



# ECSEL impact to LTU

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# Technology research impact at LTU

- Technology
  - Arrowhead Framework
    - Architecture and implementation support for automation and digitalisation solutions based on IoT and SoS technologies
    - Arrowhead engineering tools are emerging
    - Open source since 2016
    - Long term governance - Eclipse Arrowhead
    - Growing recognition in industry
    - Standardisation in relation to engineering tools - SysML
    - LTU is a key competence source

# Comparison IoT/SoS frameworks

Features	Arrowhead	AUTOSAR	BaSyx	FIWARE	IoTivity	LWM2M	OCF
<b>Key principles</b>	SOA, Local Automation Clouds	Runtime, Electronic Control Unit (ECU)	Variability of production processes	Context awareness	Device-to-device communication	M2M, Constrained networks	Resource Oriented REST, Certification
<b>Real-time</b>	Yes	Yes	No	No	Yes (IoTivityConstrained)	No	No
<b>Run-time</b>	Dynamic orchestration and authorization, monitoring, and dynamic automation	Runtime Environment layer (RTE)	Runtime environment	Monitoring, dynamic service selection and verification	No	No	No
<b>Distribution</b>	Distributed	Centralize	Centralize	Centralize	Centralize	Centralize	Centralize
<b>Open Source</b>	Yes	No	Yes	Yes	Yes	Yes	No
<b>Resource accessibility</b>	High	Low	Very low	High	Medium	Medium	Low
<b>Supporters</b>	Arrowhead	AUTOSAR	Basys 4.0	FIWARE Foundation	Open Connectivity Foundation	OMA SpecWorks	Open Connectivity Foundation
<b>Message patterns</b>	Req/Repl, Pub/sub	Req/Repl, Pub/sub	Req/Repl,	Req/Repl, Pub/sub	Req/Repl, Pub/sub	Req/Repl	Req/Repl
<b>Transport protocols</b>	TCP, UDP, DTLS/TLS	TCP, UDP, TLS	TCP	TCP, UDP, DTLS/TLS	TCP, UDP, DTLS/TLS	TCP, UDP, DTLS/TLS, SMS	TCP, UDP, DTLS/TLS, BLE
<b>Communication protocols</b>	HTTP, CoAP, MQTT, OPC-UA	HTTP	HTTP, OPC-UA	HTTP, RTPS	HTTP, CoAP	CoAP	HTTP, CoAP
<b>3<sup>rd</sup> party and Legacy systems adaptability</b>	Yes	Yes	Yes	Yes	No	No	No
<b>Security Manager</b>	Authentication, Authorization and Accounting Core System	Crypto Service Manager, Secure Onboard Communication	--	Identity Manager Enabler	Secure Resource Manager	OSCORE	Secure Resource Manager
<b>Standardization</b>	Use of existing standards	AUTOSAR standards	Use of existing standards	FIWARE NGSI	OCF standards	Use of existing standards	OCF standards

# Education impact at LTU

- Courses based on results from ECSEL projects are now part of LTU curricula for
  - Computer Science
  - Electrical Engineering and Engineering physics
- Major course content based on Arrowhead Framework
- Courses also provided as open courses on distance
  - High number of applicants



# Key impact to LTU

- LTU being recognised as a key competence center for IoT and SoS based automation and digitalisation
  - Resulting in substantial funding for research and industrial cooperation
    - Sweden
    - Europe
    - Cooperation request from ex Europe
      - Japan, Korea, Turkey, ...