Title: **System/Subsystem Specification For Vision System**

Total Pages: **26**

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Revision Instructions
1. Method of revision will be through the issue of new document.
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1 INTRODUCTION

1.1 PURPOSE

The purpose of this System/Subsystem Specification (SSS) is to describe the design requirements and specifications of the vision system to be used in Project Terrex Gen 5 (TG5). The Vision System shall consist of Video Server (VSR), intelligent Driver Display Panel (iDDP), and various camera (3-in-1 ,2-in-1 and Single Day Camera).

VSR shall have an in-build with network switch to for future scalability and expandability.

The design of the Vision System shall meet the following requirement:

- **Close Hatch Driving (CHD)**
  Provide selection of real-time video images from cameras to the intelligent Driver Display Panel (iDDP) with minimal video latency introduced, vehicle information, side OSD and dynamic OSD on front centre and rear centre. Glass to Glass Latency target <140ms.
    - Targeted VSR System latency: < 50 ms
    - Targeted iDDP System Latency: < 40 ms
    - Targeted Camera System Latency: < 50 ms

- **All Round Surveillance System (ARSS)**
  Provide a selection of video images to achieve up to 360 deg software stitched view around the vehicle and independently send the images to the device terminals. Glass to Glass Latency target <350ms
    - Targeted VSR System latency: < 200 ms
    - Targeted UIT System Latency: < 100 ms
    - Targeted Camera System Latency: < 50 ms

- **Driver Assist System (DAS) – Optional**
  - **Stereo Vision** – To enable Depth Perception ability.
  - **Night Vision Enhancement –** To enhance visual experience during night operation without Thermal Imaging (TI) camera.
  - **External System Video Feed –** Equipped driver with the ability to react faster and in an effective approach.
  - **Drive By Wire –** Enable VC with the ability to take over basic driving functions using the UIT as driving display, **(Degraded driving mode with higher video latency)**.
  - **Obstacle detection –** Enable objective detection (Human, vehicle, object)

1.2 SCOPE

This SSS covers the functionality, specification, environmental and EMC/EMI requirement of the Vision System.

1.3 INTENDED AUDIENCE

The intended audience for this document is written for hardware (electrical and mechanical), software and safety engineers.

1.4 ACRONYM & ABBREVIATION

Abbreviation	Definition
VSR	Video Server
iDDP	intelligent Driver Display Panel
TC	Trooper Commander
VC	Vehicle Commander
CHD	Closed Hatch Driving
ARSS	All Round Surveillance System
DAS	Driver Assist System
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
GigE	Gigabit Ethernet
YcbCr	Digital Component Video
SD	Standard Definition

HD-SDI	High Definition Serial Digital Interface (Digital Video)
DC	Direct Current
NUC	Non-Uniformity Correction
TI	Thermal Image
CAN	Controller Area Network
CSCI	Computer Software Configuration Item
UIT	User Interface Terminal
TG5	Terrex Gen 5

1.5 REFERENCE DOCUMENTS

The documents listed below are either used to create this document or are referenced in it:

Document No.	Title
MIL-STD-461	Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility
MIL-STD-810	Test Method standard for Envrionmental Engineering Consideration and Laboratory Tests
MIL-STD-1472	Human Engineering Design Criteria for Military System, Equipment and Facilities. Material.
IEC 61000-4-2	Electrostatic DisUAVcharge Immunity Test

1.6 OVERVIEW OF THIS DOCUMENT

The document is organized in the following sections:

- Section 1 introduces the scope and document overview.
- Section 2 describes the overview of the system.
- Section 3 describes the architecture of the system.
- Section 4 describes the system operation.
- Section 5 describes system requirements.

