Advanced Driver Assistance Systems & Automated Driving (ADAS/AD):

Improve Testing Efficiency with IBM Video Data Management Solutions

Feb 2016 – Frank Kraemer (mailto:kraemerf@de.ibm.com)

Agenda

- Advanced Driver Assistance Systems & Automated Driving (ADAS/AD)
- Testing ADAS/AD Systems
- IBM Solution Approach
- Summary

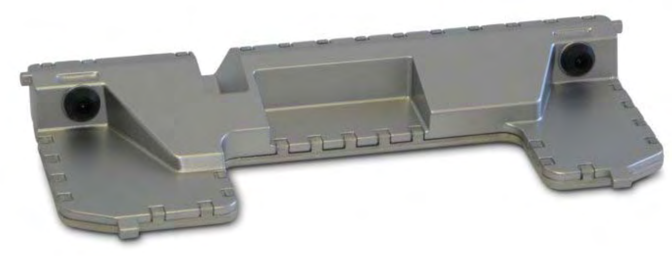
Executive Summary

IBM is uniquely positioned to address todays challenges in ADAS/AD testing, bringing together technology, assets and know-how from

- the storage and archive landscape – from physical storage solutions to virtual cloud-based „software-defined-storage“
- data transmission and data compression
- essence management in the media industry
- systems and software engineering in the automotive industry including simulation and testing

thus helping automotive OEMs and Tier-1s to optimize current workflows and significantly reduce costs for ADAS/AD related video data management.

Welcome to the STIXEL world!



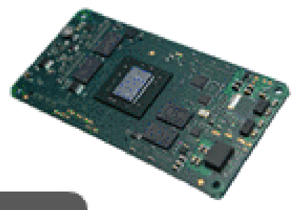
Continental Stero Cam for Automotive

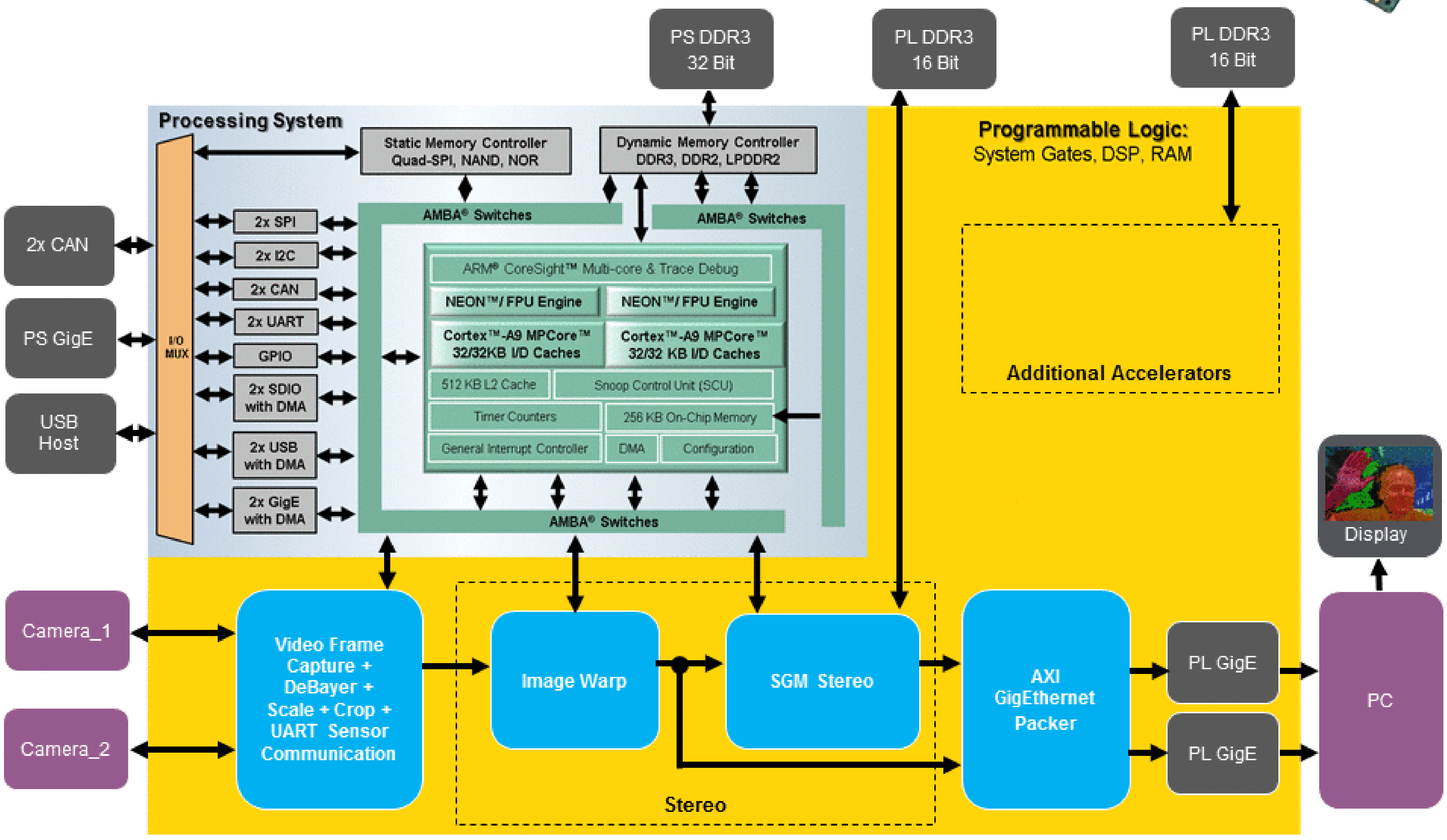
http://www.scs.ch/ueber-scs/departments/felix-eberli.html

http://www.6d-vision.com/autonomousdriving

SGM Stereo on SCS Zynq Box

Scale, Crop, Image Warp, SGM Stereo, GigE Streaming





PS DDR3
32 Bit

PL DDR3
16 Bit

PL DDR3
16 Bit

Processing System

Static Memory Controller
Quad-SPI, NAND, NOR

Dynamic Memory Controller
DDR3, DDR2, LPDDR2

AMBA® Switches

AMBA® Switches

2x CAN

PS GigE

USB
Host

I/O
MUX

2x SPI

2x I2C

2x CAN

2x UART

GPIO

2x SDIO
with DMA

2x USB
with DMA

2x GigE
with DMA

ARM® CoreSight™ Multi-core & Trace Debug

NEON™/ FPU Engine

NEON™/ FPU Engine

Cortex™-A9 MPCore™
32/32KB I/D Caches

Cortex™-A9 MPCore™
32/32 KB I/D Caches

512 KB L2 Cache

Snoop Control Unit (SCU)

Timer Counters

256 KB On-Chip Memory

General Interrupt Controller

DMA

Configuration

AMBA® Switches

Programmable Logic:
System Gates, DSP, RAM

Additional Accelerators

Display

Camera_1

Camera_2

Video Frame
Capture +
DeBayer +
Scale + Crop +
UART Sensor
Communication

Image Warp

SGM Stereo

Stereo

AXI
GigEthernet
Packer

PL GigE

PL GigE

PC

SCS
super computing systems

XILINX
ALLIANCE PROGRAM
CERTIFIED MEMBER — BASE

www.scs.ch/fpgabox

XILINX ALL PROGRAMMABLE.

Research Papers:

Stereo-Assist: Top-down Stereo for Driver Assistance Systems

Gideon P. Stein, Yoram Gdalyahu and Amnon Shashua

Abstract—**This paper presents a top-down approach to stereo for use in driver assistance systems. We introduce an asymmetric configuration where monocular object detection and range estimation is performed in the primary camera and then that image patch is aligned and matched in the secondary camera. The stereo distance measure from the matching assists in target verification and improved distance measurements. This approach, Stereo-Assist, shows significant advantages over the classical bottom-up stereo approach which relies on first computing a dense depth map and then using the depth map for object detection. The new approach can provide increased object detection range, reduced computational load, greater flexibility in camera configurations (we are no longer limited to side-by-side stereo configurations), greater robustness to obstructions in part of the image and mixed camera modalities FIR/VIS can be used. We show results with two novel configurations and illustrate how monocular object detection allows for simple online calibration of the stereo rig.**

I. INTRODUCTION

Camera based driver assistance systems can be divided into two main types: monocular systems and stereo systems. The latter typically employ two symmetric cameras mounted side by side where epipolar lines are aligned with the horizontal image scan lines.

Due to the compact nature, simplicity in hardware and lower cost, driving assistance applications using a monocular camera system are gaining traction. Recent years have witnessed product launches of Lane Departure Warning (LDW), Adaptive High-Beam Assist (AHB) and Traffic Sign Recognition (TSR) as a bundle driven by a monocular camera (available in BMW 7 Series, Mercedes E-class and Audi A8 among others). LDW and Monocular vehicle detection for Forward Collision Warning (FCW) [1], [4], [5] are bundled in the Mobileye AWS. Fusion between radar and a monocular camera is used in applications such as LDW and Collision Mitigation by Braking (CMBB) on licensed vehicles (Volvo "Collision Avoidance Package") and on Pedestrians [2]. The NHTSA safety ratings for model year 2011 include LDW and FCW [3] and underscore the need to integrate both customer functions into a single monocular camera system in order to save costs.

