A Model-driven development framework for highly Parallel and EneRgy-Efficient computation supporting multi-criteria optimisation

Railway use-case
AMPERE Webinar
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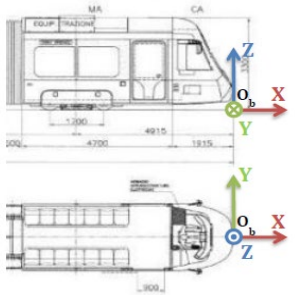
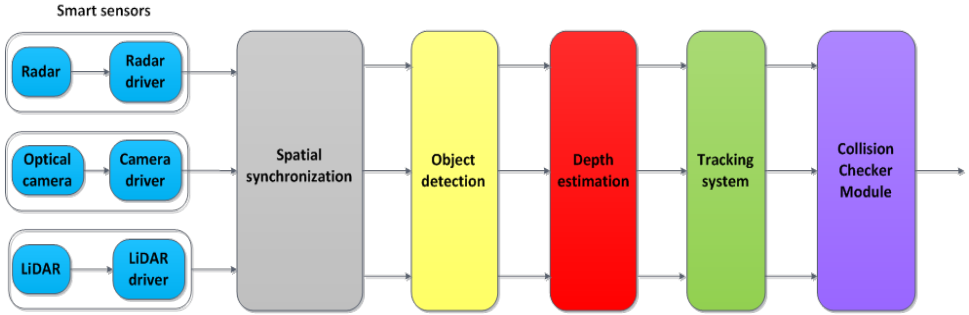
GTSI mission in AMPERE

- Providing RAILWAY Use case as application of ODAS (Obstacle Detection and Avoidance System) to the Florence Tramway
- Railway use-case DSML Model: ODAS system model made by Capella and AMALTHEA.
- Capella extension to deal with safety aspects associated to use case
- Cooperation with partners to create a tool chain from Capella to Amalthea by a dedicated bridge.
- Software Kernel from ODAS in collaboration with UNISI: Kalman filter and Observer (later better described in the real-time part).
- ODAS Safety approach and relating constraints to use case to feed activities of partners developing the technological solutions



ODAS

- ODAS (Obstacle Detection and Avoidance System) is a GTSI system that is under finalization and that will become a product for the Tramway market.
- ODAS recently passed the MAIN GATE examination that is the last technologic verification step that GTSI performs to new systems before they are allowed to become products.
- ODAS prototypes (PoC) were installed on three vehicles of the Florence Tramway.