2 SYSTEM OVERVIEW

The Vision System, which consists of VSR, IDDP, various cameras and TI Camera shall meet the following functions:

- Provide operators with multi-channel video HD-SDI receiver with multiple video outputs for CHD and ARSS displays.
- Using control interfaces such as RS422, Network based Control (H.264) and Discrete I/O to select the required video input to be viewed on each display.
- Provide driver with vehicle information e.g vehicle speed, Gear status, brake status, driver BIT fault indicator, Pitch and Roll indicators, dynamic OSD and side OSD via the iDDP.
- Thermal Imaging Camera shall be ON during operation.
- Driver assist system provide operator with means to reduce human errors during operation, DAS consist of Stereo vision, night vision enchantment, External System video feed, drive-by-wire, and obstacle detection. (Optional)

3 SYSTEM ARCHITECTURE

3.1 System Interconnection/ Block Diagram

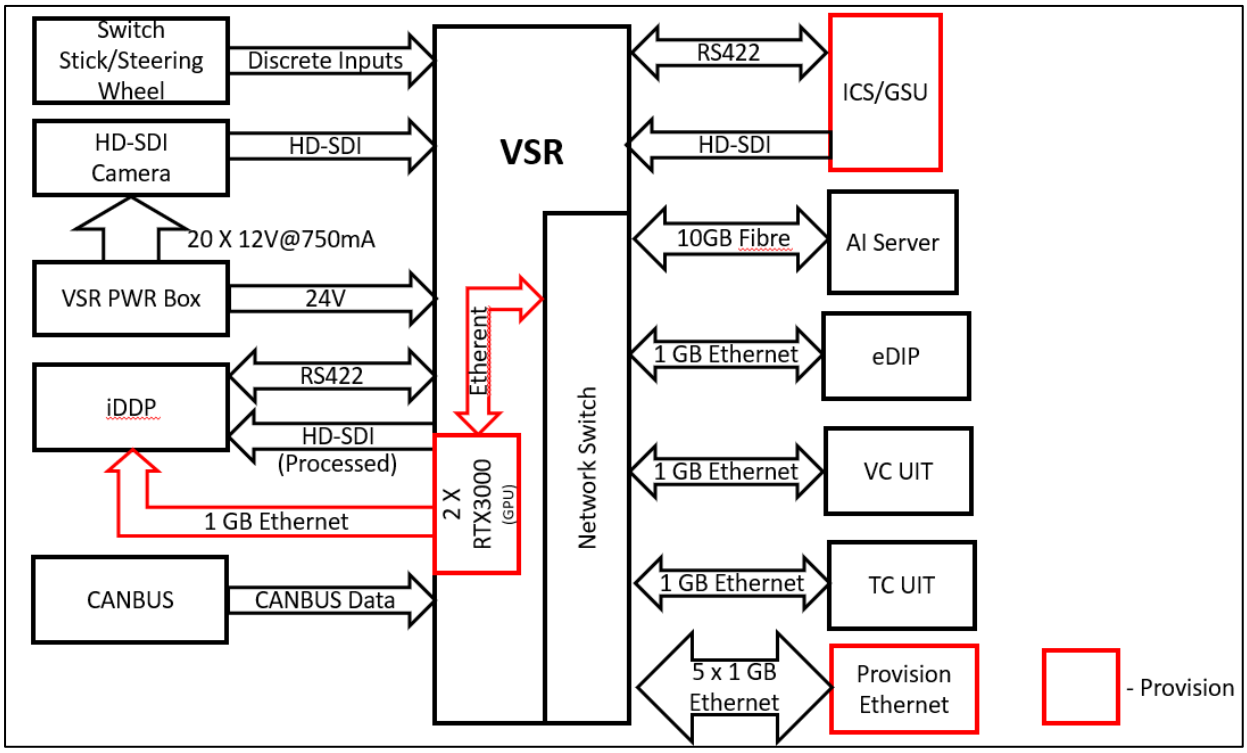


Figure 1: VSR System Overall Interface to External Devices

3.2 Description of Operation of Each Block/ Sub-System

4 SYSTEM DESCRIPTION

4.1 VIDEO SERVER (VSR)

a) 20 x channel HD-SDI receiver
b) 3 x HD-SDI ultra-low video latency output with multiplexer to the DDP.
c) Inbuild network switch consist of
   1. 1 x 10Gb Fibre Port
   2. 8 x 1Gb Ports each with independent selectable video matrix configuration
d) 4x RS422 control ports
e) 8x Discrete Input, 4x Discrete output. (24V/0V)
f) 2 x CANBUS
g) Video deinterlacer and scaler.
h) Emergency mode for the HD-SDI DDP output to bypass internal video processing of HD-SDI inputs from VCU.

i) Video image processing
- Software Image stitching
- Dynamic OSD and side OSD

– Overlay of CANBUS information, vehicle icon and Vehicle guideline.