Taken together, one can identify three important trends: (i) monocular camera systems are in high demand and entering into the domain of (model-based) object detection (Vehicles for certain with possibility for Pedestrians as well), (ii) as a result, there is a strong drive to push the performance envelope of a monocular camera system in order to maximize the return on investment, (iii) monocular camera systems are quite mature. However, monocular systems have no direct method for measuring distance so information about the object class and/or context, such as the road plane, must be used.

Depth can be computed directly using multiple cameras. In the classic stereo approach, a dense disparity map is used to create a 3D map of the environment. This 3D representation is then used for foreground/background segmentation (e.g., for finding candidate regions for further processing), for triggering object detection processing and for estimating range and range-rate to detected objects. The classical stereo approach is a low-level pixel-based process and, in principle, can handle arbitrary shapes without modeling the object class beforehand. By contrast, monocular systems use pattern recognition for detection of a specific object class *prior* to monocular range estimation.

The classical stereo approach works well for close targets and in good weather conditions. However, the utility drops rapidly for longer distances and inclement weather. Furthermore, the effective range increases only by the square root of the camera resolution (see Sec. III-C for details) and thus, will not increase significantly with the introduction of the newer 1M pixel automotive sensors entering the market. Finally, it is not clear how truly useful the depth map is in cluttered scenes (see Fig. 1 and Fig. 2). The images themselves hold much more information than the depth map for segmenting out objects (and object parts) in the presence of clutter. Moreover, in an automotive setting, packaging a stereo rig with light-shield and windscreen wiper protection is not a simple feat. It adds to the cost of introducing a stereo system, and thereby is a hinderance for high-volume adoption.

Instead of having depth estimated at an early stage throughout the image (classical stereo), we propose to invert the process on its head. Monocular camera systems are ma-

(a) (b)

Fig. 1. *Examples of "cluttered" scenes where a depth map is not useful for detecting the pedestrians but Stereo-Assist can be used. (a) Pedestrian near a row of parked cars. (b) Driver stepping out of car or truck.*

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Efficient Stereo Matching for Moving Cameras and Decalibrated Rigs

Christian Unger, Eric Wahl and Slobodan Ilic

Abstract—**In vehicular applications based on motion-stereo using monocular side-looking cameras, pairs of images must usually be rectified very well, to allow the application of dense stereo methods. But also long-term installations of stereo rigs in vehicles require approaches that cope with the decalibration of the cameras. The need for such methods is further underlined by the fact that offline camera calibration is a costly and time-consuming procedure at vehicle production sites.**

In this paper we propose an approach for dense stereo matching that overcomes issues arising from inaccurately rectified images. For this, we significantly increase the search range for correspondences, but still preserve a high efficiency of the method to allow operation on platforms with highly limited processing resources.

We demonstrate the performance of our ideas quantitatively using well known stereo datasets and qualitatively using real video sequences of a motion-stereo application.

I. INTRODUCTION

Modern vehicles are often equipped with many different cameras. Famous examples include a front camera for advanced driver assistance and a rear camera for parking assistance.Lesser known examples are side looking cameras, which are usually integrated into the side mirrors or into the front bumper and help the driver at parking maneuvers or to observe crossing traffic (see Fig. 1).

The background of this paper are applications which are based on real-time motion-stereo using side-looking monocular cameras, for example [1], [2], [3]. In this case, we estimate depth by processing consecutive video frames using dense stereo methods. From these depth maps a reconstruction is computed, so that several applications can be realized, for example a parking assistant [2]. Since stereo matching is very demanding in terms of processing power, only highly efficient real-time methods are relevant.

In practice, an accurate rectification is of eminent importance when applying dense stereo methods to pairs of images. The reason for this lies in practical considerations to maximize the efficiency of stereo methods, where rectification usually transforms the epipolar geometry of both images in a way, such that epipolar lines are horizontal and *matched up*. This means, that after rectification the y-coordinate of corresponding image pixels is always constant and that the search-space for stereo-processing is heavily constrained. Therefore, an inaccurate rectification directly affects stereo matching. It is known that even slight inaccuracies of the epipolar geometry may result in significant degradation of the stereo matching performance.

In motion-stereo applications, the rectification of two consecutive camera frames must be estimated from available vehicle sensors, for example, from odometry using wheels and the levels of the dampers. However, practical experience shows that the accuracy of both odometry and damper-levels does not suffice for an accurate rectification, due to slippery or uneven ground.

Furthermore, future vehicles may be equipped with binocular front cameras, which implies the use of stereo algorithms in vehicles. For long-term installations of stereo rigs in vehicles, an adaption to decalibration issues is preferable, since there is very limited experience with vehicular stereo rigs over very long periods of time (e.g. 10 years). In these cases, the stability of the mounting concept (with respect to deterioration or deformation) and termal influences on material might have a huge impact on the accuracy of rectification. Moreover, camera calibration is costly, time-consuming and critical for the quality of serial production vehicles. From this point of view, methods are preferable that do not require an exhaustive calibration procedure, but work well with rough, approximate settings, that might, for example, be computed from CAD models.

In this paper we propose an algorithm to overcome issues arising from inaccurate rectification. We assume that the pair of images is approximately rectified and that the *epipolar deviation* of corresponding image points (i.e. distance from the epipolar line) is smaller than a predefined value. In our algorithm, we significantly increase the search range for correspondences and, although based on window-based block matching, still maintain a surprisingly high efficiency.

For this, we generalize and extend the concepts of the efficient disparity computation approach given in [4], which was originally designed for highly efficient disparity computation using accurately rectified image pairs. There, stereo matching is performed iteratively by alternating minimization and propagation phases at every pixel.

In the rest of the paper, we will first review related work, then present our method and finally show an exhaustive experimental evaluation.

II. RELATED WORK

Binocular stereo matching is a well explored direction [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], but to our knowledge, all of these methods require an accurate rectification of the images. However, relaxing the epipolar constraint immediately leads to optical flow methods [15], [16]. While real-time GPU implementations exist, most of

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Research Papers:

Exploiting the Power of Stereo Confidences

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Abstract

Applications based on stereo vision are becoming increasingly common, ranging from gaming over robotics to driver assistance. While stereo algorithms have been investigated heavily both on the pixel and the application level, far less attention has been dedicated to the use of stereo confidence cues. Mostly, a threshold is applied to the confidence values for further processing, which is essentially a sparsified disparity map. This is straightforward but it does not take full advantage of the available information.

In this paper, we make full use of the stereo confidence cues by propagating all confidence values along with the measured disparities in a Bayesian manner. Before using this information, a mapping from confidence values to disparity outlier probability rate is performed based on gathered disparity statistics from labeled video data.

We present an extension of the so called Stixel World, a generic 3D intermediate representation that can serve as input for many of the applications mentioned above. This scheme is modified to directly exploit stereo confidence cues in the underlying sensor model during a maximum a posteriori estimation process.

The effectiveness of this step is verified in an in-depth evaluation on a large real-world traffic data base of which parts are made publicly available. We show that using stereo confidence cues allows both reducing the number of false object detections by a factor of six while keeping the detection rate at a near constant level.

1. Introduction

Stereo vision has been an actively researched area for decades. In recent years, stereo algorithms and applications have matured significantly spawning products in fields ranging from industrial automation over gaming up to driver assistance systems. The underlying stereo algorithms and their properties are well understood, at least for the current real-time algorithms, typically approaches based on correlation [20] or semi-global matching (SGM) [10]. Benchmarks that compare stereo algorithms on a 100 % density level are available [19], also for the automotive domain [8].

Figure 1: The Stixel World computed from stereo data. The scene is segmented into free space and vertical obstacles. The color (from red to green) represents the object distance.

The computation of stereo confidences has only recently been researched in more detail. Hu and Mordohai [12] performed an excellent review of known stereo confidence metrics comparing them to ground truth scenes on a pixel level. In related work on confidence estimation for stereo or optical flow computation, the so called sparsification plots are established as the main method to show the effectiveness of the considered confidence metric. This procedure gives a good impression with respect to how well the confidence helps reducing the average error of the disparity map when the least confident values are removed. However, no explicit use of both the disparity map and the confidence map in further processing has been reported so far.

Our work is centered around the driver assistance scenario. The main objective is to robustly extract free space and obstacle information from dense disparity maps and to represent the results in a compact and simple fashion.

The Stixel World, firstly introduced by Badino *et al.* [2], is a very suitable representation for this task. Based on an occupancy map [1, 5], this scheme allows to extract the closest row of objects for each image column. In a generalization of this work, we introduced the multi-layered Stixel World [17] that allows to detect all objects in a scene. A result of this scheme is shown in Figure 1.

