Scenario Based Coverage Driven Verification – Supported By Evolving Standards

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基于场景的覆盖驱动验证 – 得益于不断发展的标准的支持




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Outline

- ADAS and ADS – The infinite scenario space challenge
- Coverage Driven Verification
- Evolving standards
- Closer look at ASAM OpenSCENARIO 2.0.0, SOTIF

概述

- ADAS（ 高级驾驶辅助系统）和ADS（可调式避震系统）– 无限场景空间挑战
- 覆盖驱动验证
- 不断发展的标准
- 进一步了解ASAM（自动化及测量系统标准协会）开放场景2.0.0，SOTIF（ 预期功能安全）

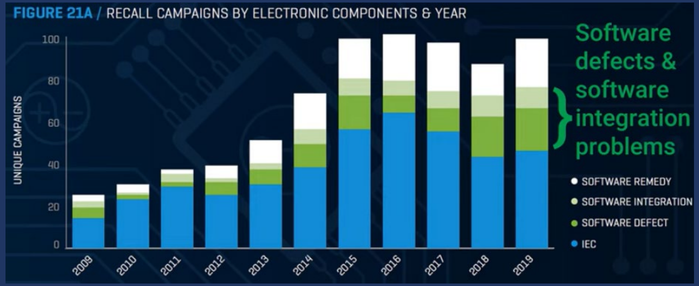
Current ADAS/ADS Deployment Does Not Meet Safety Requirements

Product Recalls

Volvo recalls 736,000 Vehicles due to Automated Emergency Braking issue

March 2020

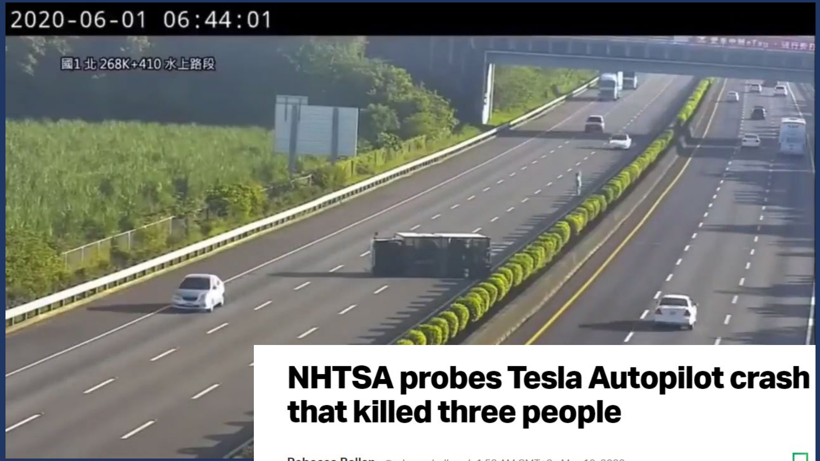
Product recalls increase due to software and integration issues

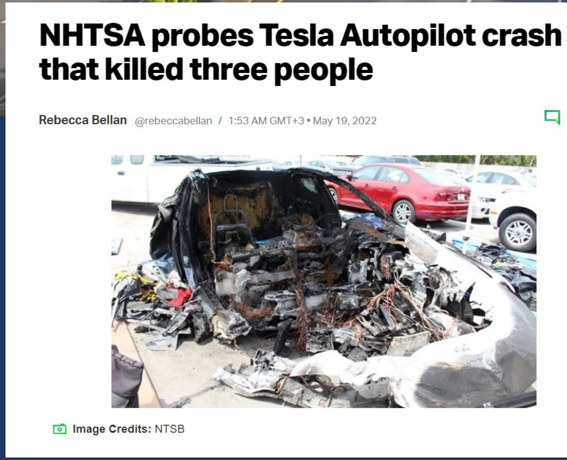


Auto Pilot Failure

Tesla on autopilot crashes into overturned truck

June 2020





AAA ADAS Study

AAA found problems occurring every 8 miles
Recommends limiting use of partially automated driving systems
“At night, none of the cars tested were able to detect an adult pedestrian”
Aug 2020

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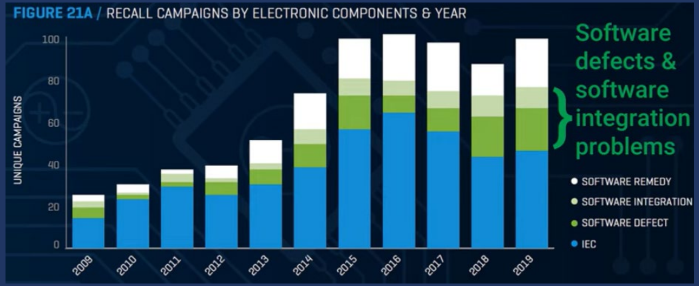
目前的ADAS（高级驾驶辅助系统）部署不符合安全要求

产品召回

沃尔沃因汽车自动紧急制动问题召回736,000辆汽车。

2020年03月

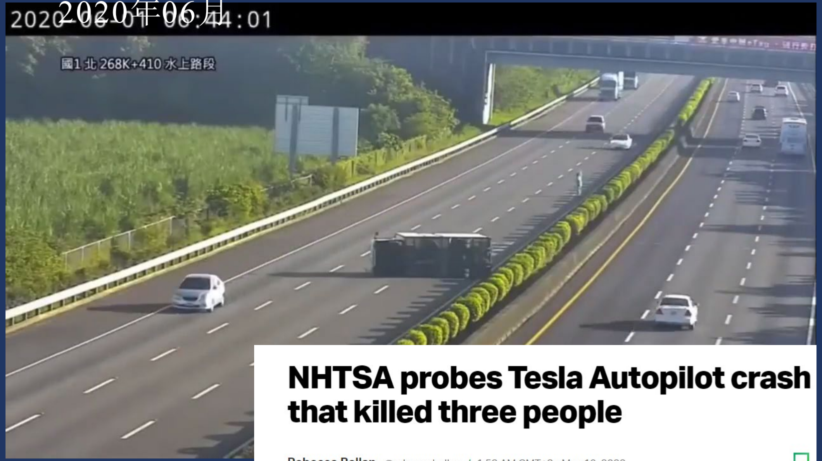
由于软件和集成问题，产品召回的情况有所增加

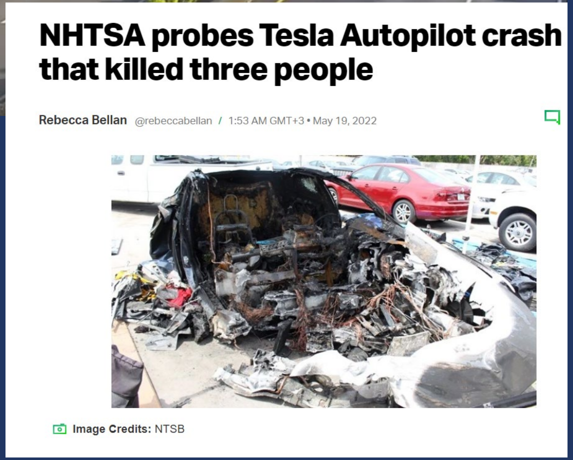


自动驾驶失灵

自动驾驶的特斯拉撞上倾覆的卡车

2020年06月




NHTSA probes Tesla Autopilot crash that killed three people

Rebecca Bellan @rebeccabellan / 1:53 AM GMT+3 • May 19, 2022

Image Credits: NTSB

AAA（美国汽车协会） ADAS（高级驾驶辅助系统）研究表明

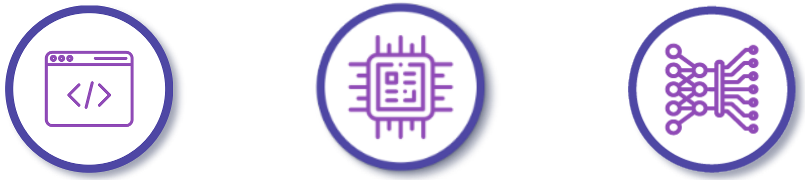
AAA （美国汽车协会）发现高级驾驶辅助系统每 8 英里就会出现问题

“在夜晚，所有被测试的汽车都无法检测到成年行人”。

2020年08月

Defining The Challenge

Most Complicated System



150M Lines of Code

>100's Chips

Several Machine Learning Systems

X

Most Complex Environment

=

Millions of Scenarios

The Infinity challenge

Millions

of Scenarios

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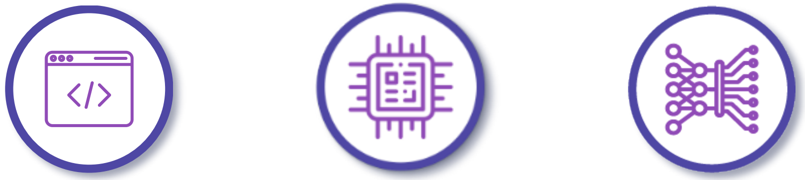
对挑战进行定义