Provision

j) **Stereo Vision** - To enable Depth Perception ability.
k) **Night Vision enhancement -** To enhance visual experience during night operation without Thermal Imaging (TI) camera.
l) **External System video feed -** equipped driver with the ability to react faster and in an effective approach.
m) **Drive By Wire –** Enable VC with the ability to take over basic driving functions using the UIT as driving display **(Degraded driving mode with higher video latency)**.
n) **Obstacle detection –** Enable objective identification (Human, vehicle, object)

4.2 INTELLIGENT DRIVER DISPLAY PANEL (IDDP)

a) 3 x 10.2” 1920 x 1080P LCD panel.
b) Video Latency: < 40 ms
c) 1 x RS422 to communicate with VSR.
d) 1 x Ethernet for redundancy.
e) 3 x HD-SDI input to accept video feed from driving cameras via VSR.
f) Display vehicle data, vehicle icons, dynamic OSD and side OSD.
g) **(+) and (-) Buttons :** for brightness adjustment
h) **POWER Button:** Toggle between power ON and Standby mode
i) **OSD Button:** ON/OFF OSD
j) **NUC Button:** To Manually trigger TI NUC (TI Image calibration)
k) **TI Button:** to toggle between Front TI and Front Day Cameras
l) **Front Button:** Scroll through the Front Views when in Drive or Neutral gear.
m) **FRONT (Press and Hold)** : Temporary switch to Default front view in Reverse gear
n) **Rear Button:** Scroll through Rear view and Ramp view in Neutral and Reverse gear
o) **REAR (Press and Hold)** : Temporary switch to Rear view when in Drive gear.

4.3 CAMERAS

a) **3-in-1 Camera** – Houses 3 x IMX429 camera sensor with water, air and purging nozzles. Camera resolution at 1920 x 1080P, each sensor with FOV of 70(H) x 40(V).
b) **2-in-1 Camera** – Houses 2 x IMX429 camera sensor with water, air and purging nozzles. Camera resolution at 1920 x 1080P, each sensor with 2 different FOV of 70(H) x 40(V) and 90(H) x 50(V).
c) **Single Day Camera** – Houses 1 x IMX429 camera sensor with water, air and purging nozzles. Camera resolution at 1920 x 1080P, FOV of 90(H) x 50(V).

4.4 List of Operational Modes

The Vision System shall have 3 primary Operation Modes:

1) Close Hatch Driving (CHD)
    a. Land Mode
    b. Swim Mode
2) All Round Surveillance System (ARSS)
3) Driver Assist System (DAS) (Optional)

4.5 Description of Individual Operational Modes

4.5.1 Close Hatch Driving (CHD) Operational Modes

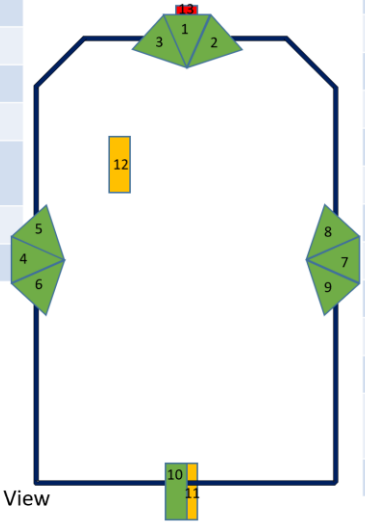
In CHD operation mode, the VSR shall provide driver the selection of 3 x real-time video images from cameras to the intelligent Driver Display Panel (iDDP) with minimal video latency introduced, it shall also overlay OSD and related vehicle status onto the video feed, operator shall be able to select desired views from either Video switch stick at the steering column or iDDP buttons.