This paper extends our Bayesian approach [17] to use stereo confidence cues. The idea is that each disparity mea-

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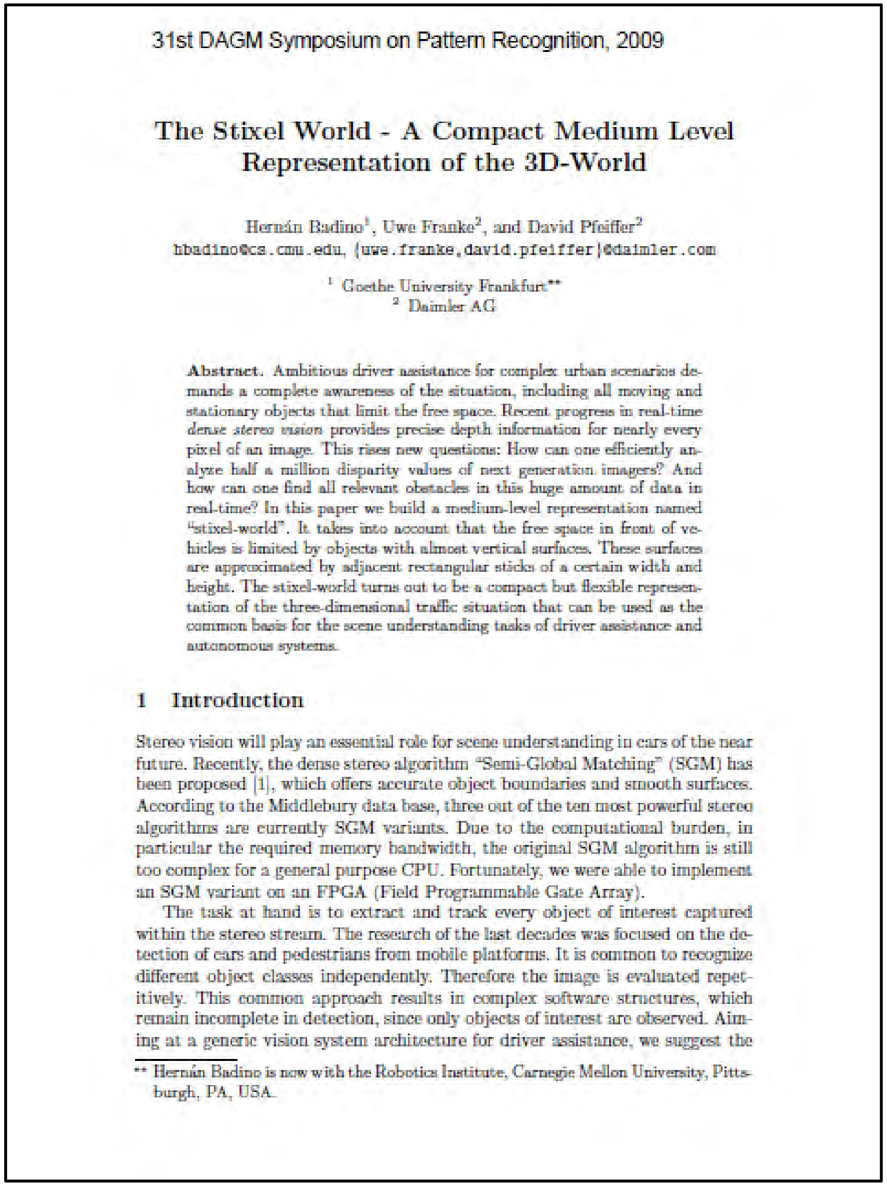

31st DAGM Symposium on Pattern Recognition, 2009

The Stixel World - A Compact Medium Level Representation of the 3D-World

Hernán Badino[1], Uwe Franke[2], and David Pfeiffer[2]
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[2] Daimler AG

Abstract. Ambitious driver assistance for complex urban scenarios demands a complete awareness of the situation, including all moving and stationary objects that limit the free space. Recent progress in real-time *dense stereo vision* provides precise depth information for nearly every pixel of an image. This rises new questions: How can one efficiently analyze half a million disparity values of next generation imagers? And how can one find all relevant obstacles in this huge amount of data in real-time? In this paper we build a medium-level representation named "stixel-world". It takes into account that the free space in front of vehicles is limited by objects with almost vertical surfaces. These surfaces are approximated by adjacent rectangular sticks of a certain width and height. The stixel-world turns out to be a compact but flexible representation of the three-dimensional traffic situation that can be used as the common basis for the scene understanding tasks of driver assistance and autonomous systems.

1 Introduction

Stereo vision will play an essential role for scene understanding in cars of the near future. Recently, the dense stereo algorithm "Semi-Global Matching" (SGM) has been proposed [1], which offers accurate object boundaries and smooth surfaces. According to the Middlebury data base, three out of the ten most powerful stereo algorithms are currently SGM variants. Due to the computational burden, in particular the required memory bandwidth, the original SGM algorithm is still too complex for a general purpose CPU. Fortunately, we were able to implement an SGM variant on an FPGA (Field Programmable Gate Array).

The task at hand is to extract and track every object of interest captured within the stereo stream. The research of the last decades was focused on the detection of cars and pedestrians from mobile platforms. It is common to recognize different object classes independently. Therefore the image is evaluated repetitively. This common approach results in complex software structures, which remain incomplete in detection, since only objects of interest are observed. Aiming at a generic vision system architecture for driver assistance, we suggest the

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** Hernán Badino is now with the Robotics Institute, Carnegie Mellon University, Pittsburgh, PA, USA.

Agenda

- Advanced Driver Assistance Systems & Automated Driving (ADAS/AD)
- Testing ADAS/AD Systems
- IBM Solution Approach
- Summary

Growth and Importance of Advanced Driver Assistance Systems (ADAS) and Autonomous Driving (AD)

- **ADAS features are becoming part of all kind of vehicles,** including increasingly small/midsize passenger cars
  - 70% of all serious accidents could be avoided by Driver Assistance Systems according the BAST Germany
  - Standardization and customer expectations are leading to further significant ADAS growth

- **ADAS is seen as between “Level 2” and “Level 3” on the way to a fully “Level 5” Autonomous Driving (AD)**
  - SAE Level 2 Definition: Driver needs to monitor; Level 3: Driver does not need to monitor, but must always be in a position to resume control;
- **All major OEM and Tier-1 are currently implementing and testing AD functionalities**

Agenda

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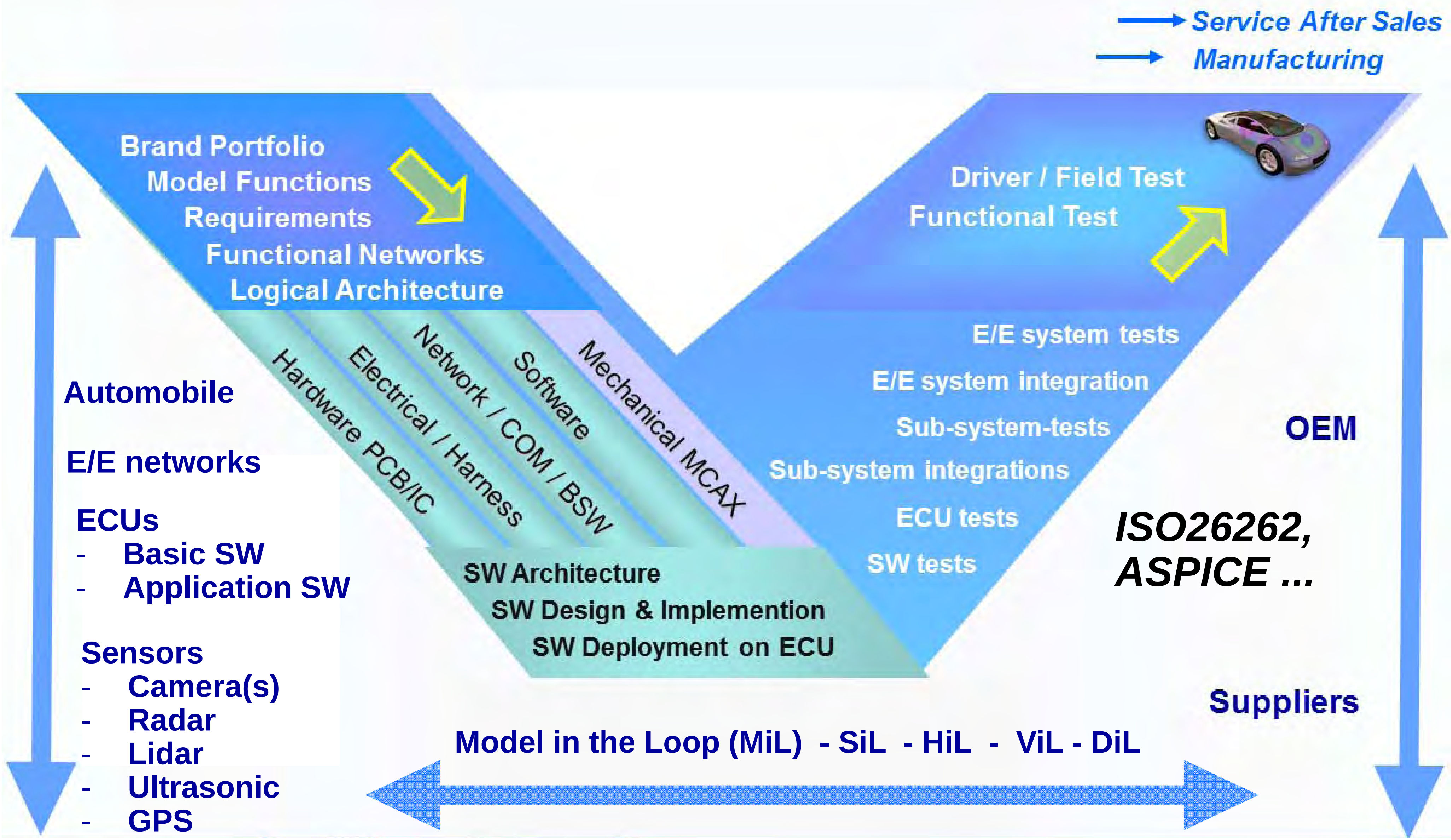
Developing and Testing of ADAS/AD Systems is highly complex



Automobile

E/E networks

ECUs
- **Basic SW**
- **Application SW**

Sensors
- **Camera(s)**
- **Radar**
- **Lidar**
- **Ultrasonic**
- **GPS**

ISO26262, ASPICE ...