最复杂的系统

X



1.5亿行代码

>100以上芯片

若干个机器
学习系统

最复杂的环境

ADS（可调式避震系统）

数以百万计的场景

=

无限挑战

数以百万计的
场景

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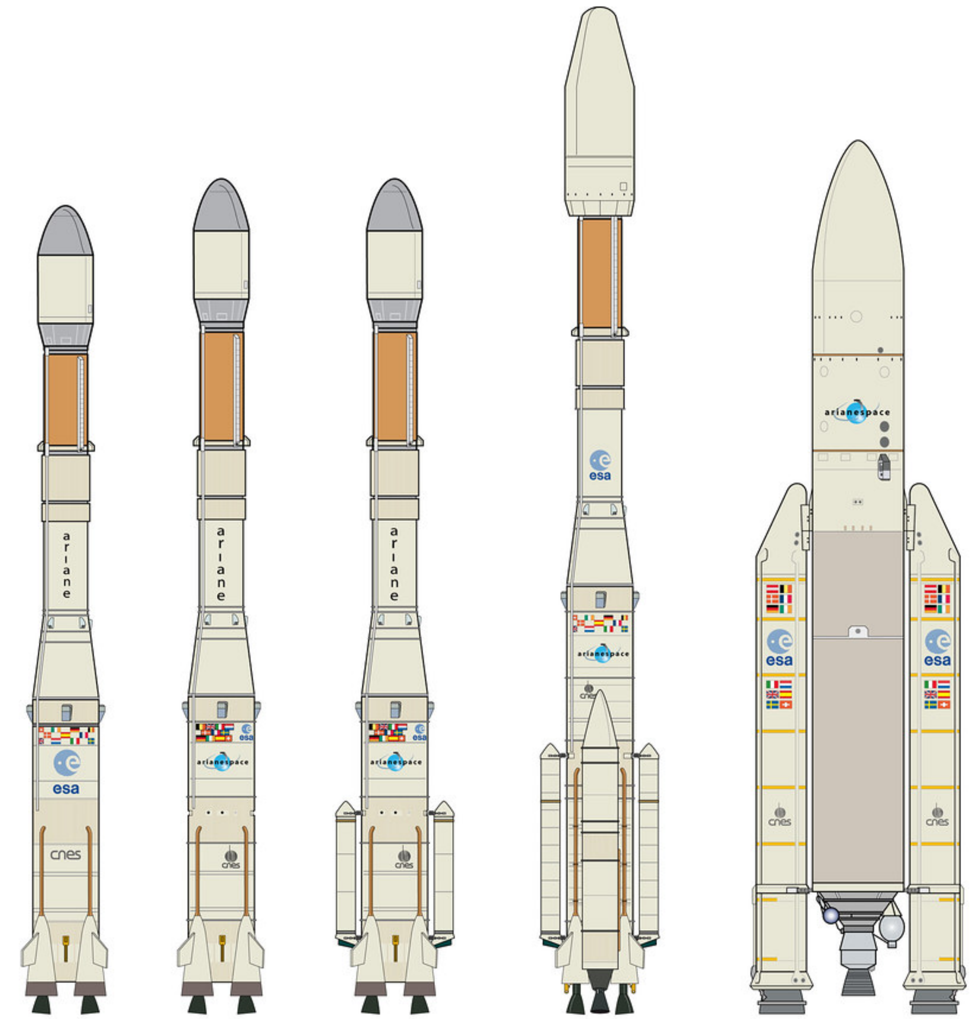
Evolution of complex HW/SW Automated Driving Systems

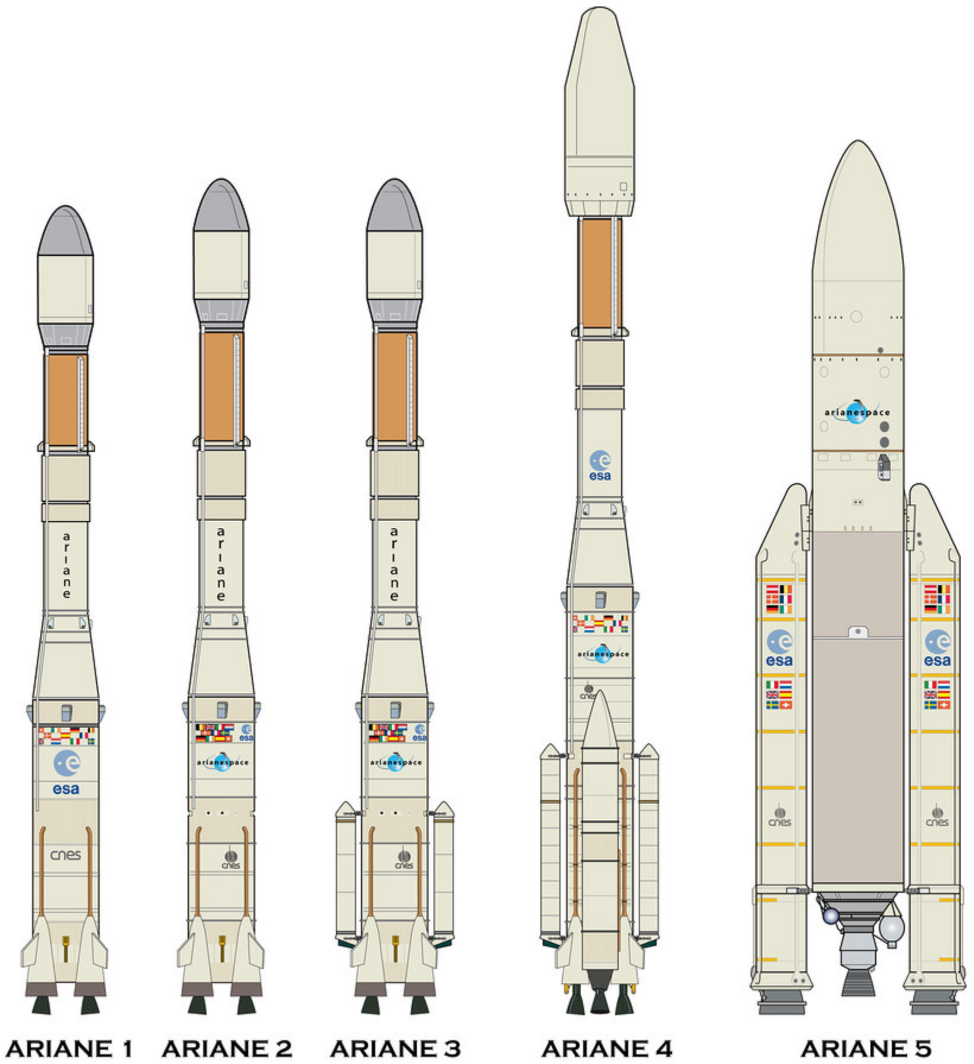


June 4th, 1996

- Safety Argument? – In place
- Similar ODDs
- Re-use of tested s/w? – In place
- Virtual testing ? – In place

http://www2.ing.unipi.it/~a009435/issw/extra/ariane5-benari.pdf

复杂的硬件/软件自动驾驶系统的演变过程



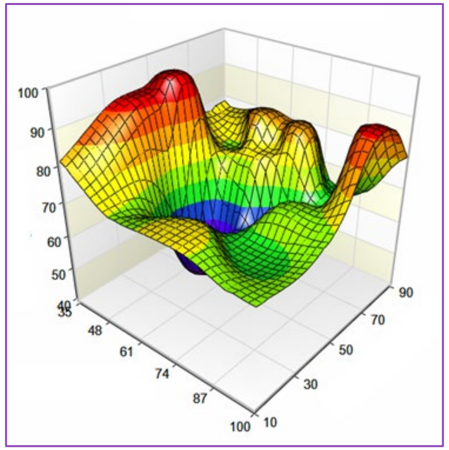
June 4th, 1996

- **安全论证？** -正在运作/（已就绪）
- 类似的ODD **（自动驾驶设定运行域）**
- **测试软件的重复使用**– 正在运作/（已就绪）
- **虚拟测试？** – 正在运作/（已就绪）

http://www2.ing.unipi.it/~a009435/issw/extra/ariane5-benari.pdf

The challenge: Mechanical hazards vs. Software hazards

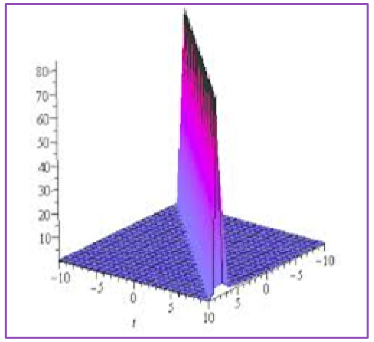
- **Continuous, analog-like phenomena**
- **Statistical methods can help predict failure triggers**

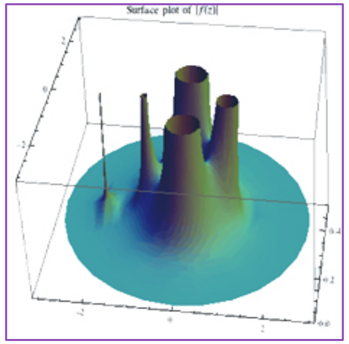


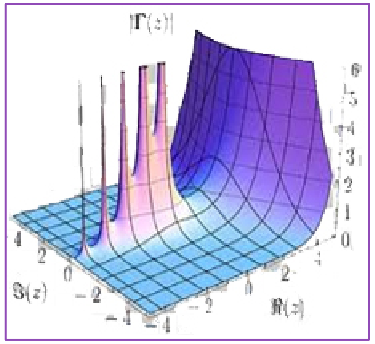
- **Systematic and Singular**

OR

- **Random by nature**







FTA (1962), FMEA (1949), HACCP (1960s') and other methods that evolved to analyze mechanical hazards are less effective.

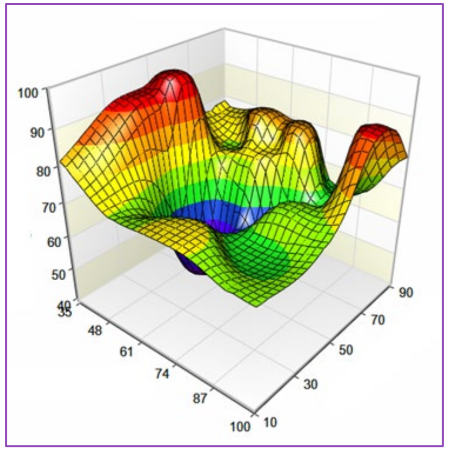
挑战：机械危险对决软件危险

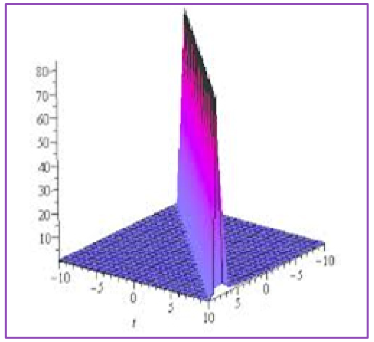
- 连续地对现象进行模拟
- 统计方法有助于预测故障
- 触发器

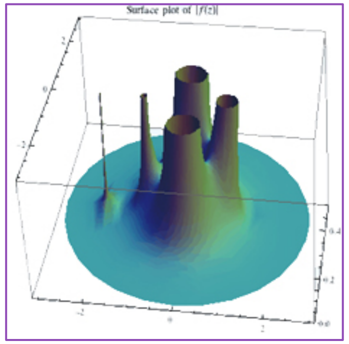
- 系统性和单一性

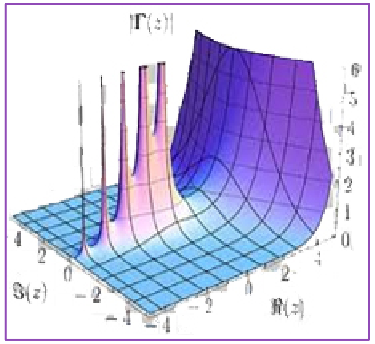
或者

- 自然随机









FTA（1962年）、FMEA（1949年）、HACCP（20世纪60年代）和其他用于分析机械危险的方法效率较低。

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- Coverage Driven Verification
- Tying CDV to evolving standards
- Closer look at ASAM OpenSCENARIO 2.0.0, SOTIF