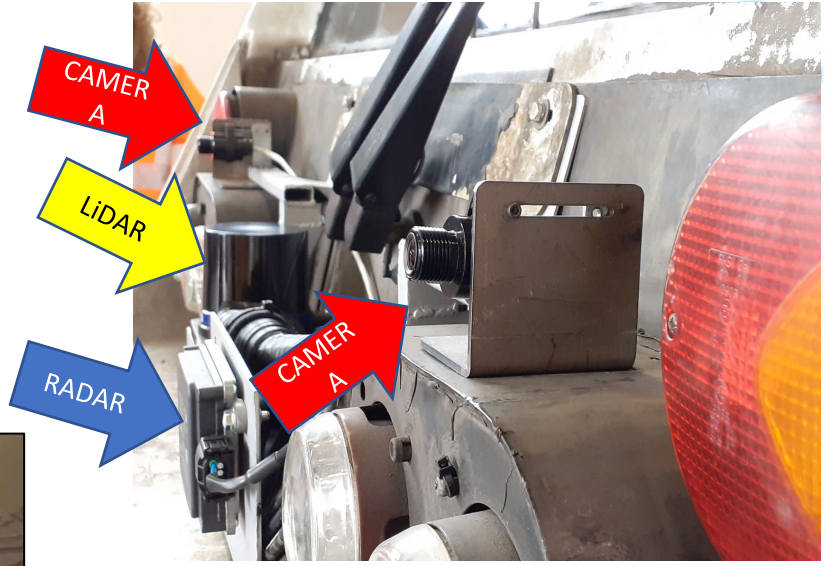


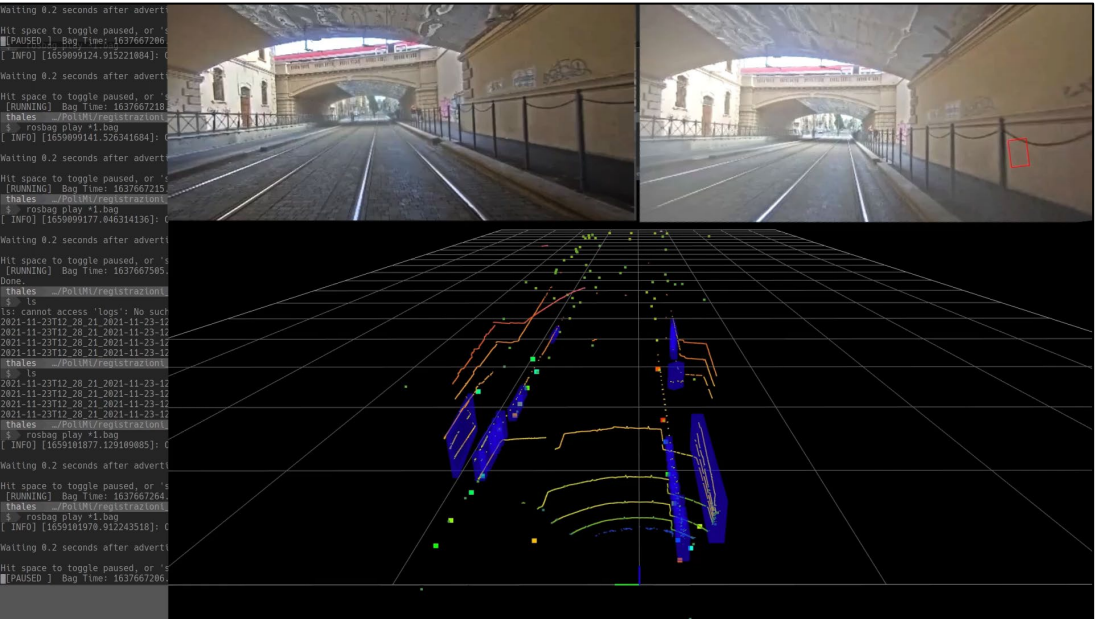
ODAS Installation on prototypes

ODAS relies on sensors mounted on the tram nose:

- Cameras
- LiDAR
- RADAR

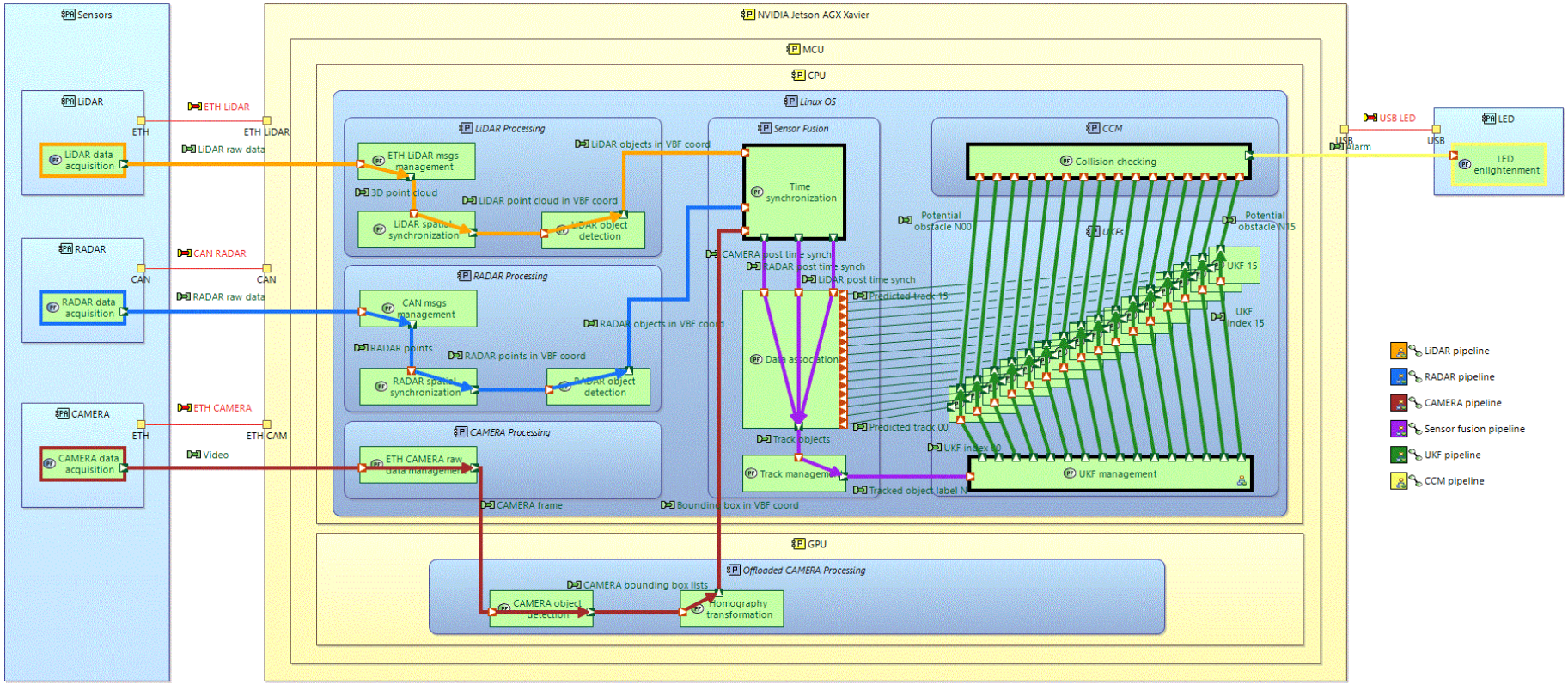
Control system based on XAVIER NVIDIA board