What is a HiL Station ?

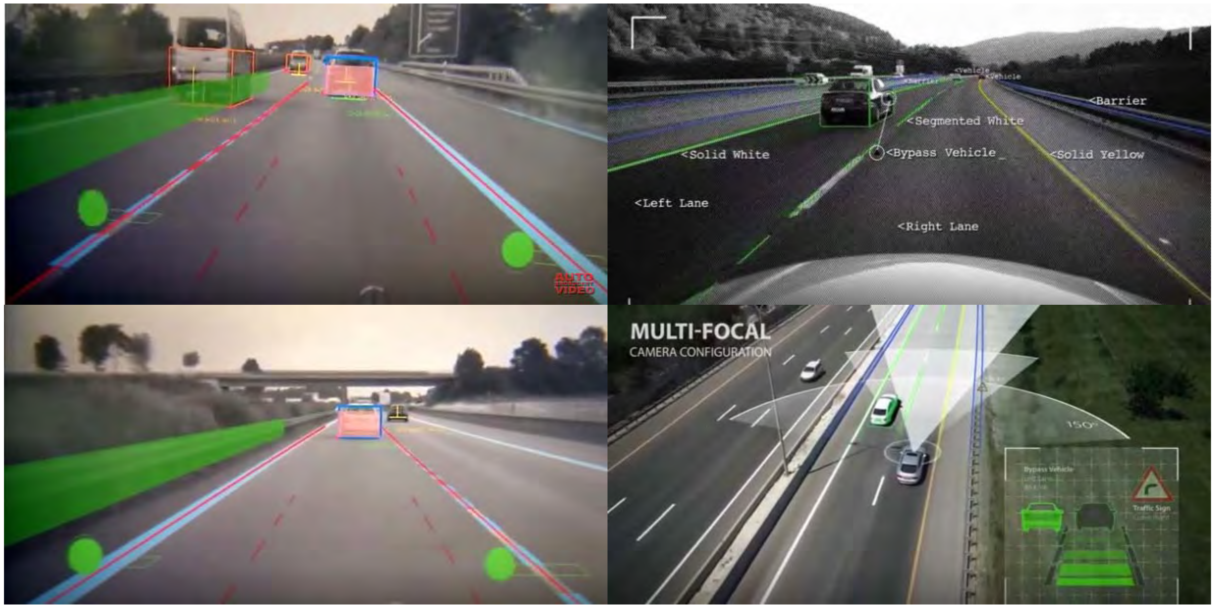
Hardware-in-the-loop (HiL) simulation, is a technique that is used in the development and test of complex real-time embedded systems.

HiL simulation provides an effective platform by adding the complexity of the plant under control to the test platform. The complexity of the plant under control is included in test and development by adding a mathematical representation of all related dynamic systems.

https://en.wikipedia.org/wiki/Hardware-in-the-loop_simulation

Automotive industry generates large amounts of video data – used in various ADAS/AD development and testing processes

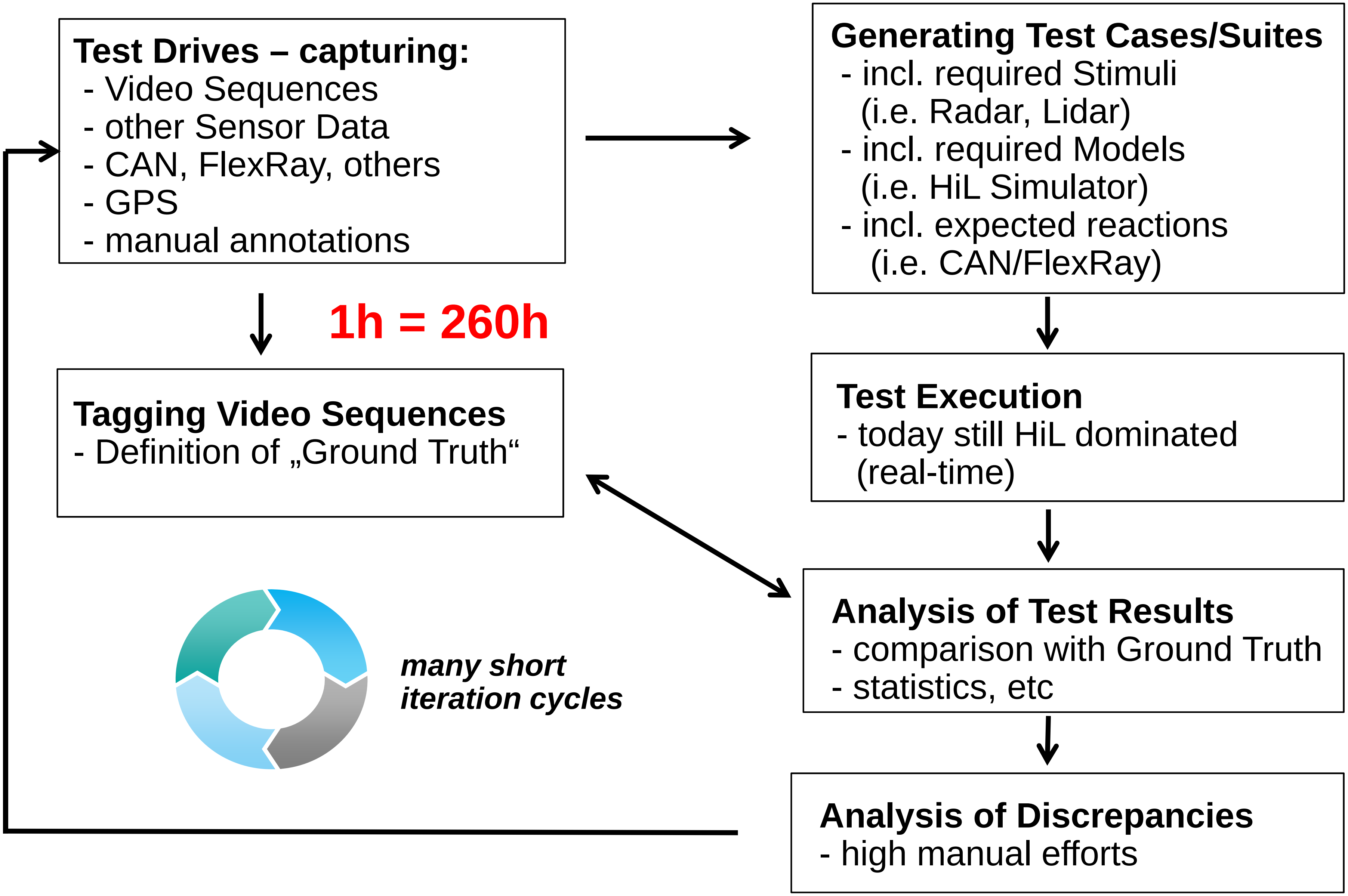
- Storage of these video data is very costly
- Handling of these data is difficult i.e. due to high required bandwith
- For testing purposes video data are much more complex in comparison to discrete bus signals, electronic values, etc.



Sources: Images from https://www.youtube.com/watch?v=4jW0fJ80VG8 https://www.youtube.com/watch?v=dhEgD6ZFlQE https://www.youtube.com/watch?t=21&v=39QMYkx89j0

- Video Data must be synchronously captured, stored, modified and executed with other testing data such as CAN, FleyRay, Radar, LiDAR, HiSonic, etc.

Exemplary Test Process – Test of a Camera-based ADAS System



Test Drives – capturing:
- Video Sequences
- other Sensor Data
- CAN, FlexRay, others
- GPS
- manual annotations

1h = 260h

Tagging Video Sequences
- Definition of „Ground Truth“

many short iteration cycles

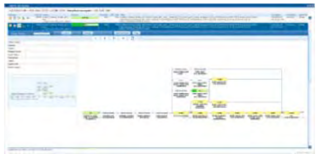
Generating Test Cases/Suites
- incl. required Stimuli (i.e. Radar, Lidar)
- incl. required Models (i.e. HiL Simulator)
- incl. expected reactions (i.e. CAN/FlexRay)

Test Execution
- today still HiL dominated (real-time)

Analysis of Test Results
- comparison with Ground Truth
- statistics, etc

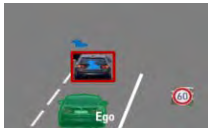
Analysis of Discrepancies
- high manual efforts

Major Challenges (as of Jan 2016)

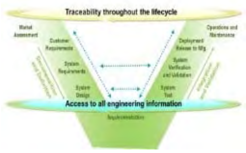


1. How to implement & operate an efficient storage, workflow and management system within the different testing environments?