Camera Placement

Views	Cam ID
Front View 1(Default for Drive & Neutral Gear)	5, 1, 8
Front View 2	3, 1, 2
Front View 3 (TI)	5, 13, 8
Front View 4 (TI)	3, 13, 2
Rear View (Default for Reverse Gear)	6, 10, 9**
Ramp View	6, 11, 9 **

- HD-SDI Day (70(H) x 40(V))
- HD-SDI Day (90(H) x 50(V))
- HD-SDI TI (70(H) x 42(V))

** - Mirrored View



Cam ID	Cam Position	Abbreviation
1	Front Center	FC
2	Front Right	FR
3	Front Left	FL
4	Left Center	LC
5	Left Side Front	LSF
6	Left Side Rear	LSR**
7	Right Center	RC**
8	Right Side Front	RSF
9	Right Side Rear	RSR**
10	Rear Far	RF**
11	Rear Near	RN**
12	Swim/Driver Cam	DC
13	Front TI Cam	FIC

Figure 2: CAMERA PLACEMENT

a) Land Mode

View	Description	Cam ID
Front View 1	Front Side view	5,1, 8
Front View 2	Front 3 in 1 view	3, 1, 2
Rear View	Rear Side View	6, 10, 9
Ramp View	Ramp view	6, 11, 9

b) Swim Mode

View	Description	Cam ID
Front View	Front Side trim vane view	5,12, 8
Rear View	Rear Side View	6, 10, 9

View	Description	Cam ID
Rear View	Rear side view	6,10, 9

Video Switch stick shall provide discrete signals and iDDP will provide RS422 signals to the VSR, VSR shall feedback the corresponded views required.

The VSR shall output any one of the following display modes to the iDDP:

Actions	Land Mode		
	Drive	**Neutral**	**Reverse**
Default View	**5, 1, 8**	**5, 1, 8**	**6, 10, 9****
Toggle Front	3, 1, 2	3, 1, 2	5, 1, 8
Toggle Front again	5, 1, 8	5, 1, 8	3, 1, 2
Toggle Rear	6, 10,9**	6, 10,9**	6, 11, 9**
Toggle Rear again	6, 11, 9**	6, 11, 9**	6, 10, 9**
Toggle TI	5, 13, 8	5, 13, 8	5, 13, 8
Toggle TI again	Previous Front View	Previous Front View	3, 13, 2