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- 将 CDV（覆盖率驱动的验证算法）与不断发展的标准联系起来
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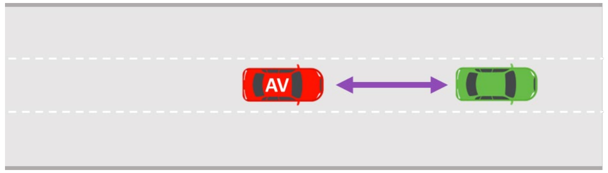
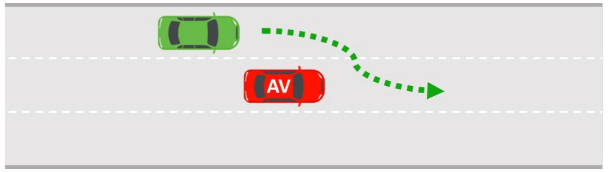
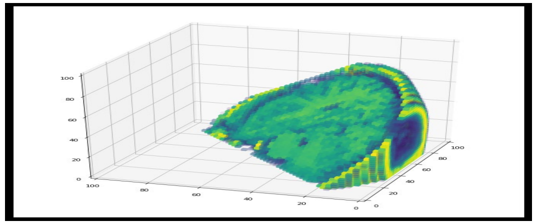
KPI/Metrics vs Coverage



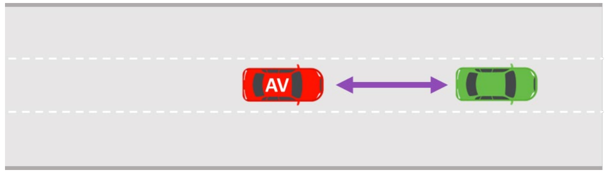


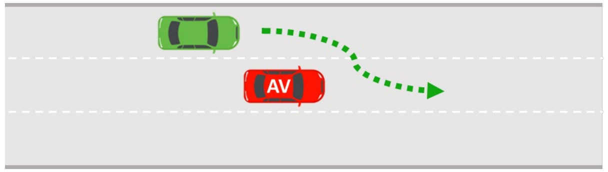


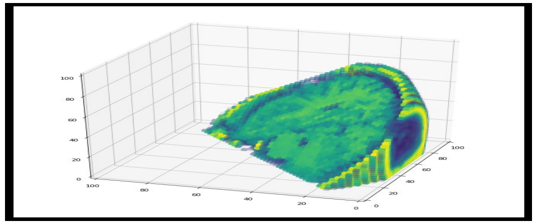
- <u>**How did the AV perform within a given ODD? On a specific test ?**</u>
- KPI/Metrics specify the specific measurements to be analyzed, given specific test conditions /ODD. Usually – "simulation output"
- <u>**Can answer:**</u>
  - **In ODD X, How did the ego perform for all performed tests variations in the context of "cut in" ? (aggregate of all specific measurement)**
  - **What was TTC, when the AV was driving at 55kph, and the other player deceleration was -3 m/s^2 ? Is it above my threshold ?**

- <u>**What was actually tested, out of the possible space of testing values [per ODD]**</u>
- Coverage can be measured both on test input/settings ,as well on output/results of the tests. It can be measure on one ,two, or multiple dimensions
- <u>**Can answer:**</u>
  - **For "cut in" scenario, on a road with 2 lanes and only green cars, what % of the possible AV speeds between 50KPH and 100KPH did I test ?**
  - **What % of the TTC space between 0 and 3S was demonstrated during all tests ?**

关键绩效指标/指标　　对决　　覆盖范围







- 自动汽车在给定的自动驾驶设计运行域内表现如何？在特定测试中表现如何？
- 关键绩效指标/指标指定了特定测试条件/自动驾驶设计运行域下要分析的特定度量。通常-“模拟输出”
- 可以回答为:
  - 在未知的自动驾驶设计运行域中, 在“切入车道”的情况下，自动驾驶如何执行所有已执行测试的变化？（所有具自动汽车以55公里/小时的速度行驶，而另一辆汽车的减速度为-3米/平方秒，TTC是什么？它是否高于我的阈值？

- 实际测试的内容，超出测试值的可能空间[根据自动驾驶设计运行域]
- 覆盖率既可以在测试输入/设置上测量，也可以在测试的输出/结果上测量。它可以在一个、两个或多个维度上测量
- 可以回答为:
  - 对于“切入车道”场景，在只有两条车道和行驶新能源汽车的道路上，自动驾驶测试的在50公里/小时和100公里/小时之间可能达到自动汽车速度的百分之几？
  - 在所有测试中，0到3秒之间的安全距离空间的百分比是多少？

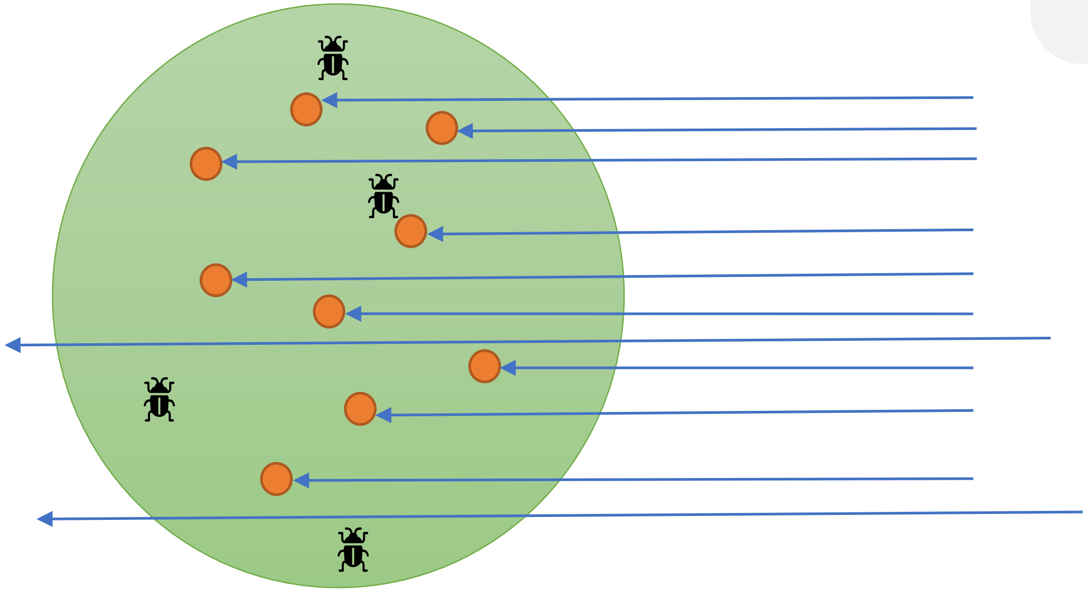
Coverage Driven Verification (CDV)
Finding More Hazards and Edge Cases

No CDV:

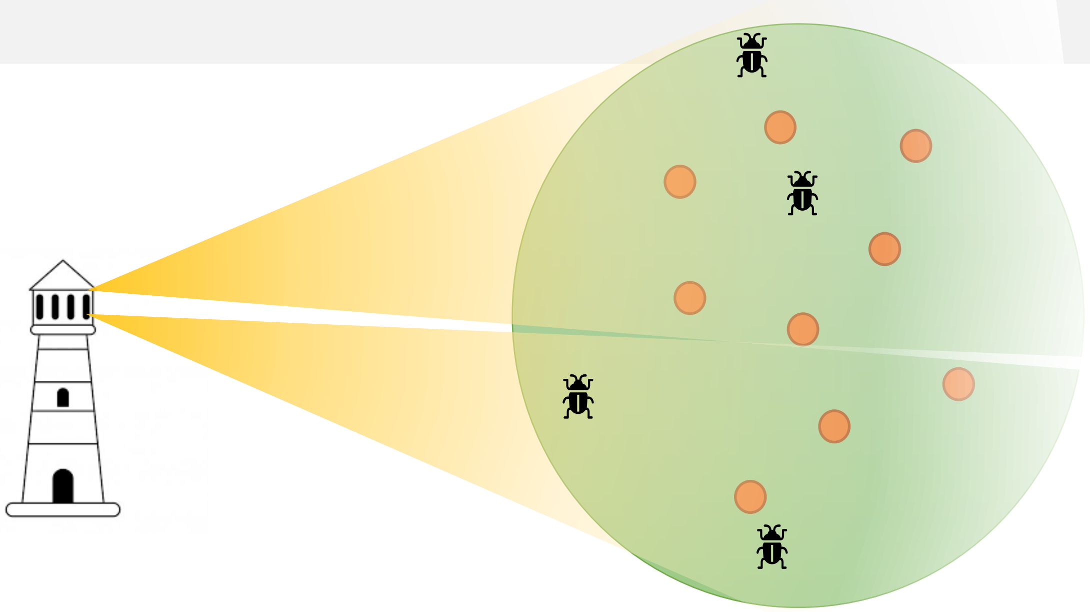
- You hit all test points one by one
- Time-consuming Manual process
- Lack of visibility of what was indeed tested
- Within a limited project cycle, we can't address each individual test point
- Resulting in undiscovered bugs

With CDV:

- You use **automated** constraint-driven **randomization** to scan the to-be-tested area
- Using **automated functional coverage** to observe what test points have been addressed
- Enables exploring and covering the test space at **massive scale** with **minimal human intervention** and **optimized compute**
- Resulting in finding **more bugs and edge cases**