Screen capture of verification tool for sensors' data and their fusion

ODAS Model


Sensors
LiDAR
ETH
LiDAR data acquisition
ETH LiDAR
ETH LiDAR
LiDAR raw data
RADAR
CAN
RADAR data acquisition
CAN RADAR
CAN
RADAR raw data
CAMERA
ETH
CAMERA data acquisition
ETH CAMERA
ETH CAM
Video
NVIDIA Jetson AGX Xavier
MCU
CPU
Linux OS
LiDAR Processing
ETH LiDAR msgs management
3D point cloud
LiDAR spatial synchronization
LiDAR point cloud in VBF coord
LiDAR object detection
LiDAR objects in VBF coord
RADAR Processing
CAN msgs management
RADAR points
RADAR spatial synchronization
RADAR points in VBF coord
RADAR object detection
RADAR objects in VBF coord
CAMERA Processing
ETH CAMERA raw data management
CAMERA frame
Sensor Fusion
Time synchronization
CAMERA post time synch
RADAR post time synch
LiDAR post time synch
Data association
Predicted track 15
Predicted track 00
Track objects
Track management
Tracked object label N
Bounding box in VBF coord
CCM
Collision checking
Potential obstacle N00
Potential obstacle N15
UKFs
UKF 15
UKF index 15
UKF index 00
UKF management
USB LED
USB Alarm
USB
LED
LED enlightenment
GPU
Offloaded CAMERA Processing
CAMERA bounding box lists
CAMERA object detection
Homography transformation
LiDAR pipeline
RADAR pipeline
CAMERA pipeline
Sensor fusion pipeline
UKF pipeline
CCM pipeline

ODAS overview

- **Data from sensors are collected independently one from each other:**
  - 100 ms LiDAR raw data
  - 92 ms RADAR raw data
  - 40 ms for video (25 frames per second)
- **Data processed for spatial synchronization(e.g. homography and distortion correction) and time synchronization (data from different sensors)**
- **Detection of objects**
- **Data association to establish when different detections from different sensors refer to the same objects**
- **Tracking of objects. A Kalman filters track each detected object up to a maximum number (now set to 60). In case the number of detected objects exceeds the maximum number, the farthest one is not tracked.**
- **Collision checker evaluates if the estimated position of each object can lead to a collision, in order to warn the driver.**

ODAS and Safety (1/2)

