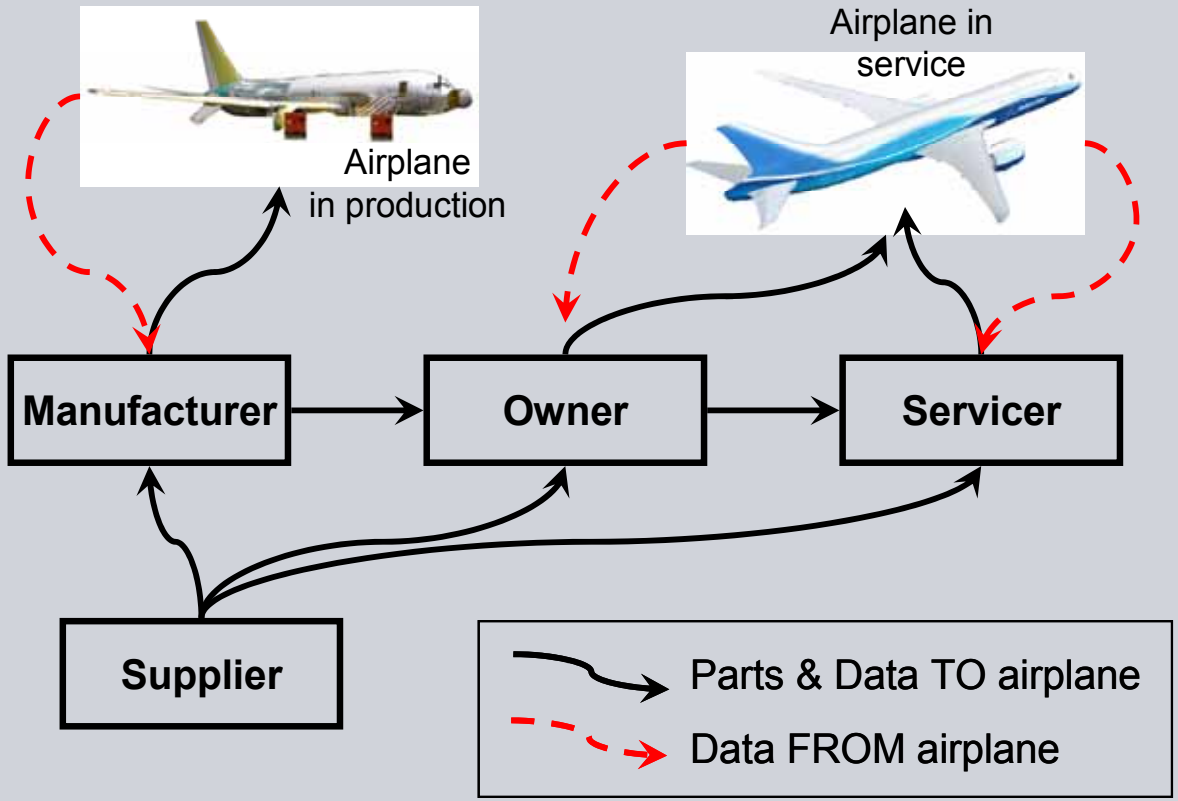
Electronic Distribution of Software (EDS) for aircraft