Before

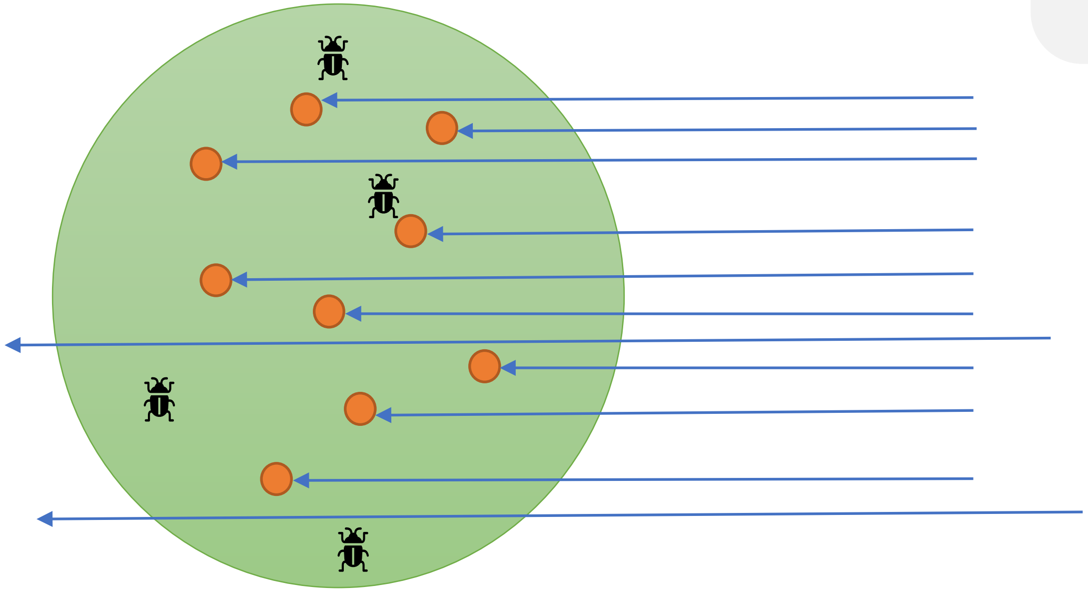


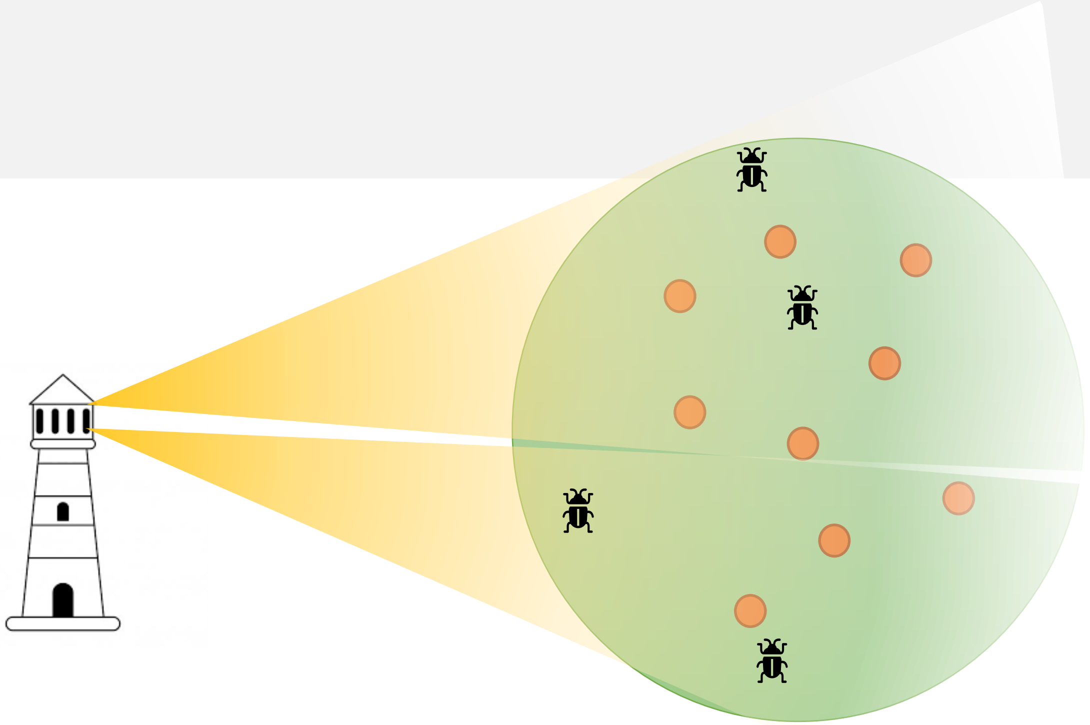
After

覆盖率驱动的验证算法 (CDV) 所发现的更多危险和边缘案例情况

无CDV（覆盖率驱动的验证算法）验证:
- 需要对所有测试点进行逐一测试
- 花费时间，手动操作测试过程
- 缺乏对实际测试内容的可见性
- 在有限的项目周期内，我们无法解决每个单独的测试点
- 会存在未发现错误的情况

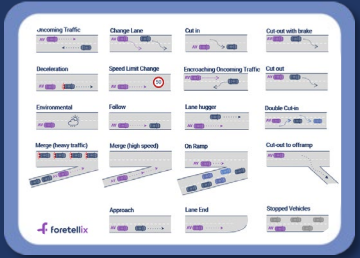
进行CDV（覆盖率驱动的验证算法）验证:
- **您可以使用自动约束驱动随机化扫描待测区域**
- **使用自动化功能覆盖率观察已解决的测试点**
- **能够以最小的人为干预和优化的计算，大规模探索和覆盖测试空间**
- 能够**发现更多错误和边缘**情况。





CDV – Required Technology Building Blocks

Scenario Libraries

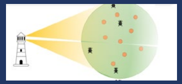


Planning & Scenario Description Using OSC 2.0

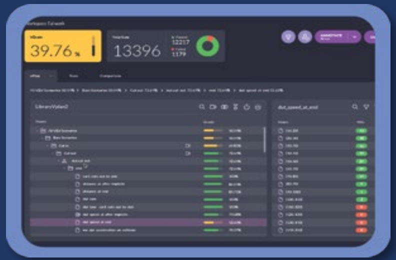
```
v1: vehicle            # the target car
side: av_left_right
r: rout with:          # an abstract road with minimum of two lanes
   keep(it.min_lanes >= 2)

do parallel(equal, duration: in [1..5]s):
   sut.vehicle.drive() with:
      along(r)
   v1.drive()  with:
      along(r)
      position([5..100]m, behind:sut.vehicle, at: start)
      position([5..15]m, ahead_of:sut.vehicle, at: end)
```

Automatic Generation of Scenarios Variants



Coverage Aggregation Analytics & Metrics



SIMULATION

HW-IN-THE-LOOP

TEST DRIVING

PROVING GROUND

INTELLIGENT OPTIMIZATION

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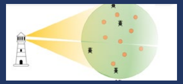
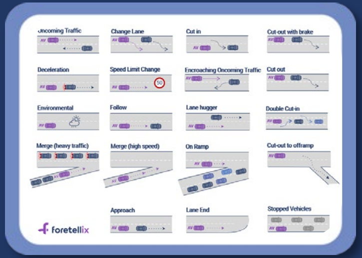
CDV（覆盖率驱动的验证算法） – 所需的技术构建块



场景库



使用开放场景2.0 进行规划和场景描述

```
v1: vehicle             # the target car
side: av_left_right
r: rout with:           # an abstract road with minimum of two lanes
   keep(it.min_lanes >= 2)

do parallel(equal, duration: in [1..5]s):
   sut.vehicle.drive() with:
      along(r)
   v1.drive()  with:
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      position([5..100]m, behind:sut.vehicle, at: start)
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```
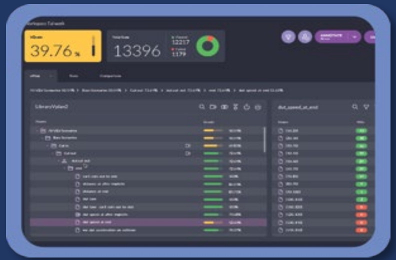

自动生成 场景变体

覆盖率聚合 分析和指标



模拟

硬件在环

试驾车

试验场

智能优化

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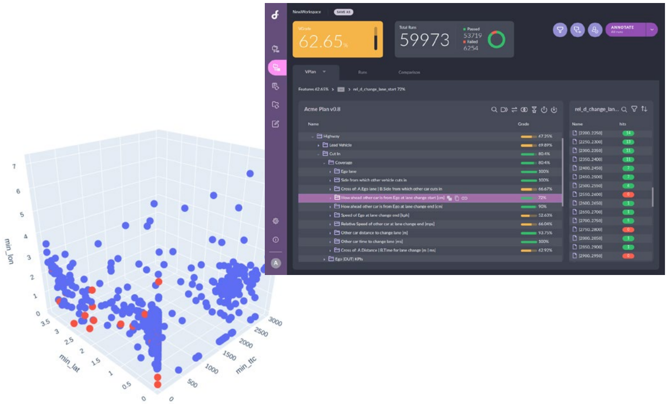
Foretify™ - Foretellix Coverage Driven Verification Flow



Analyze Coverage & KPI Metrics

Define V&V Plan

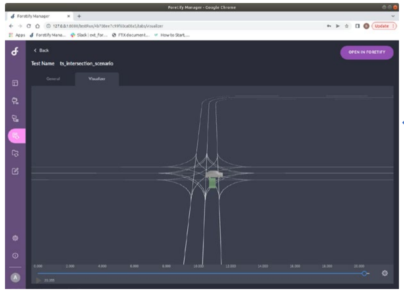
Requirements

IBM Rational
DOORS Next Generation

jama software

Risk Dimensions

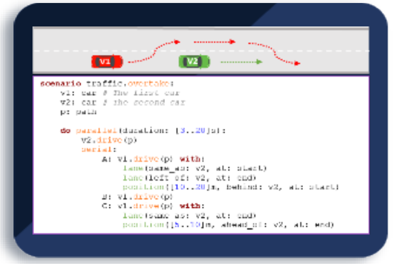
Weather
Roads
Cyclists
Drivers

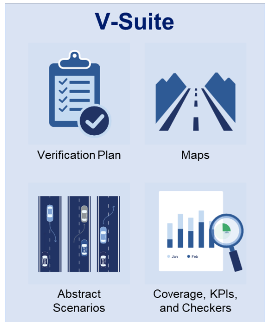


Triage failures

Create or Reuse Abstract Scenarios

OpenSCENARIO2





NVID
AVSIMULATION
ve
VIRES
AIMOTIVE
In-house simulators

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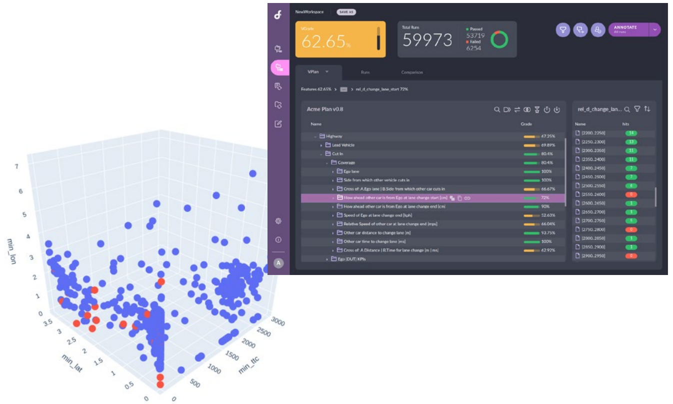
Foretify™ - 覆盖驱动的验证流程



分析覆盖率和关键绩效指标

定义 V&V 计划

Requirements

IBM Rational
DOORS Next Generation

jama software

Risk Dimensions

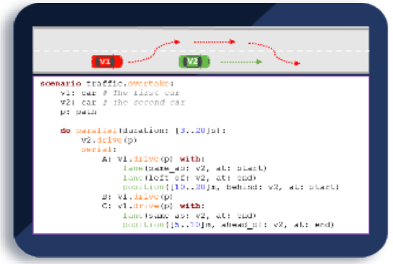
Weather

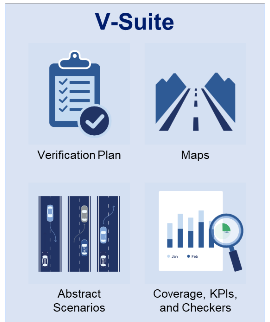
Roads

Cyclists

Drivers

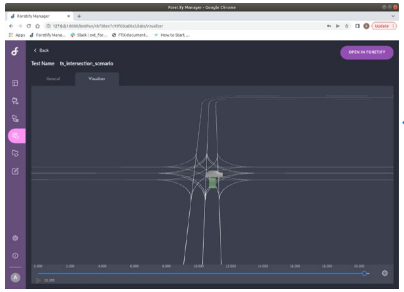
OpenSCENARIO2





创建或重新使用抽象场景

分类失败



NVIDIA

AVSIMULATION

VIRES

AIMOTIVE

In-house simulators

foretellix

Outline

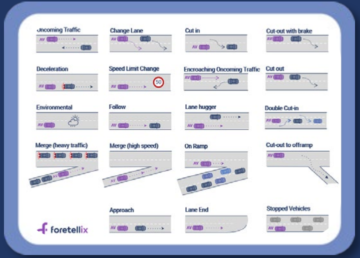
- ADAS and ADS – The infinite scenario space challenge
- Coverage Driven Verification
- Tying CDV to evolving standards
- Closer look at ASAM OpenSCENARIO 2.0.0, SOTIF

概述

- ADAS（ 高级驾驶辅助系统）和ADS（可调式避震系统）– 无限场景空间挑战
- 覆盖驱动验证
- 将 CDV（覆盖率驱动的验证算法）与不断发展的标准联系起来
- 进一步了解ASAM（自动化及测量系统标准协会）开放场景2.0.0，SOTIF（ 预期功能安全）

CDV – Required Technology Building Blocks

Scenario Libraries

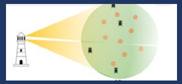


Planning & Scenario Description Using OSC 2.0

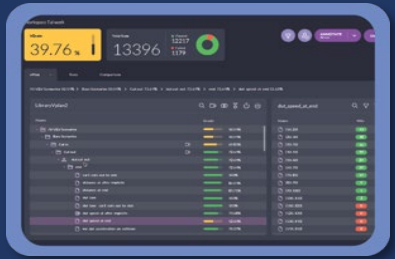
```
v1: vehicle            # the target car
side: av_left_right
r: rout with:          # an abstract road with minimum of two lanes
   keep(it.min_lanes >= 2)