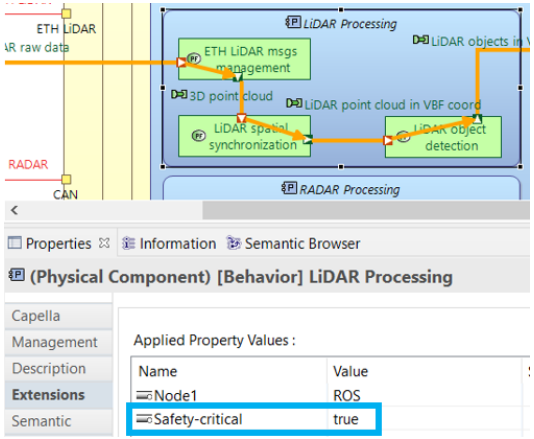
- **Use cases have been used as a source of *non-functional* requirements to test AMPERE ecosystem**

- **Preliminary Hazard Analysis identified safety requirements on**
  - ODAS system
  - AMPERE ecosystem (ex. generated SW must comply to EN50128 standard)

- **Modelling of ODAS system safety requirements triggered a modification to the DSML tools at different design levels**
  - Inception design: Capella
  - Detailed design: Amalthea

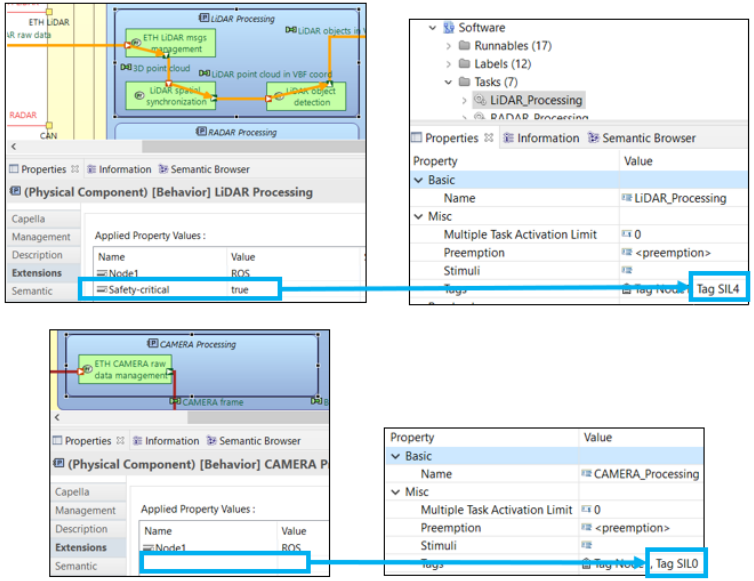
ODAS and Safety (2/2)

- **Capella DSLM modification**
  - Tag “Safety-critical”



Bridge
(by TRT)

- **Amalthea DSLM modification**
  - Tag “SIL*x*”