Transition from media-based (CD-ROMs etc.) to networked SW transport

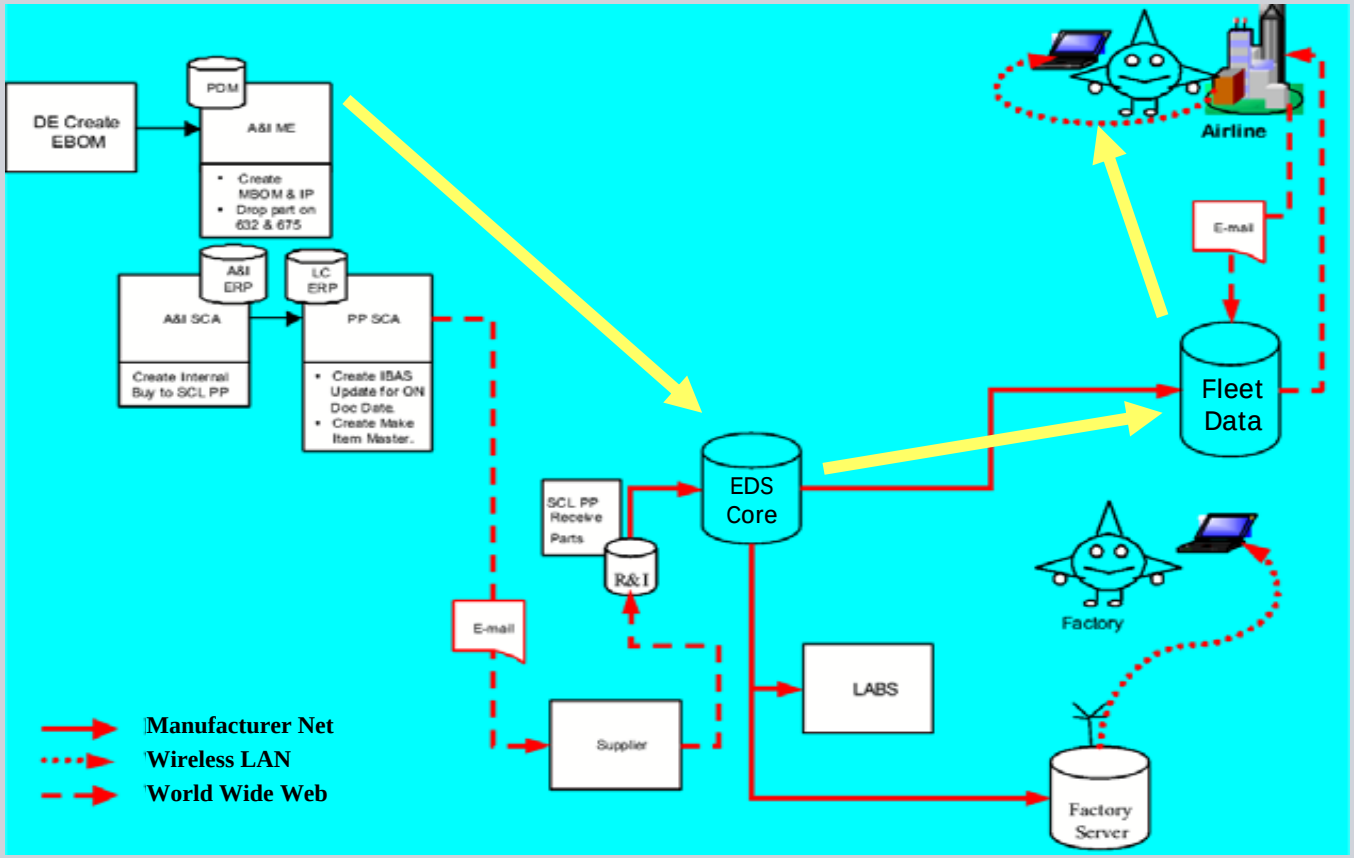
EDS is a system for storage and distribution of airplane software assets, including *Loadable Software Airplane Parts* (LSAP) and airplane health data



EDS system architecture

A complex distributed store-and-forward middleware (incl. web services) with heterogeneous components (incl. off-the-shelf and open-source SW)

Figure is heavily simplified and not up-to-date!