2. How to distribute video data globally within an enterprise?



3. How to (automatically) tag and label video data?



4. How to embed video data management into system and software development and quality management?

5. How to preserve digital data for decades in a secure and cost effective way?

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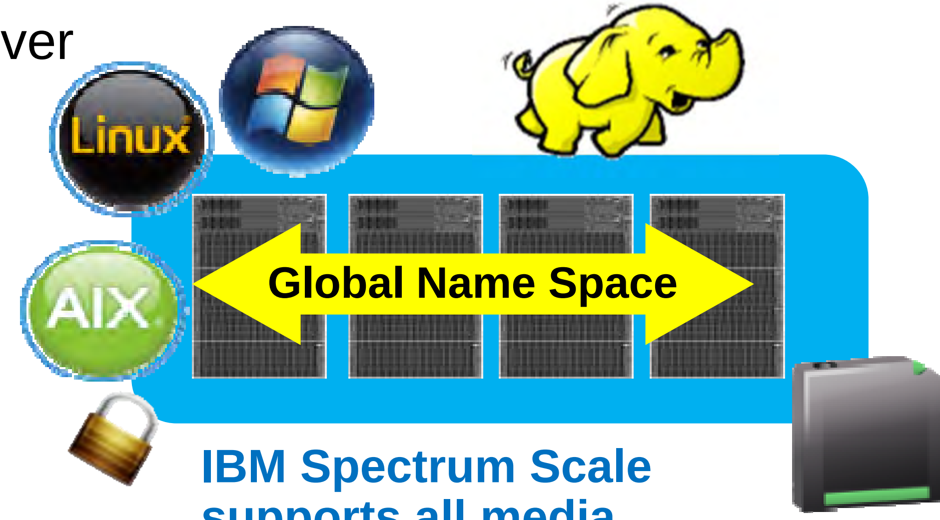
IBM Solution Elements (1-1)

1. How to implement &
operate an efficient storage
and management system?

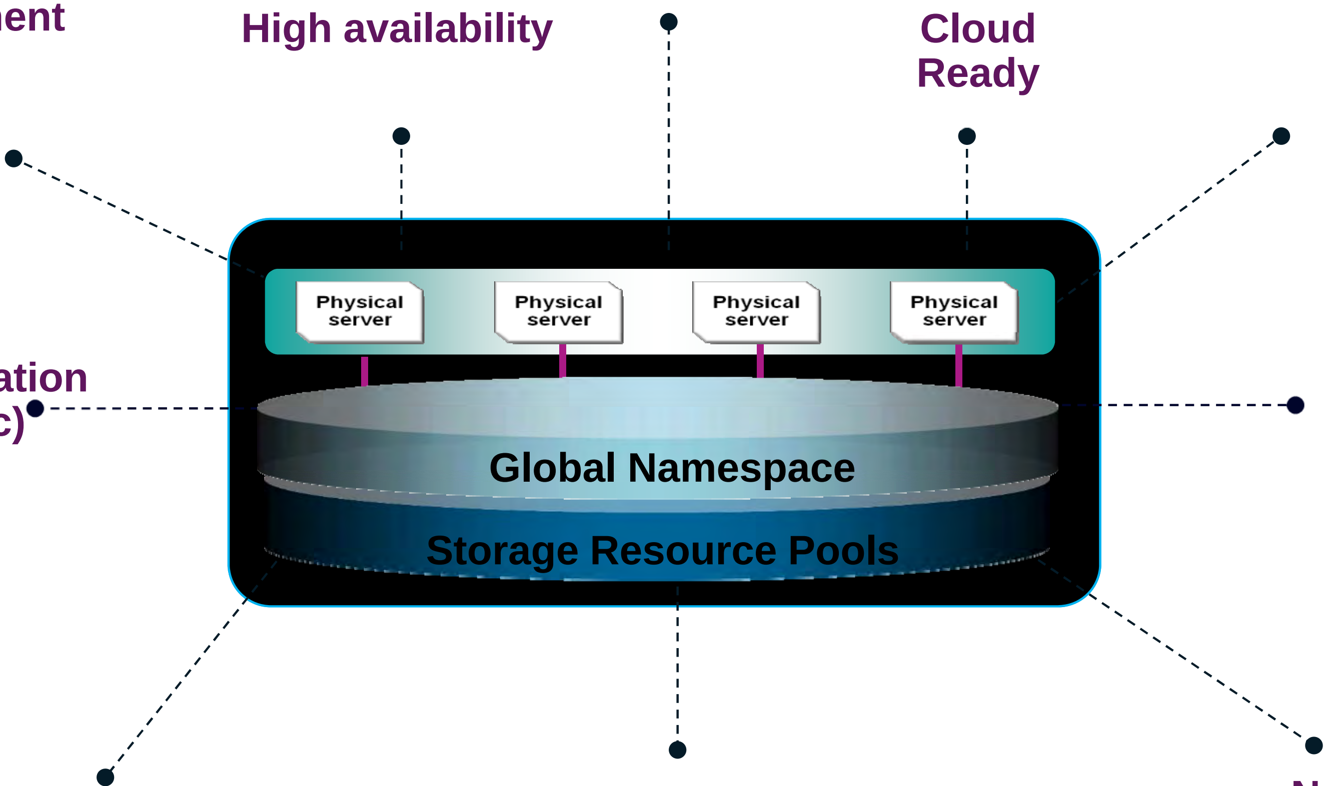
- **Storage Solution: IBM Elastic Storage Server with Spectrum Scale Software and IBM LTFS-EE Tape Library** enables an economic storage system mix meeting diverse access and distribution requirements
- Cost-effective „tiering“ and „staging“ of different storage elements based on Spectrum Scale as best format for media files:
  - Spectrum Scale client OS driver for HIL workstations in order to support „native“, high bandwidth access to videos on Global Namespace
  - High Performance IBM Elastic Storage Server
  - IBM Tape as cost-efficient storage tier
  - Spectrum Scale compression feature
  - Spectrum Scale encryption feature
  - Suitable load and distribution times for ADAS and AD testing



IBM Spectrum Scale supports all media

Spans flash, disk and tape media

IBM Solution Elements (1-2): IBM Spectrum Scale (GPFS)



Global Namespace

Information Lifecycle Management

High availability

Cloud Ready

Backup and recovery services

Advanced replication (sync & async)

Active File Management

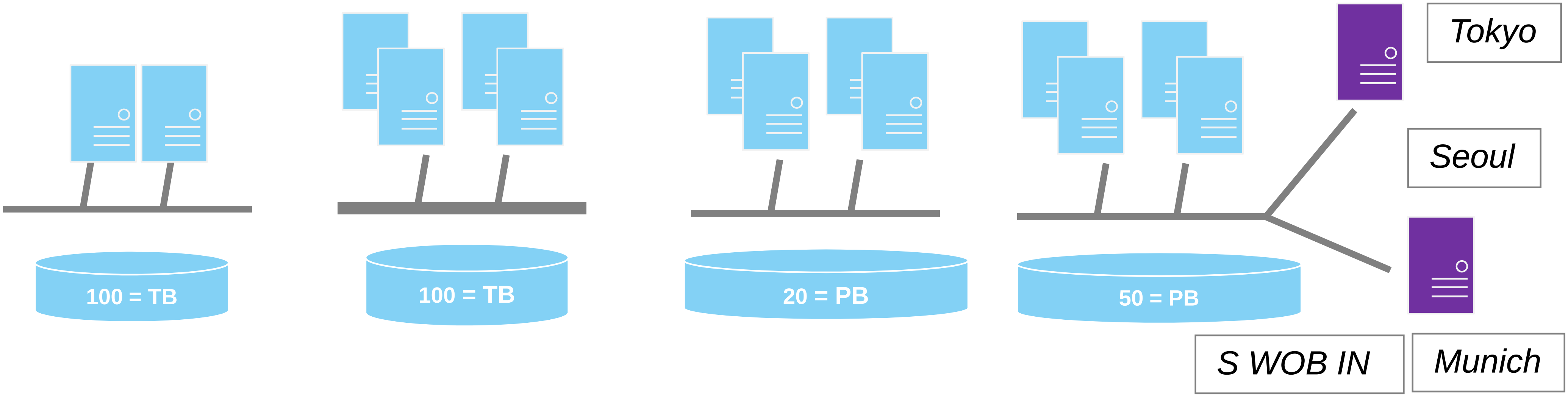
Standard protocols (POSIX,NFS, SMB,Swift)

Native Encryption and Secure Erase

Native declustered RAID

IBM Solution Elements (1-3)

IBM Spectrum Scale software lets you build an extremely flexible architecture on a worldwide scale



Case 1:

Initial system

- 2 servers with Spectrum Scale Software
- Fronting 100 TB storage

Case 2:

Add Performance

- Add compute nodes
- Faster Network

Case 3:

Increase Capacity

- Add any storage (BYOD)
- Virtually unlimited scaling

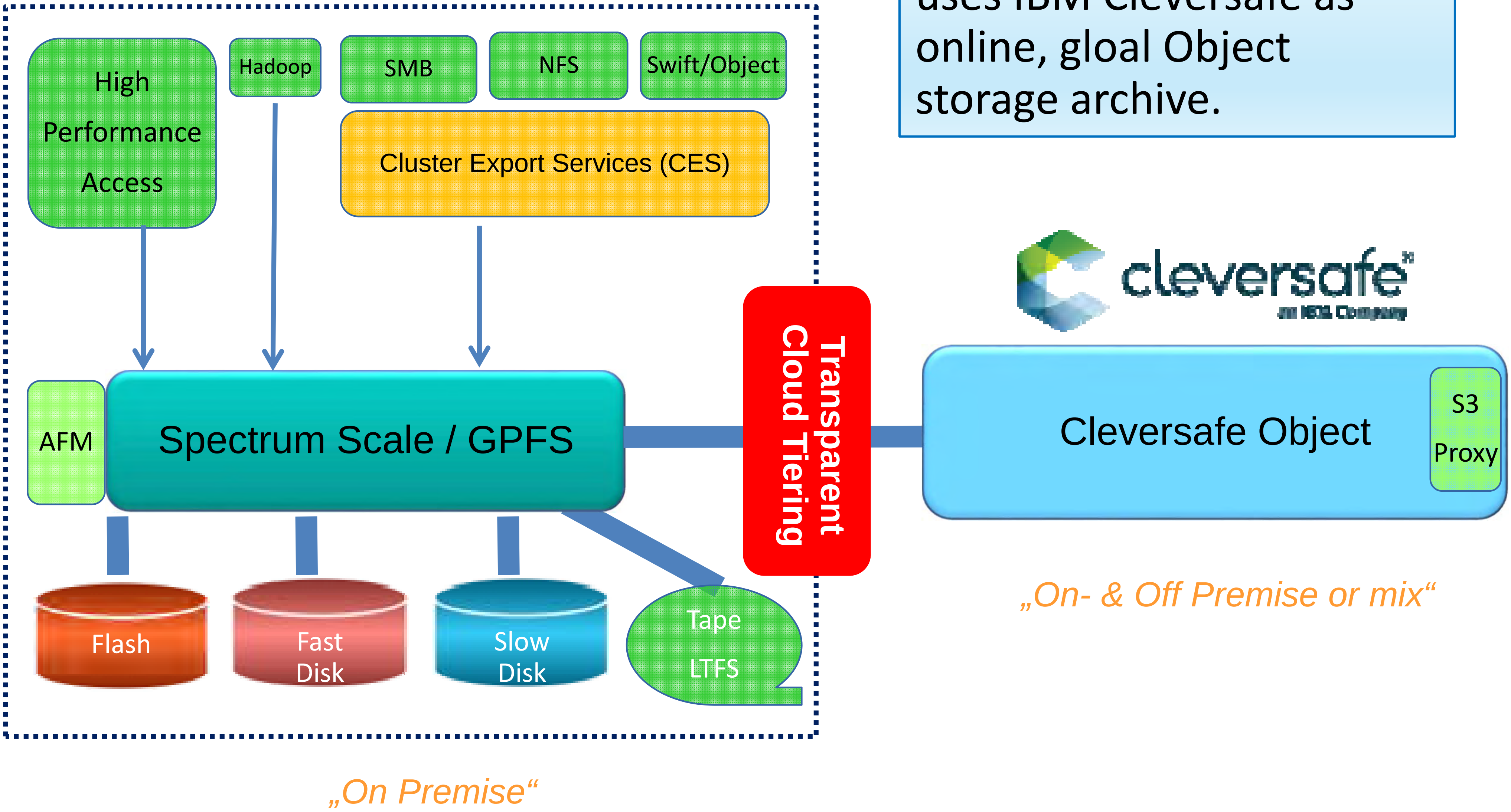
Case 4:

Global Share

- Use Active File Management to expand your global namespace
- AFM is part of Spectrum Scale

IBM Solution Elements (1-4)

IBM Spectrum Scale **Transparent Cloud Tiering** uses IBM Cleversafe as online, gloal Object storage archive.



„On- & Off Premise or mix“

„On Premise“

IBM Solution Elements (1-5)

NEW!

cleversafe® an IBM Company

https://www.cleversafe.com/

Leveraging New Object Storage Technologies

- Unstructured data store
- Flat names space organized in buckets/containers
- Simple RESTful access (GET, PUT, DELETE) using S3 or Swift
- Designed for very large scale (>500 TB)
- Designed for global access/distribution
- Designed for eventual consistency
- Access granularity is whole object (no in place updates)
- Read mostly write once data: images, video, audio, scans, etc.

IBM Solution Elements (1-7)

- **IBM Archive and Essence Manager (AREMA)** is a well-tested solution in the media industry, used at many broadcasters, especially in Germany with a very high market coverage
- AREMA offers a workflow orchestration around media files with more than 100 media services for transporting, transforming and manipulating media files
- Orchestrates external systems, e.g. IBM video recognition and tagging solution and others
- AREMA is a middleware and integration software – connecting different media systems, works as bridge between (legacy) media systems
- AREMA can easily be adapted to the automotive ADAS/AD testing needs

IBM Solution Elements (1-8)

- **IBM Archive and Essence Manager (AREMA)** significantly improves
  - the handling of many large video files
  - the editing, transcoding, splitting and merging
  - the storage costs by combining various storage solutions, integrating them seamlessly
  - integrating existing testing silos with data-centric workflows
  - browsing and searching of videos with the AREMA media portal
  - the integration with other testing tools and environments, from HiL to ADTF and others

IBM AREMA Customers (as of Nov 2015)

ERR
Eesti Rahvusringhääling

ORF

BBC

NDR

IVZ

rtbf

BR

RTL GROUP

DFL DIGITAL SPORTS

SF SCHWEIZER FERNSEHEN

N24

radiobremen

arte

WDR

vrt

maxdome

mdr

WDR mediagroup

SWR

ARD
HAUPTSTADTSTUDIO

JAXA

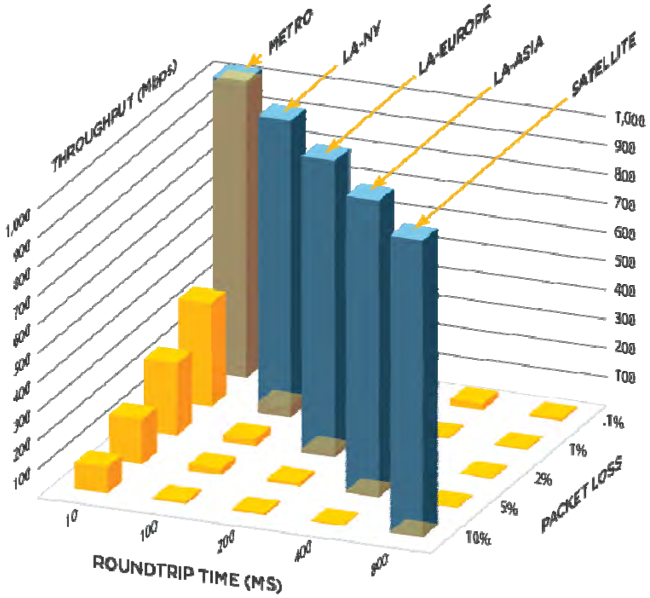
ytv

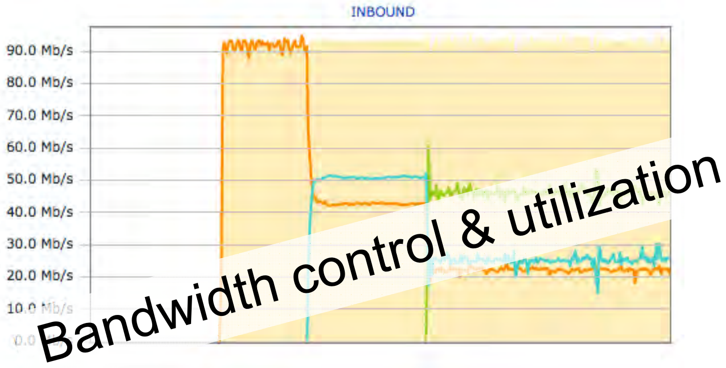
JOGMEC

IBM Solution Elements (2-1)

2. How to distribute video data globally within an enterprise?

Overcome limitations in classic TCP/IP transfer by using Aspera patented FASP protocol





Bandwidth control & utilization

Reliable speed for data-transfer on your existing network

How big is your file?

10 GB

Select your network bandwidth

100 Mbps

How far are you sending your file?