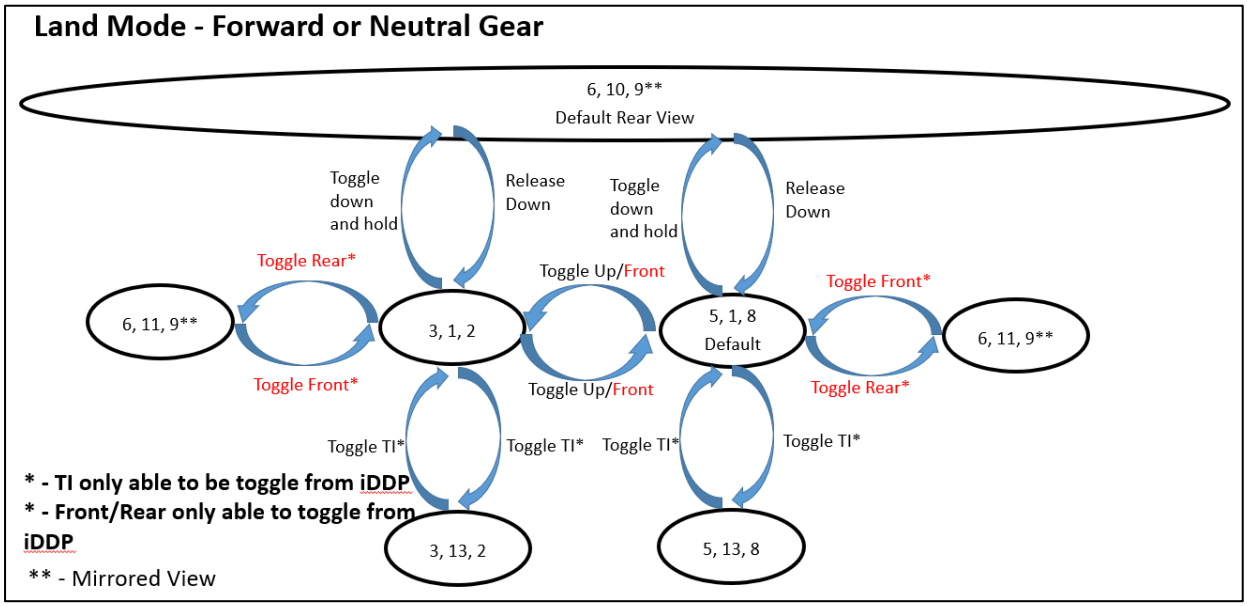
iDDP – Toggling Mode

4.5.2 Selection of Video Display Mode

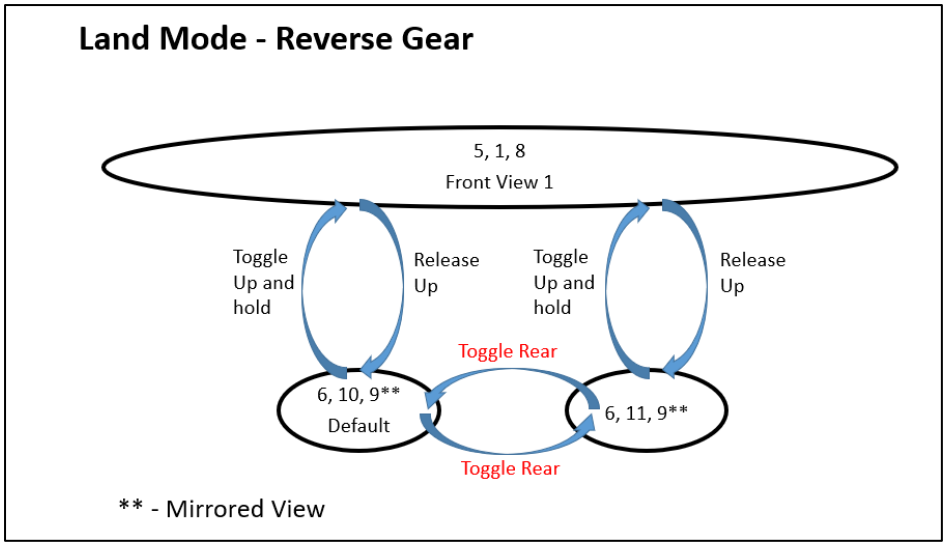
The output display modes can be selected using the steering wheel buttons/ switch Box(TBD) . The control signals are via discrete I/O. **There shall be a Land Mode/Swim Mode CANBUS data for VSR to read from.**

a) Land Mode

Inputs	Forward/ Neutral Gear
Gear Signal	Gear Forward Signal = 0
Toggle Up	Toggle between front view 1 and front view 2
Toggle down and hold	Toggle to rear view
Release down button	Toggle back to previous view
Rear	Toggle between ramp view and Rear view

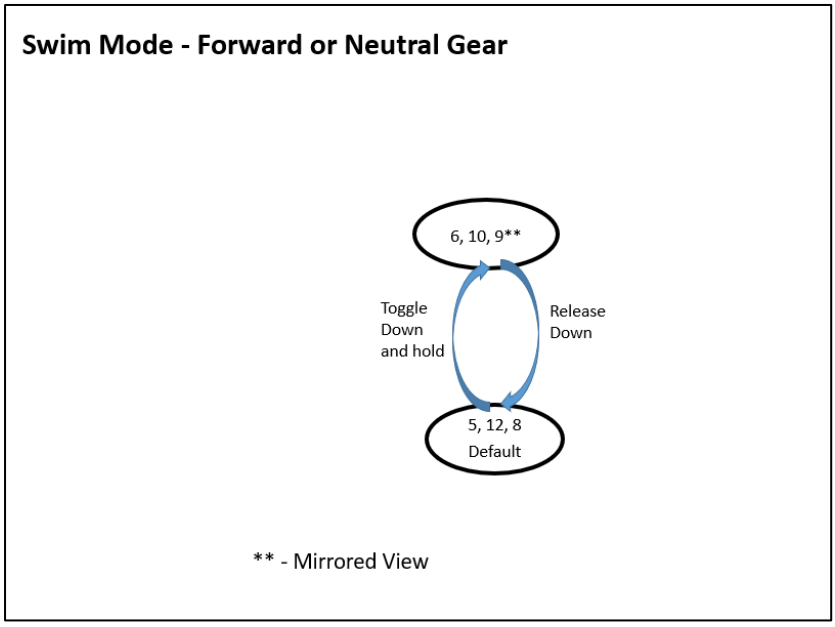


Inputs	Reverse Gear
Gear Signal	Gear Reverse Signal = 1
Toggle down	Stay at rear view
Toggle up and hold	Toggle front view 1
Release up button	Toggle back to rear view
Rear Button	Toggle between ramp view and Rear view