do parallel(equal, duration: in [1..5]s):
   sut.vehicle.drive() with:
      along(r)
   v1.drive()  with:
      along(r)
      position([5..100]m, behind:sut.vehicle, at: start)
      position([5..15]m, ahead_of:sut.vehicle, at: end)
```

Automatic Generation of Scenarios Variants



Coverage Aggregation Analytics & Metrics



SIMULATION

HW-IN-THE-LOOP

TEST DRIVING

PROVING GROUND

INTELLIGENT OPTIMIZATION

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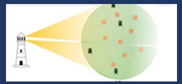
CDV（覆盖率驱动的验证算法） – 所需的技术构建块

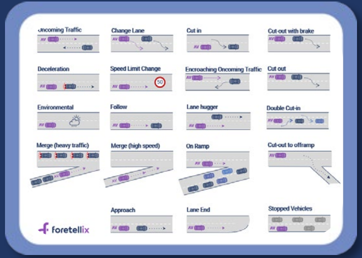


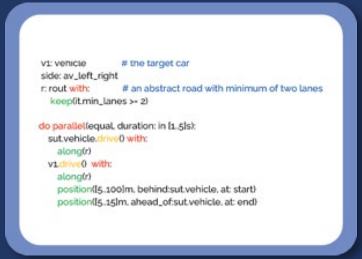
场景库

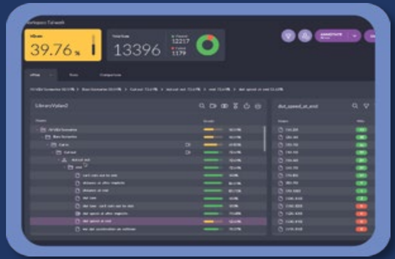
使用开放场景2.0
进行规划和场景描述

**自动生成
场景变体**

**覆盖率聚合
分析和指标**







模拟

硬件在环

试驾车

试验场

智能优化

foretellix

CDV – Required Solution and Methodology Layer :

Scenario Libraries & Catalogs

Standard Test Templates
Standard ODDs,
Common Test procedures
Virtual Testing Models Correlation

Metrics and rating analysis,
Standards and regulations:
Safety Ratings, Thresholds,
Risks

Scenario Libraries

Planning & Scenario Description Using OSC 2.0

Automatic Generation of Scenarios Variants

Coverage Aggregation Analytics & Metrics

SIMULATION

HW-IN-THE-LOOP

TEST DRIVING

PROVING GROUND

INTELLIGENT OPTIMIZATION

CDV（覆盖率驱动的验证算法） – 所需解决方案和方法层:

场景库和目录

标准测试模板
标准自动驾驶设定运行域，
通用测试程序
虚拟测试模型
相关性

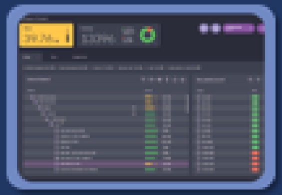
指标和评级分析，
标准和法规：
安全等级、阈值，
风险

场景库

使用开放场景2.0
进行规划和场景描述

自动生成
场景变体

覆盖率聚合
分析和指标



Measurable Safety/CDV – Standards/Regulations Eco System:

UNECE/GRVA – New Assessment and Test Methods:
Scenario Catalogue
Testing Methods
Virtual Testing Assessment

Regulatory Thresholds
UNECE – FRAV – Functional Requirements,
ISO, SAE
Safety Metrics , Behavioral Competencies

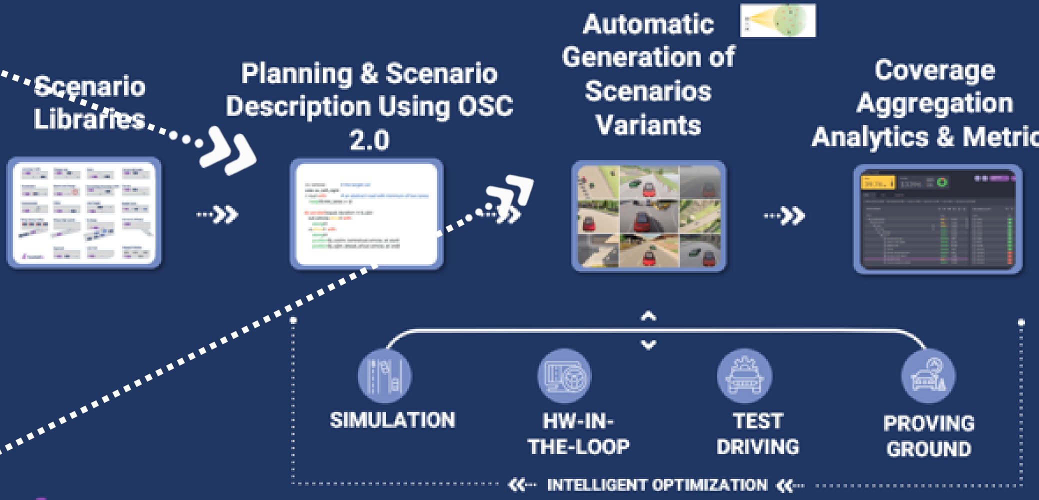
Scenario Libraries & Catalogs

Standard Test Templates
Standard ODDs,
Common Test procedures
Virtual Testing Models
Correlation

Metrics and rating analysis,
Standards and regulations:
Safety Ratings, Thresholds,
Risks

ASAM
OpenSCENARI0 2.0

SAE/AVSC
– Safety metrics,
Foretellix' coverage analysis
NCAP virtual testing
ISO 21448 , ISO 5083



ASAM Open ODD
ISO 34503
ISO 34502
ISO 21448

Simulation Correlation Methods: UNECE (EU Draft) , PEARS, ISO, UTAC-CERAM, AVL

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可衡量的安全/CDV（覆盖率驱动的验证算法）–标准/法规生态系统

- UNECE（联合国欧洲经济委员会）/GRVA(**联合国世界车辆法规协调论坛(WP29)自动驾驶车辆工作组)–新的评估和测试方法：**
  场景库
  测试方法
  虚拟测试评估

监管阈值
UNECE–FRAV–**功能要求、**ISO、SAE
安全指标、行为能力

标准测试模板
标准自动驾驶设定运行域，
通用测试程序
虚拟测试模型
相关性

场景库和目录

指标和评级分析，
标准和法规：
安全等级、阈值，
风险

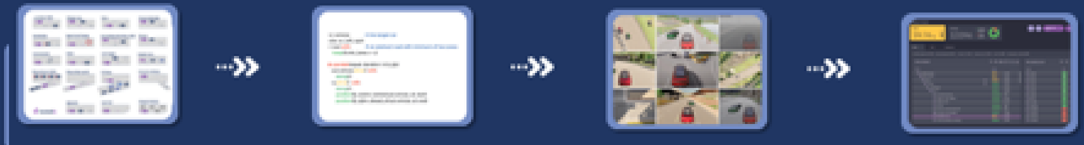
ASAM（自动化及测量系统标准协会）
开放场景 2.0

场景库

使用开放场景2.0
进行规划和场景描述

自动生成
场景变体

覆盖率聚合
分析和指标



SAE/AVSC
–**安全指标，**
Foretellix**的覆盖率分析**
NCAP**虚拟测试**
ISO 21448、ISO 5083

模拟 硬件在环 试驾车 试验场

智能优化

ASAM 开放自动驾驶设定运行域
SOO 34503
ISO 34502
ISO 21448

模拟相关方法：UNECE（联合国欧洲经济委员会）、PEARS、ISO、UTAC-CERAM、AVL

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Outline

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概述

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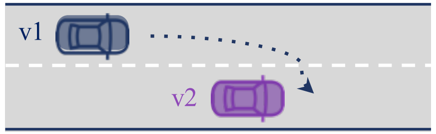
- 覆盖驱动验证
- 将 CDV（覆盖率驱动的验证算法）与不断发展的标准联系起来
- 进一步了解ASAM（自动化及测量系统标准协会）开放场景2.0.0，SOTIF（ 预期功能安全）

ASAM OpenSCENARIO 2.0.0 - breakthrough language !