Latin America

Europe

Select the Network Packet Loss

1%

File Transfer Time

ASPERA	TCP
14 MIN	2240 MIN

Effective File Transfer Speed

ASPERA	TCP
99 MBPS	0.6 MBPS

Effective Bandwidth Utilization

ASPERA	TCP
99%	0.6%

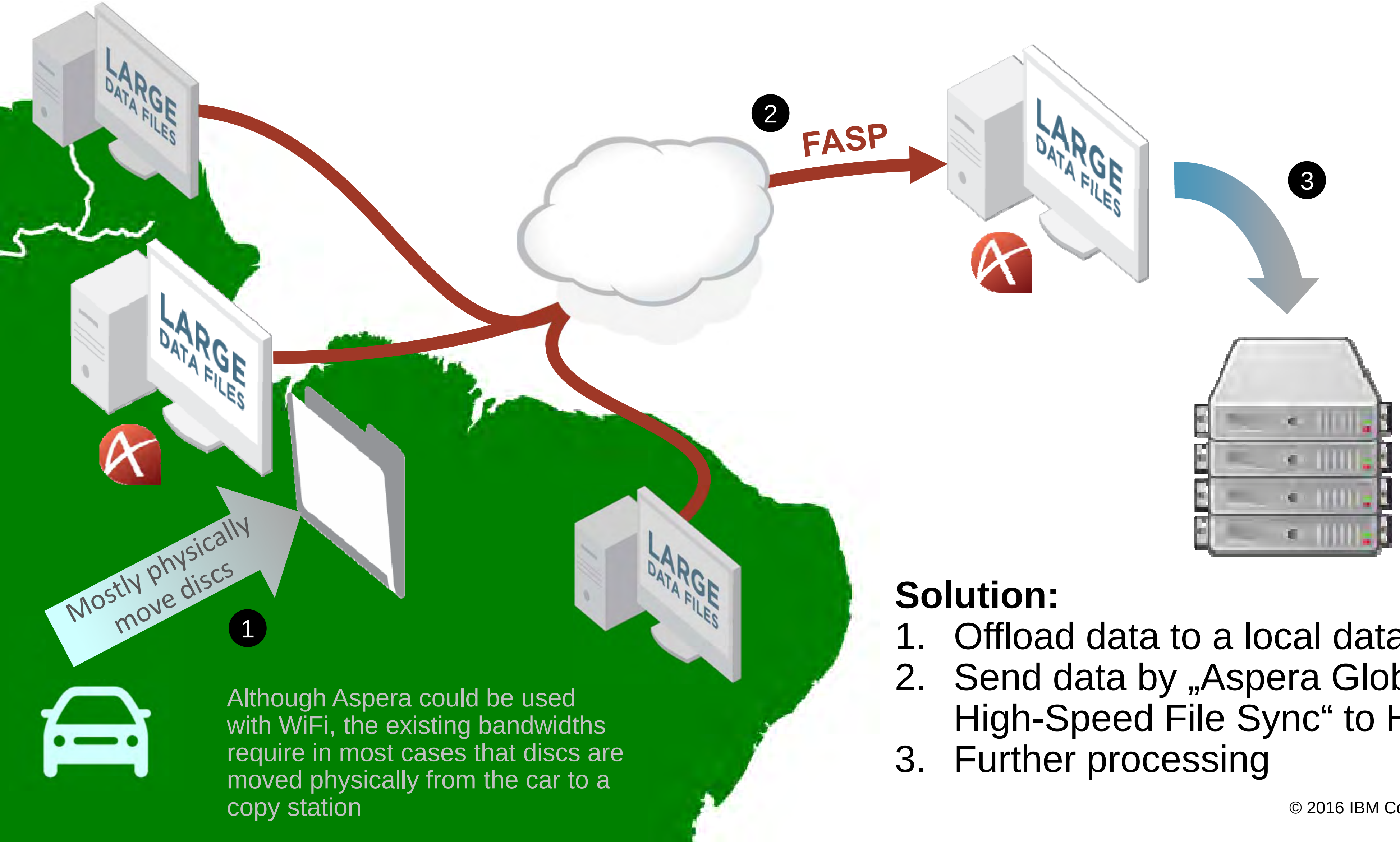
Results Summary

154.9x More Throughput with Aspera

15393% Faster with Aspera than TCP

99.355% Less Time with Aspera than TCP

IBM Solution Elements (2-2)



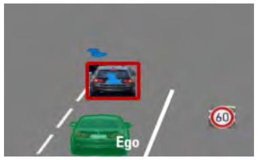
Although Aspera could be used with WiFi, the existing bandwidths require in most cases that discs are moved physically from the car to a copy station

Solution:

1. Offload data to a local datastore
2. Send data by „Aspera Global High-Speed File Sync“ to HQ
3. Further processing

IBM Solution Elements (3-1)

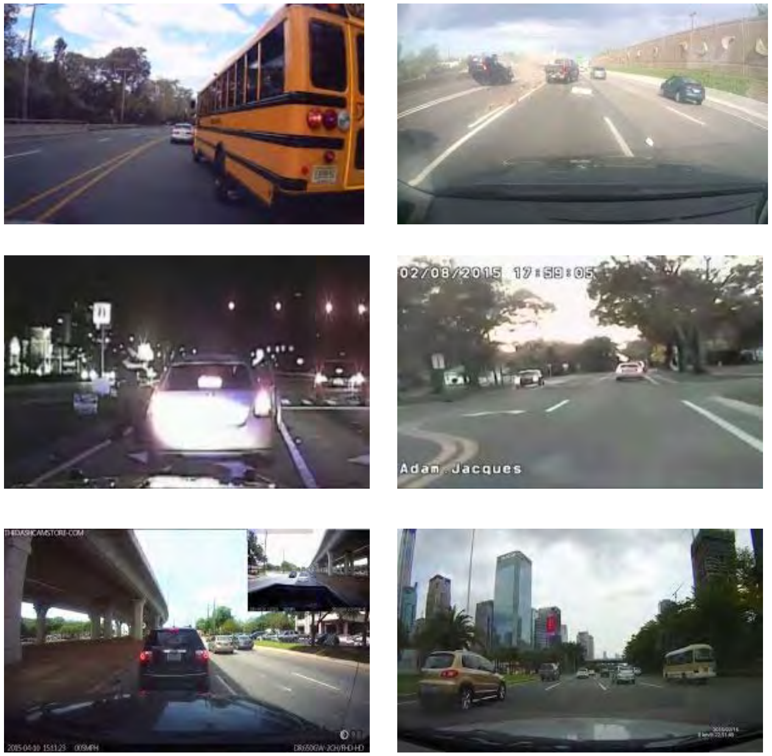
3. How to (automatically) tag and label video data?



- **IBM Multimedia Analysis and Retrieval System (IMARS)** is a trainable system for classifying images and video automatically based on visual contents
- IMARS creates classifiers from training examples using visual feature extraction and machine learning
- IMARS provides a large number of built-in visual feature representations that enable learning of highly effective semantic classifiers
- Can be trained and adapted for a variety of domains – natural photos, Web video, social media, medical images

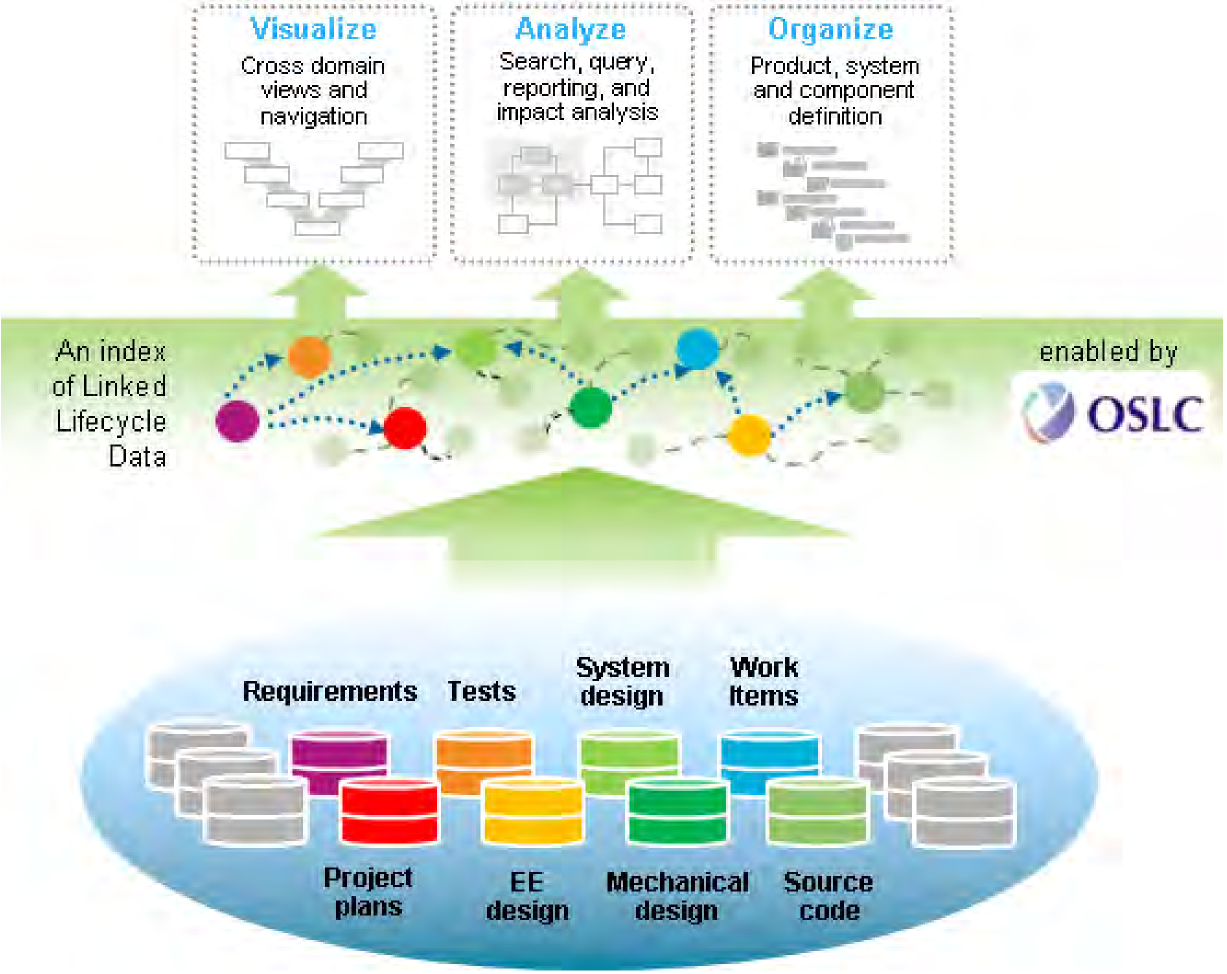
IBM Solution Elements (3-2)