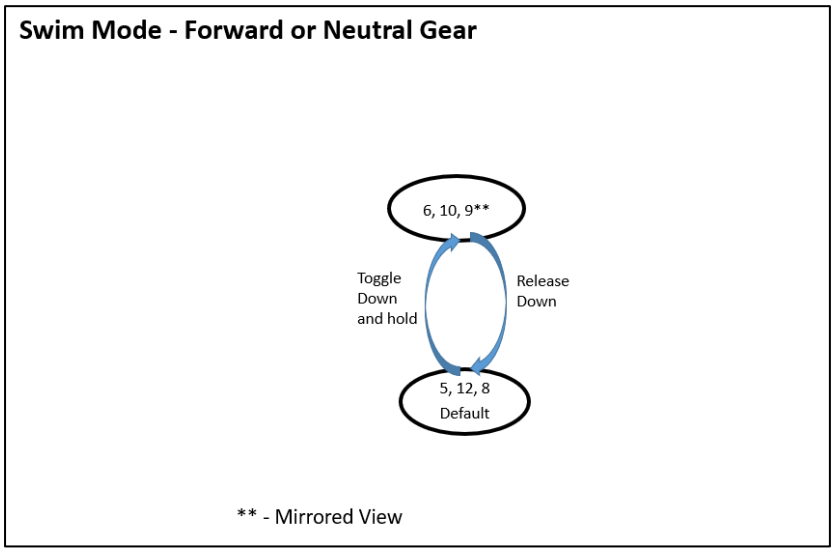
b) Swim Mode

Inputs	Forward/ Neutral Gear
Gear Signal	Gear Forward Signal = 0
Toggle Up	Stay at Front View 1
Toggle down and hold	Toggle to rear view
Release down button	Toggle back to previous view



Inputs	Reverse Gear
Gear Signal	Gear Reverse Signal = 1

Toggle down	Stay at rear view
Toggle up and hold	Toggle front view 1
Release up button	Toggle back to rear view



4.5.3 iDDP vehicle Information Display

The intelligent Driver Display Panel (iDDP) shall display information such as live video images captured from various cameras on the vehicle via VSR as well as vehicle information such as vehicle speed and engine revolution speed etc via CANBUS. iDDP shall flash various CANBUS icons when required.

Figure 3: iDDP UI INTERFACE

4.5.4 All Round Surveillance System (ARSS)

The VSR shall be able to scale down 1920 x 1080 to 1024x768 and feed the real time video to all the UITs via H.264.

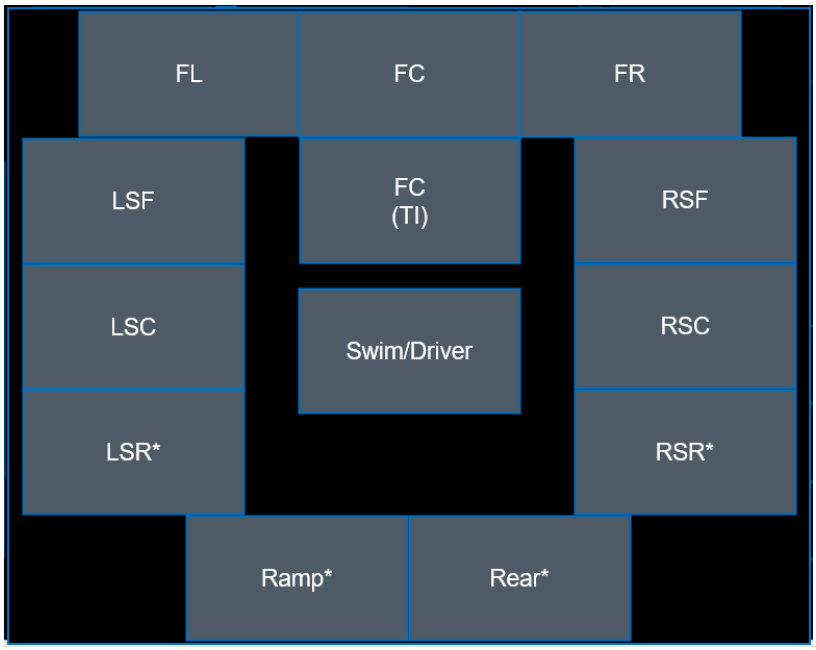
There shall be various configurations for the video image position and placement. Each configuration will be a preset which is selectable via the UIT Control. Each UIT can independently select which presets to be displayed on the screen. Each UIT shall be able to select desired zoom in view(Enlarged View).