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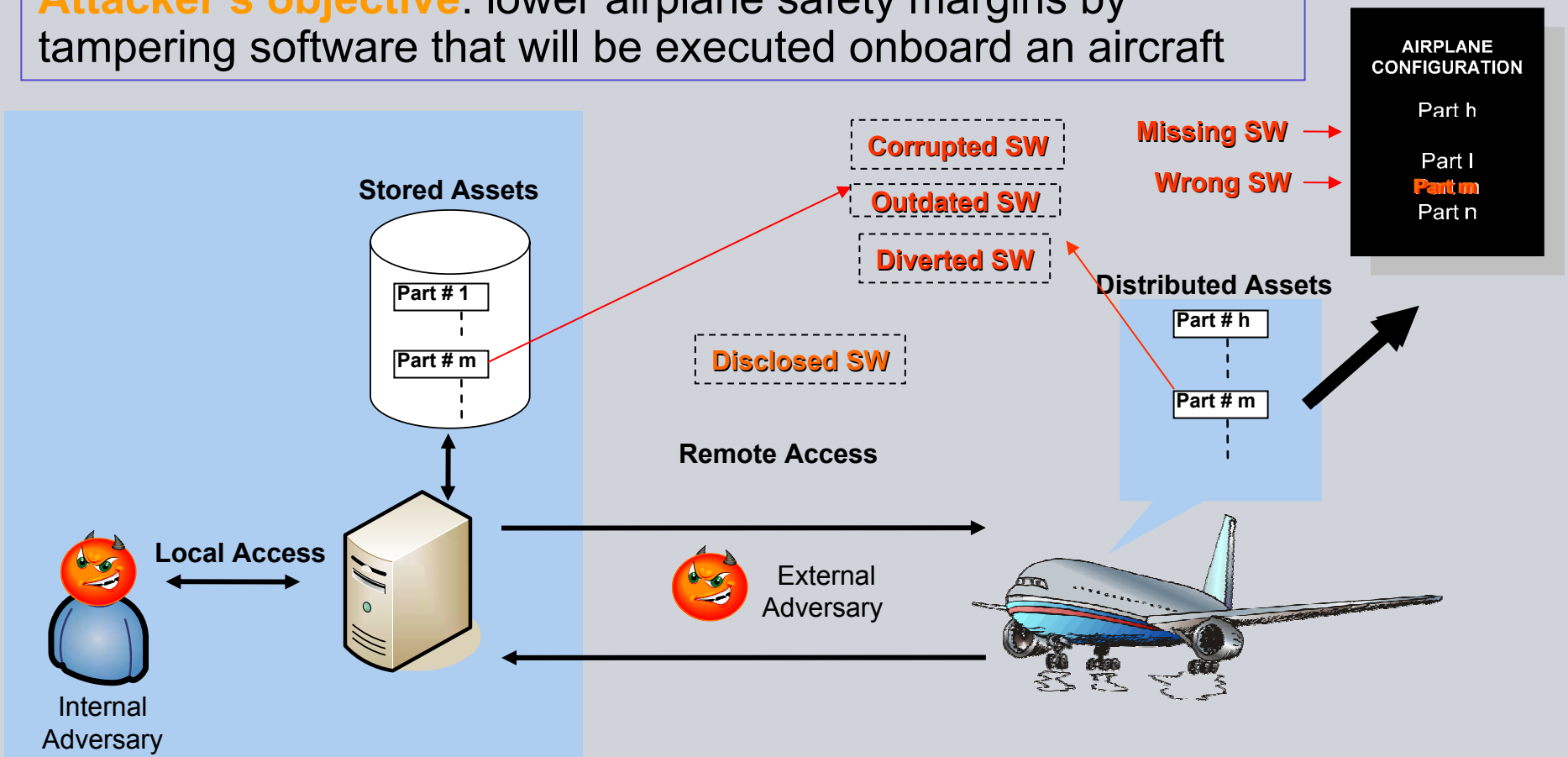
Challenges for software update process in the field

- Quality and compatibility of software update items
  - New SW must work correctly and fit in the context
- Patch management including version control
  - When to apply which update on which devices
- Efficiency of software transport (bandwidth) and installation (down time)
- Total costs of the upgrade process including all parties
  - High degree of automation and use of existing infrastructure desirable
- Safety hazards due to tampering/sabotage, business risks due to disruption of service, denial of liability, or product counterfeiting
  - Main problem: transport over open, untrusted networks
- Regulators or customers may require safety/security certification
  - Software update must be dealt with as part of the overall system/process

Safety-related security threats for EDS in aviation

Attacker's objective: lower airplane safety margins by tampering software that will be executed onboard an aircraft



Corruption/Injection **Wrong Version** **Diversion** **Disclosure**

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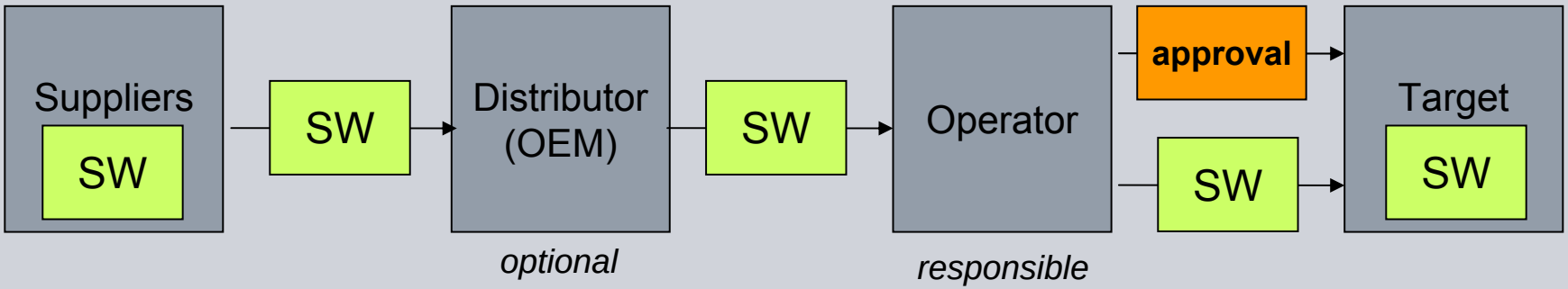
Generic Software Distribution System (SDS)

Consider any IT system with networked devices in the field performing safety-critical and/or security-critical tasks and requiring the option to update software components

Software Distribution System (SDS):
System providing secure distribution of software
from software suppliers ultimately to target devices in the field