```
Scenario: sut.cut_in_and_slow:
  v1: vehicle          # the target car
  side: av_left_right
  r: route with:           # an abstract road with minimum of two lanes
    keep(it.min_lanes >= 2)

 do parallel(equal, duration: in [1s..5s]):
   sut.vehicle.drive() with:
     along(r)
   v1.drive()  with:
     along(r)
     position(distance, [5m..100m], behind:sut.vehicle, at: start)
     position(distance, [5m..15m], ahead_of:sut.vehicle, at: end)
```



Simplify

Human Readable Scenario Definition and Promote Reuse

Measure

Performance KPI's and Scenario Coverage

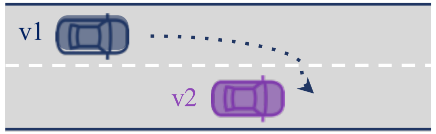
Mix/Compose

Multiple Scenarios & Risk Dimensions

ASAM（自动化及测量系统标准协会）开放场景 2.0.0 - 突破性语言！

```
Scenario: sut.cut_in_and_slow:
  v1: vehicle             # the target car
  side: av_left_right
  r: route with:             # an abstract road with minimum of two lanes
    keep(it.min_lanes >= 2)

 do parallel(equal, duration: in [1s..5s]):
   sut.vehicle.drive() with:
     along(r)
   v1.drive()  with:
     along(r)
     position(distance, [5m..100m], behind:sut.vehicle, at: start)
     position(distance, [5m..15m], ahead_of:sut.vehicle, at: end)
```



简化
人类可读的场景
定义并促进重新使用

测量
执行关键绩效指标和
场景覆盖率

混合/合成
多种场景和
风险尺度

ASAM OpenSCENARIO 2.0 – In Plain language

- This is a declarative domain specific programming language combined with a domain model, specifying entities with their properties
- The language supports abstract, logical and concrete levels of scenario abstraction

	Concrete	Logical	Abstract	Functional
OpenSCENARIO 1	✓	✓		
OpenSCENARIO 2	✓	✓	✓	

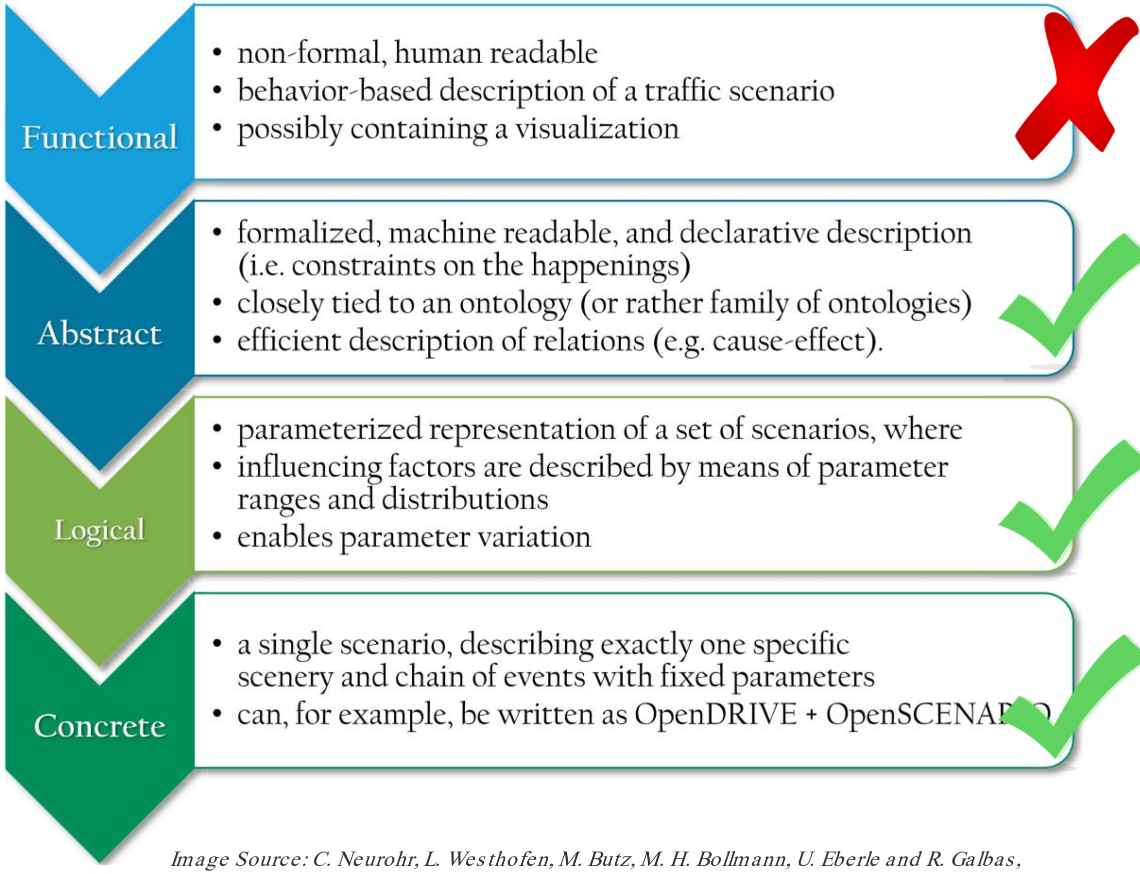
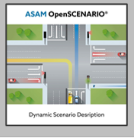


Image Source: C. Neurohr, L. Westhofen, M. Butz, M. H. Bollmann, U. Eberle and R. Galbas, "Criticality Analysis for the Verification and Validation of Automated Vehicles," in IEEE Access, vol. 9, pp. 18016-18041, 2021, doi: 10.1109/ACCESS.2021.3053159.

ASAM（高级驾驶辅助系统）开放场景2.0 – 简明介绍

- 该语言是一种具有声明性的特定于域的编程语言，与领域模型相结合，指定实体及其属性
- 该语言支持所提取场景抽象、逻辑和具体的级别

	Concrete	Logical	Abstract	Functional
OpenSCENARIO 1 	✓	✓		
OpenSCENARIO 2 	✓	✓	✓	

功能性	非正规，人类可读 交通场景的基于行为的描述 可能包含可视化	✗
概要性	形式化的、机器可读的和声明性的描述（即对事件的约束） 与本体密切相关（更确切地说是本体系列） 关系的有效描述（例如因果关系）	✓
逻辑性	一组场景的参数化表示，其中影响因素通过参数范围和分布来描述 - 启用参数变化	✓
具体性	一个场景，只描述一个特定的场景 以及具有固定参数的事件链 例如，可以编写为OpenDRIVE+开放场景	✓

图像来源: C. Neurohr, L. Westhofen, M. Butz, M. H. Bollmann, U. Eberle和R. Galbas, "自动化车辆验证和确认的关键性分析," 发表于IEEE Access杂志, 第9卷, 页数18016-18041, 2021, doi: 10.1109/ACCESS.2021.3053159.

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OpenSCENARIO – 1 vs 2…

OpenSCENARIO 2.0.0
(3 different levels of abstraction)

 # Concrete – specific test

```
ego.drive() with:
   speed(10kph)
```

 # Logical (R-157 speed range)

```
ego.drive() with:
   speed(ë0kph..60kph])
```

 # Abstract

```
ego.drive() with:
   keep(it.speed <= speed_limit)
```

"The ADS shall not cross the legal speed limit "

OpenSCENARIO 1.1.0
(concrete)

```xml
<!-- Concrete -->
    <Actions>
    <Private entityRef="Ego">
        <PrivateAction>
        <LongitudinalAction>
            <SpeedAction>
            <SpeedActionDynamics dynamicsShape="step"
dynamicsDimension="time" value="0" />
            <SpeedActionTarget>
                <AbsoluteTargetSpeed value="50.0 / 3.6" />
            </SpeedActionTarget>
            </SpeedAction>
        </LongitudinalAction>
        </PrivateAction>
    </Private>
    </Actions>
```

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开发场景 – 第1版 对决第 2版...

开发场景2.0.0
(3 种不同层次的抽象)

 # 具体化 – 特定试验

```
ego.drive() with:
   speed(10kph)
```

 # 逻辑化 (R-157 速度范围)