VSR shall have the capabilities to broadcast up to 20 video windows via RTP streams using 1Gbps and 10 Gbps port. User shall be able to configure the RTP stream parameters on 10 Gpbs.

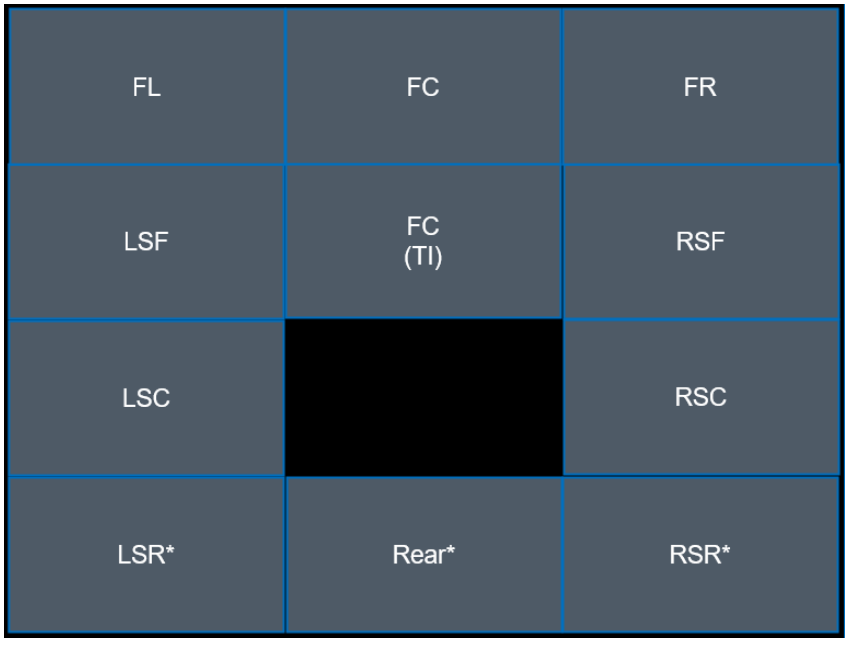
STELS shall be able to have control over the ARSS Layout creation, updating of the driving OSDs, rotating, flipping of each individual image. VSR shall transmit health and BIT status periodically for STELS to read from over the 1Gbps network port.

The ARSS layout shall allow up to 15 video windows to form up 1 layout regardless of the video source, and there shall not have any video latency between video windows within the same layout.