- IBM Multimedia Analysis and Retrieval System (IMARS) is constantly enhanced by current **IBM Research** amongst others within **IBM Watson** group
- **Exemplary real-life projects include**
  - Collecting large data sets of dash cam video (public, cameras)
  - Vehicle and people detection, tracking and trajectory analysis
  - Traffic and congestion analysis
  - Sign detection
  - Safety modeling



IBM Solution Elements (4-1)

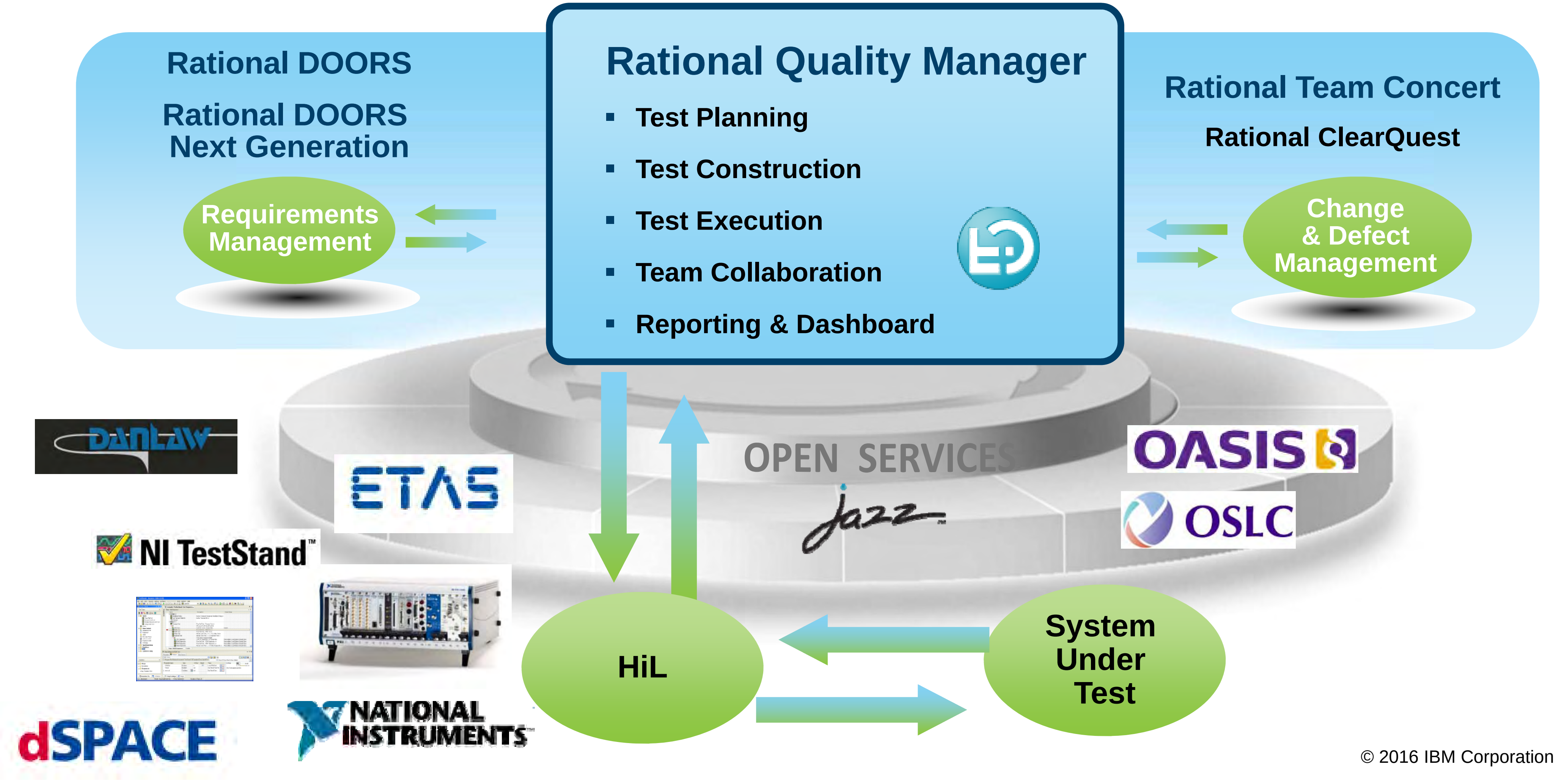
4. How to embed video data management into development and quality management?



- **OSLC** – **Open Services for Lifecycle Collaboration** – is an open standard for integrating systems- and software development tools
- Various **OSLC adapters** already exists to integrate IBM Rational tools with tools like: National Instruments (NI), Mathworks, Mentor Graphics, Siemens PLM, Wind River and more
- **IBM Rational Quality Manager and IBM Rational DOORS** are used by many Automotive OEMs and Supplier for Quality and Requirements Management

IBM Solution Elements (4-2)

Leveraging OSLC and IBM Rational tools allow to build a seamless integrated tool chain for an effective Collaborative Lifecycle Management



Rational DOORS

Rational DOORS Next Generation

Requirements Management

Rational Quality Manager

- Test Planning
- Test Construction
- Test Execution
- Team Collaboration
- Reporting & Dashboard

Rational Team Concert

Rational ClearQuest

Change & Defect Management

HiL

System Under Test

IBM Solution Elements (5)

5. How to preserve digital data?

We assume that for each model series / SOP, related video data must be **kept for potential warranty issues** and must therefore be cost-efficient archived.

We propose a solution which is based on two well-proven IBM product lines:

- **IBM Tivoli Storage Manager (TSM),** now market as **IBM Spectrum Protect**
  - is a data protection platform that gives enterprises a single point of control and administration for backup and recovery
  - enables reliable, cost effective backups and fast recovery for virtual, physical and cloud environments of all sizes, leveraging amongst others the IBM Tape Technology
- **IBM LTFS-EE Tape Library,** now market as **IBM Spectrum Archive**
  - combines the ease of use of LTFS with the scalability, manageability, and performance of IBM General Parallel File System (GPFS)
  - very cost-efficient solution for „preserving digital data“

Agenda

- Advanced Driver Assistance Systems & Automated Driving (ADAS/AD)
- Testing ADAS/AD Systems
- IBM Solution Approach
- Summary

Summary (1) – Solution Elements

Rational Quality Manager and SmarTest Asset Manager solution

Rational DOORS and others

Elektrobit ADTF and other ADTF and testing tools

Test- & Lab Management + linkages to Development

AREMA Clients

Job Management, Media Portal

IBM IMARS
IBM Watson
IBM Reserach

Automatically Label Videos

AREMA Interfaces

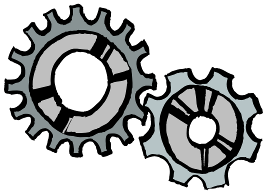
SOAP

REST

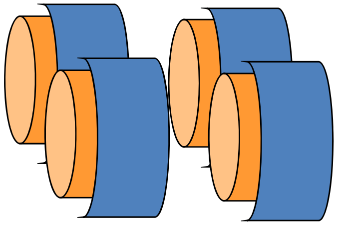
OSLC

others

AREMA Engine



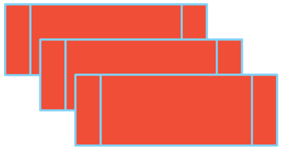
AREMA Agents



Manage & Control Video & Testing Workflow

HiL Station(s)

Spectrum Scale client OS



Test Execution

IBM Elastic Storage Server

Flash **Disk** **Tape** **Cloud**

IBM GPFS Software

aspera an IBM® company

cleversafe® an IBM Company

Site A

Site B

Site C

....

Storage & Distribution

Tivoli Storage Manager (TSM)

IBM Spectrum Protect

LTFS-EE Tape Library

Archive

Summary (2)

IBM offers key solution elements for video data management within ADAS/AD testing, including

- cost-effective storage of video and testing data (IBM Elastic Storage Server with Spectrum Scale Software, IBM LTFS-EE Tape Library and IBM Cleversafe)
- media-proven workflow and orchestration middleware (AREMA)
- automatic tagging and labeling (IMARS)
- optimized file transfer at maximum speed (ASPERA)
- cost-effective archive solutions (TSM, Spectrum Protect)
- test and lab-management solutions (IBM Rational) as well as standard-based integration to other ADAS system- and software development tools (OSLC)

and related services to design, build and operate end-to-end client-specific ADAS/AD testing solutions