```
ego.drive() with:
   speed(ë0kph..60kph])
```

 # 抽象化

```
ego.drive() with:
   keep(it.speed <= speed_limit)
```

“自动驾驶系统不得超过法定速度限制“

开放场景 1.1.0
(场景具体化)

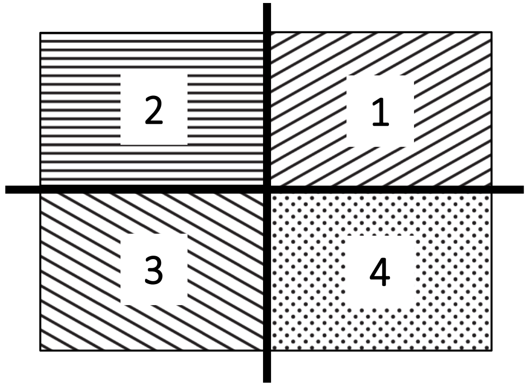
```
<!-- Concrete -->
    <Actions>
    <Private entityRef="Ego">
        <PrivateAction>
        <LongitudinalAction>
            <SpeedAction>
            <SpeedActionDynamics dynamicsShape="step"
dynamicsDimension="time" value="0" />
            <SpeedActionTarget>
                <AbsoluteTargetSpeed value="50.0 / 3.6" />
            </SpeedActionTarget>
            </SpeedAction>
        </LongitudinalAction>
        </PrivateAction>
    </Private>
    </Actions>
```

Safety Of The Intended Functionality (SOTIF – ISO 21448)

> "Absence of unreasonable risk due to hazards resulting from functional insufficiencies of the intended functionality or from reasonably foreseeable misuse by persons"

- SOTIF (ISO 21448) is dealing with Safety of Autonomous Systems, and provides guidance on design, verification, and validation measures
- SOTIF breaks down the possible scenario space to 4 categories
- "The ultimate goal is to evaluate the safety in area 2 and area 3 and to provide an argument that these areas are sufficiently small and the resulting residual risk is acceptable"

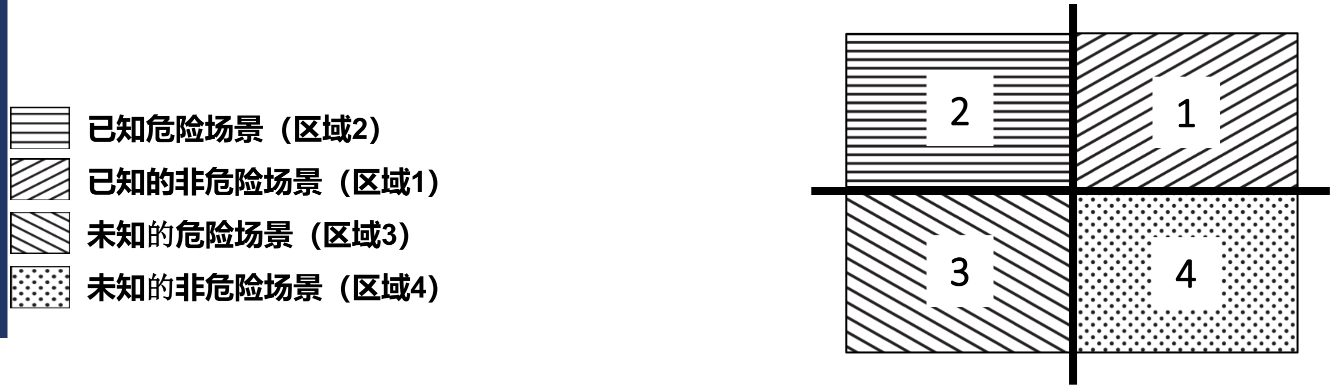
- Known, hazardous scenarios (Area 2)
- Known, nonhazardous scenarios (Area 1)
- Unknown, hazardous scenarios (Area 3)
- Unknown, nonhazardous scenarios (Area 4)



预期功能的安全性 (SOTIF – ISO 21448)

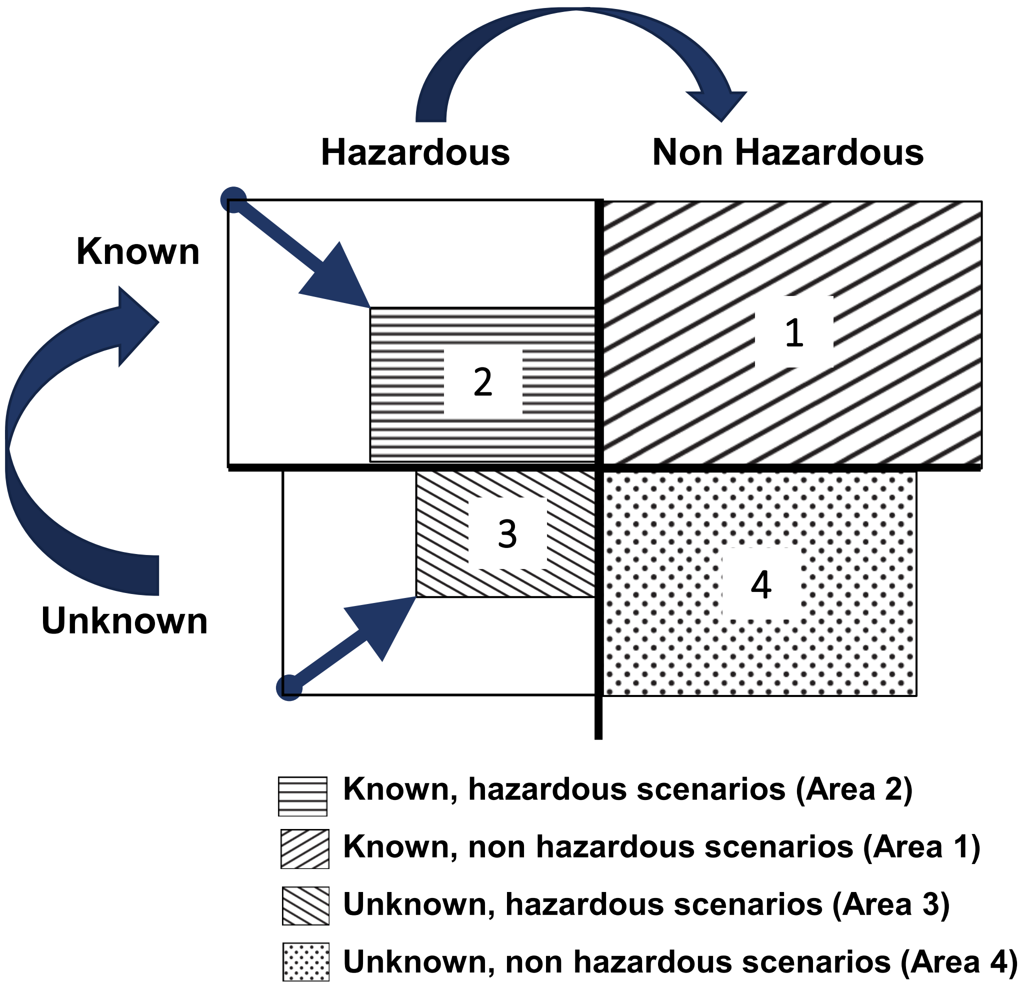
“没有由于预期功能的功能不足或合理预见的人员滥用而导致的不合理风险”

- **SOTIF（ISO 21448）处理自治系统的安全问题，并提供设计、验证和确认措施的指导**
- **SOTIF将可能的场景空间分为4类**
- **“最终目标是评估区域2和区域3的安全性，并提供证据证明这些区域非常小，由此而产生的剩余风险是可以接受的”**



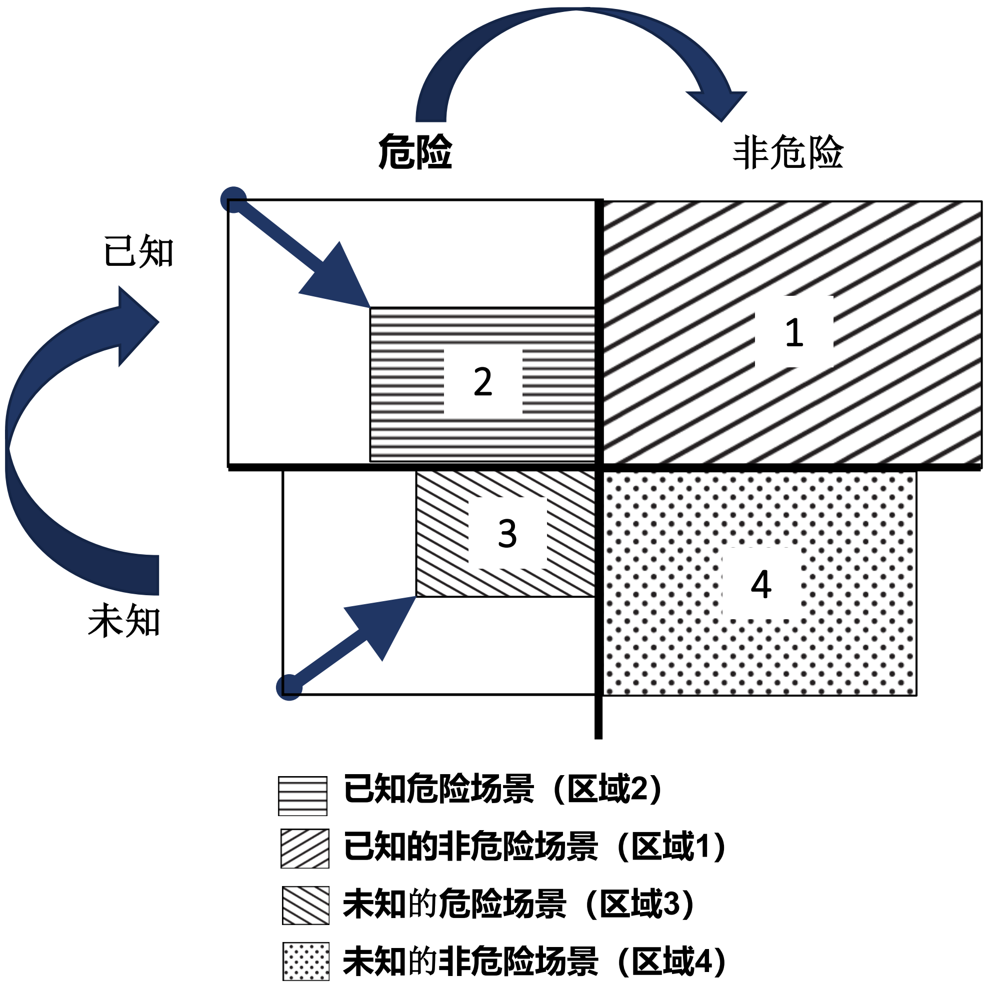
The Full SOTIF Flow

- Foretify™ is an automation and analysis tool, implementing the Coverage Driven Verification methodology
- Foretify™ provides a systematic approach to reduce both area 2 and area 3
- Foretify™ supports the SOTIF process, intended for reaching acceptable levels of risk



整套SOTIF（ 预期功能安全）流程

- Foretify™ 是一种自动化和分析工具，实现了覆盖率驱动的验证算法的方法
- Foretify™ 提供一种系统的方法来减少区域2和区域3的情况
- Foretify™ 支持SOTIF（预期功能安全）流程，旨在达到可接受的风险水平



CDV – SOTIF

SOTIF Standard mentions Coverage Driven Verification methodology as a way to expose the unknown unknowns (Annex C)

ISO/DIS 21448

ISO/TC **22**/SC **32**

Secretariat: **JISC**

Voting begins on:
2021-01-20

Voting terminates on:
2021-04-14

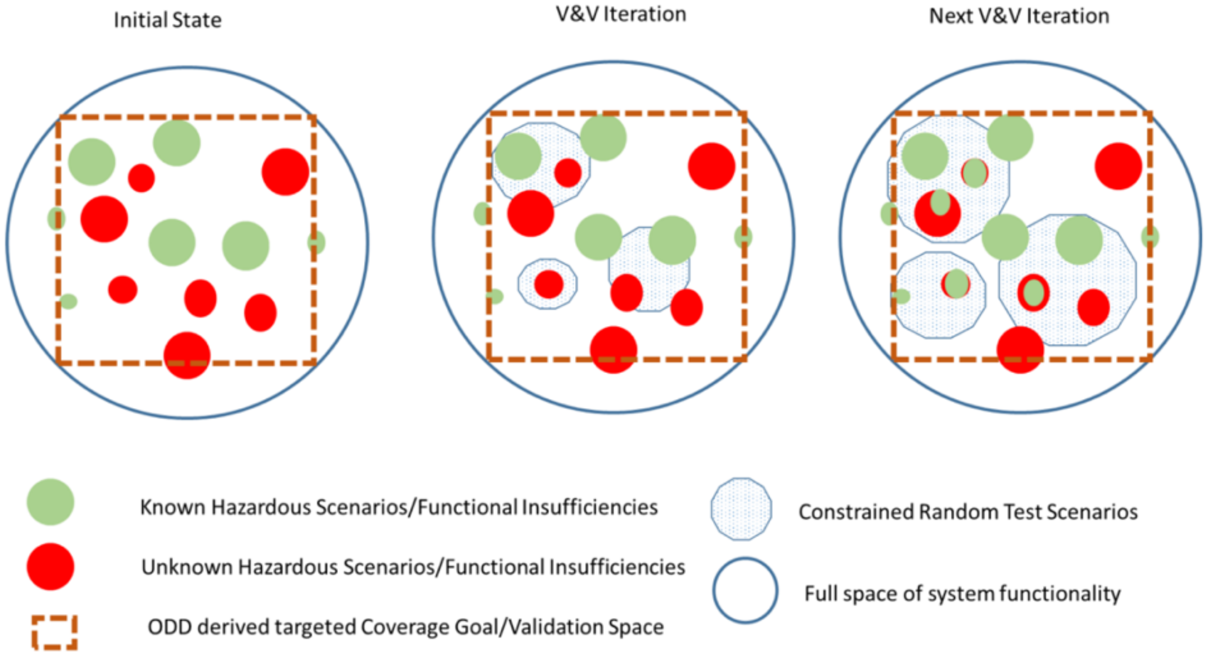
Road vehicles — Safety of the intended functionality

Véhicules routiers — Sécurité de la fonction attendue

ICS: 43.040.10