Use case evaluation

- AMPERE ecosystem has been evaluated by applying the toolchain to the railway use case

```
Capella model generation.................[OK]
Amalthea model generation through Bridge..[OK]
Code generation through SLG..............[OK]
C++ code build through LLVM..............[OK]
Execution on target platform.............[OK]
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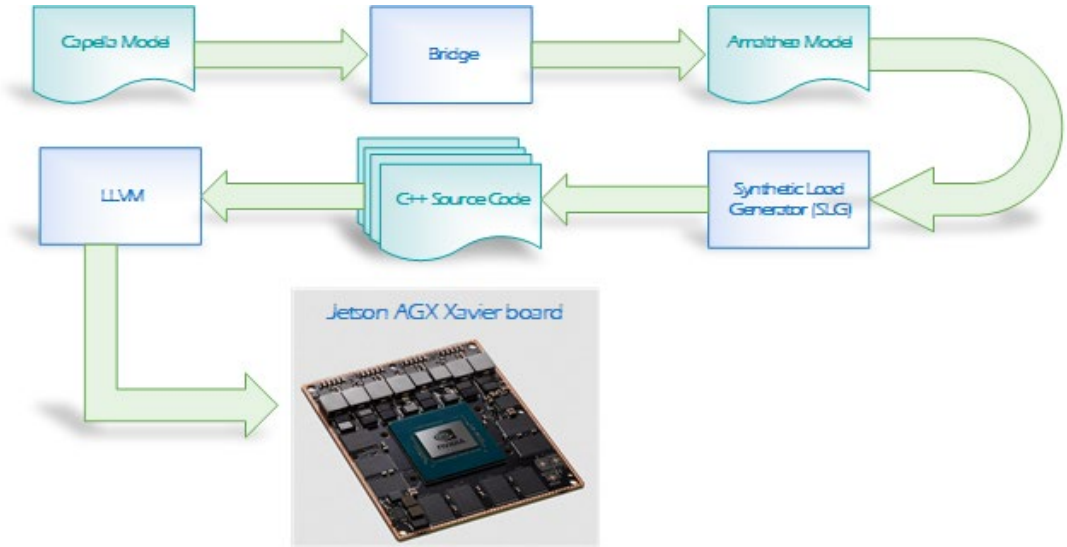

Thank you

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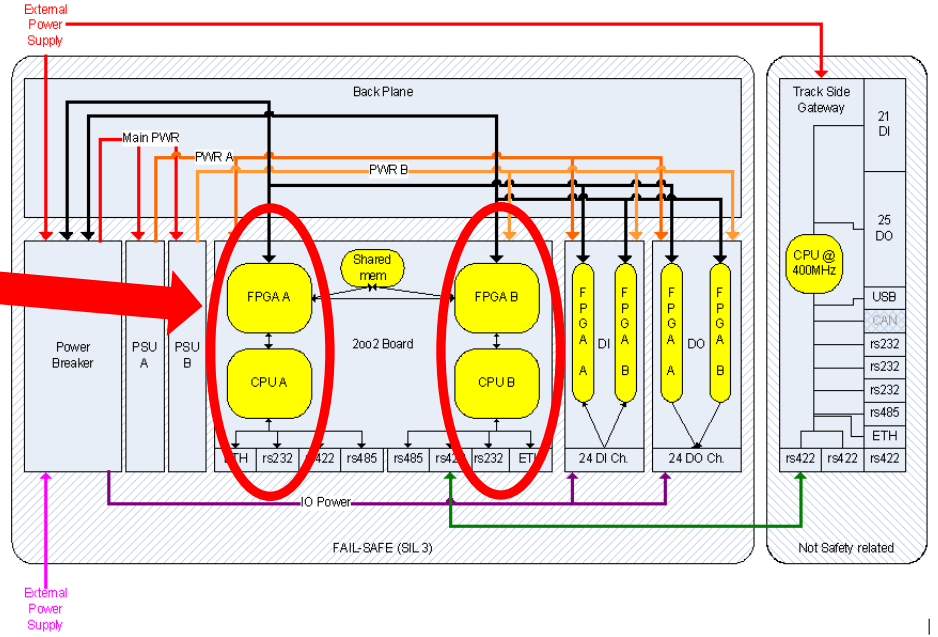
BACKUP SLIDES

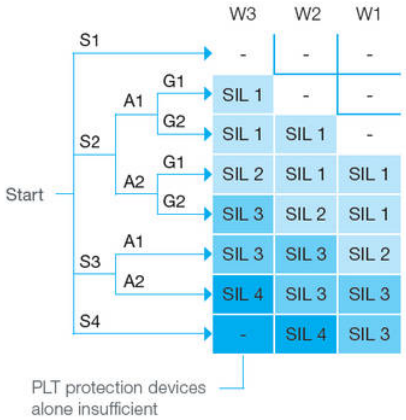
Ongoing work and open topics (4/5)

- **2oo2 Architecture**
  - Thales Switch Control Unit
  - HW Redundancy
  - Voting mechanism



SIL (Security Integrity Level)

- SIL is definitely important in RAILWAY domain.
- Technologies which cannot achieve highest SIL level are non applicable to Railway domain



S = Extent of damage
S1 minor injury of a person
S2 serious, irreversible injury of one or more people or death of one person
S3 death of several people
S4 disastrous effects with several dead

A = Likelihood of people being in the area
A1 rarely to slightly more often
A2 frequently to continuously

G = Danger prevention
G1 possible under certain conditions
G2 barely possible

W = Likelihood of occurrence
W1 very small
W2 small
W3 relatively high