Possibly many suppliers, several operators, indirect trust relations

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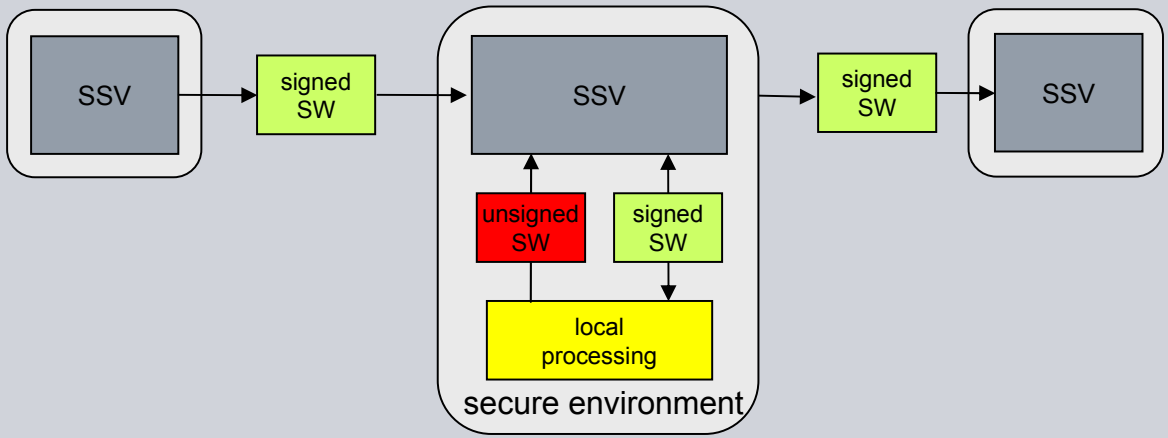
Generic core of SDS: Software Signer Verifier (SSV)

Each node in the SDS chain runs an SSV instance, used to:

- introduce software into the SDS, adding signature + optional encryption
- verify the signature on software received from other SSVs, checking software integrity, plus sender authenticity and authorization
- approve software, adding e.g. an authorized signature or tag, after e.g. checking security policy, static code analysis, runtime check injection, …
- deliver software to the installation target, optional decryption



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SDS/SSV main security mechanism: cryptography

Main security mechanism: asymmetric cryptography applied on SW item

- Sender S encrypts software with public key of receiver R: K(R)
  → only the intended receiver R can read it (using R's private key $K(R)^{-1}$)
- Sender S signs software and meta-data with private key of itself: $K(S)^{-1}$
  → any receiver can verify (using S's public key K(S)) if it comes from S

S sends to R : $\{SW\}_{K(R)}.\{hash(SW).R.\ldots\}_{K(S)^{-1}}$

SW	a software item including its identity etc.
hash(M)	the hash value (i.e. crypto checksum) of content M
M.N	the concatenated contents M and N
$\{M\}_{K(R)}$	content M encrypted with public key of R
$\{M\}_{K(S)^{-1}}$	content M digitally signed with private key of S

Alternative: secure transport channels, e.g. TLS between trusted parties

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SDS/SSV: issues and solutions wrt. cryptography

- Major issue: key management
  - Field devices must have authentic public key of SW distributor
  - For encryption, distributor must know all public keys of devices
  - More complex in multi-stage distribution (including indirect trust)
  - Most involved: revocation and update of keys stored in the field
  - Lightweight custom solutions or existing Public Key Infrastructure (PKI)
- Long-lived (10+ years) assurance required
  - Use strong algorithms with long keys and perform scheduled re-keying
- Secure key storage and prevent side-channel attacks on private keys
  - For high assurance: hardware modules and special algorithms
- Efficiency and bandwidth/storage space minimization
  - Hybrid encryption with asymmetrically encrypted symmetric transport key

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SDS: issues and solutions w.r.t. target devices

- In some cases, code quality/security can not be guaranteed
  - Isolate malicious behavior with sandboxing/virtualization
- SW maybe not installable at all times or manual processing required
  - Ensure that target is in suitable state (e.g. authorized maintenance mode)
- New version may have specific configuration requirements
  - Check if other installed SW items have conflicting versions or status
- Data/configurations of previous SW versions may be incompatible
  - Delete conflicting parts or apply transformation during installation
- SW installation might fail after partial update. Fallback strategies:
  - Keep previous configuration until correct update has been verified
  - Retry transmission/installation of new SW
  - Provide alternative source (of new version or emergency substitute)

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Conclusion

- Software distribution in aviation context needs to cover complex global dynamic heterogeneous architectures
- Main aspects: configuration management and safety/security
- Major challenge is management of cryptographic keys
- Additional issues: configuration & installation at target devices
- High assurance requires special solutions with HW support
- Maximal confidence can be obtained by security certification