C.3 Validation of SOTIF Applicable Systems

Figure C.5 denotes a possible model for how V&V iterations combined with coverage goals and constrained random testing, can be used to discover unknown hazardous scenarios or functional insufficiencies (i.e. reduce area 3) in support of the SOTIF development (Figure 9). In the Initial State (leftmost circle), which is prior to the initiation of V&V, some potential functional insufficiencies, green circles representing area 2, have been identified during the safety analyses. Other functional insufficiencies might exist but not identified at this stage (red circles, the unknown hazardous scenarios (area 3). The dashed square represents the ODD derived coverage space or a V&V target.



CDV（覆盖率驱动的验证算法） – SOTIF（ 预期功能安全）

SOTIF（预期功能安全）标准采用覆盖率驱动的验证方法，以暴露未知的未知因素（附件 C)

ISO/DIS 21448

ISO/TC 22/SC 32 Secretariat: JISC

Voting begins on: 2021-01-20 Voting terminates on: 2021-04-14

道路车辆-预期功能安全

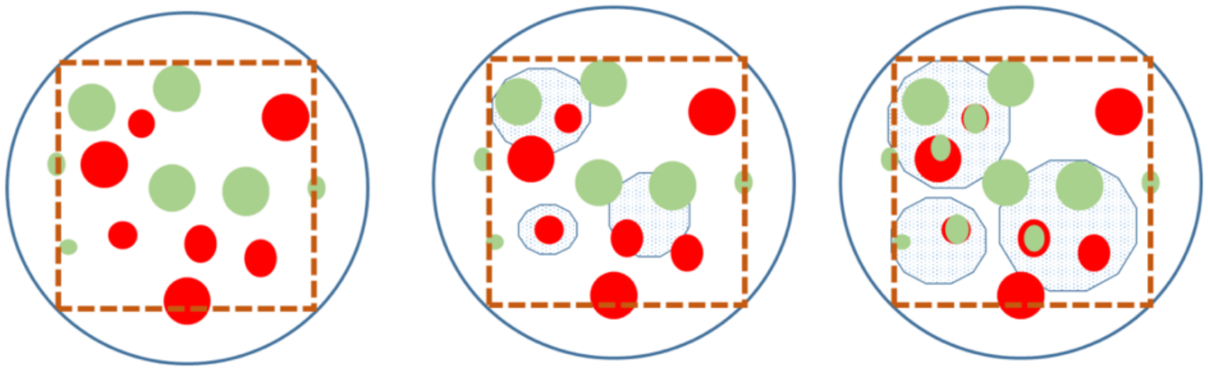
车辆路线-安全行动注意事项

ICS: 43.040.10

C.3 SOTIF（预期功能安全）适用系统的验证

图 C.5 表示验证和确认迭代如何结合覆盖目标和受限随机测试的可能模型，可用于发现未知的危险场景或功能不足（即，减少区域 3）以支持 SOTIF（预期功能安全） 开发（图 9）。 在启动验证和确认之前的初始状态（最左边的圆圈）中，在安全分析期间已识别出一些潜在的功能不足，代表区域 2 的绿色圆圈。 其他功能不足可能存在但在此阶段未确定（红色圆圈，未知危险场景（区域 3）。虚线方块表示 ODD（自动驾驶设定运行域）派生的覆盖空间或验证和确认目标。

初始状态 验证和确认迭代 下一次验证和确认迭代



已知危险情况/功能不足

未知的危险情况/功能不足

奇数派生目标覆盖率目标/验证空间

受约束的随机测试场景

完整的系统功能空间

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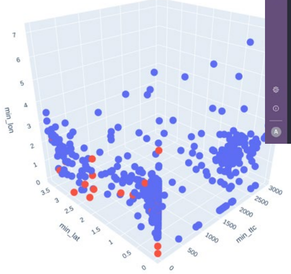
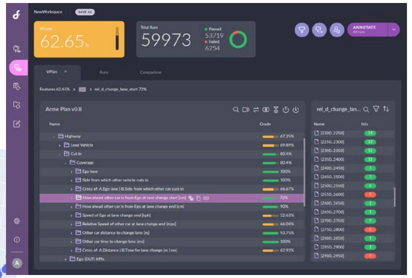
Foretify™ - Foretellix Coverage Driven Verification Flow





Analyze Coverage & KPI Metrics

Define V&V Plan

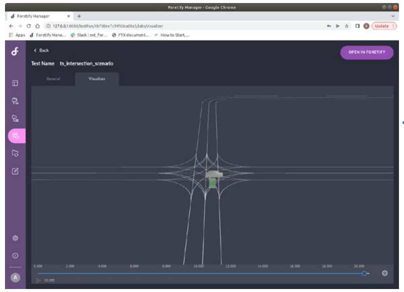
Requirements

IBM Rational
DOORS Next Generation

jama software

Risk Dimensions

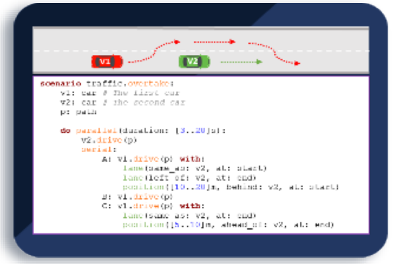
Weather Roads Cyclists Drivers

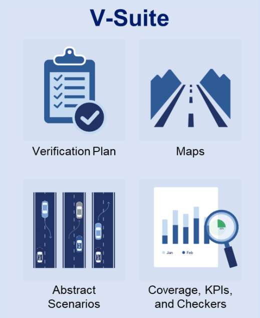


Triage failures

Create or Reuse Abstract Scenarios

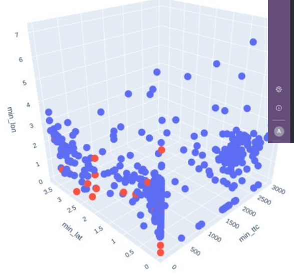
OpenSCENARIO2

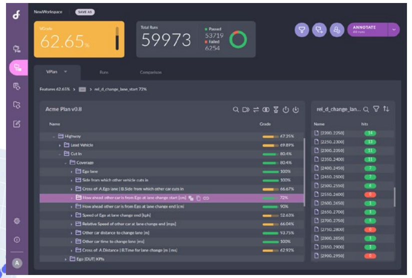




In-house simulators

Foretify™ - Foretellix覆盖驱动的验证流程





分析覆盖率和关键绩效指标

定义 V&V 计划

Requirements

IBM Rational
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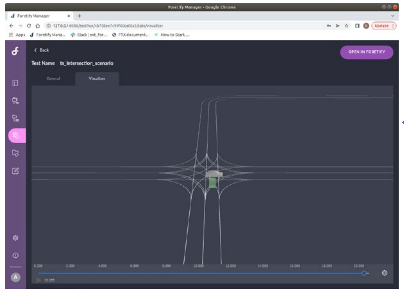
Risk Dimensions

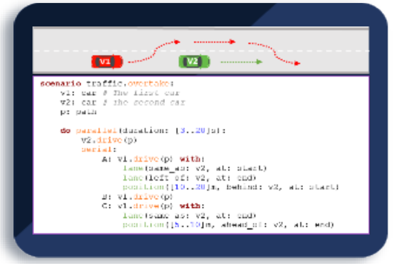
Weather Roads Cyclists Drivers

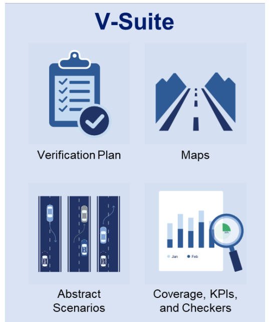


分类失败

创建或重新使用抽象场景

OpenSCENARIO2





In-house simulators

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Thank you!

More info: info@foretellix.com

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谢谢!

更多信息，请发送邮件至: info@foretellix.com

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