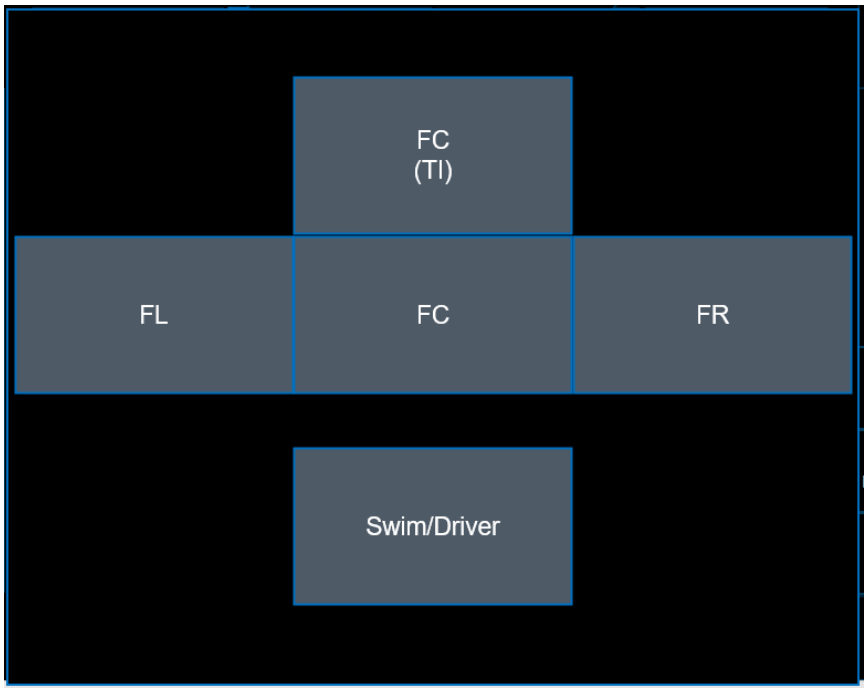
a) All Round Cam



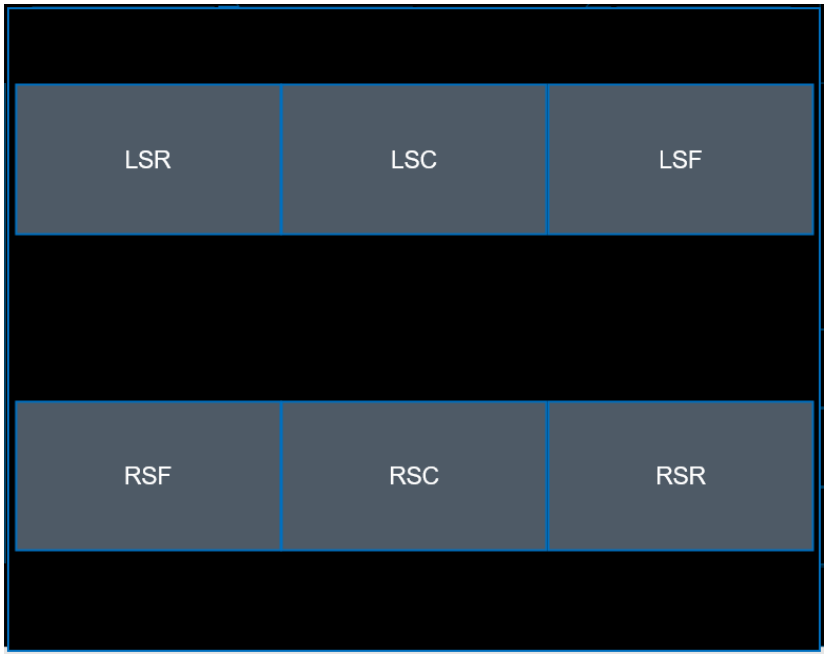
b) Surround Cam



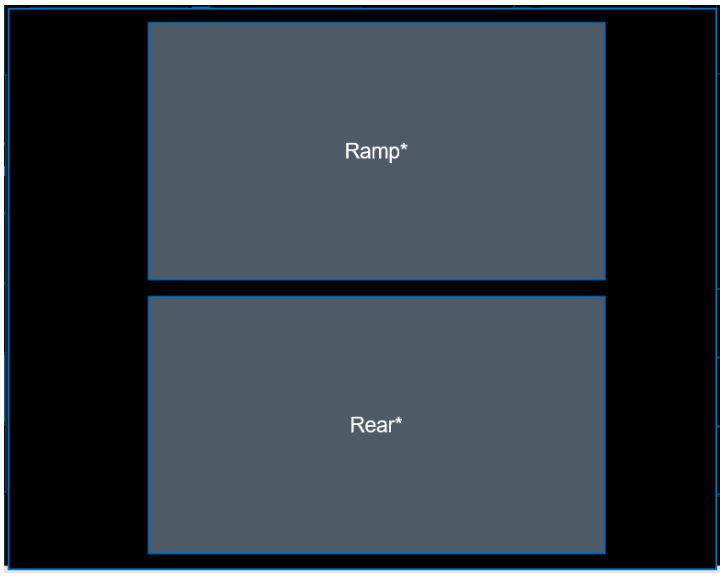
c) Front Cam



d) Side Cam

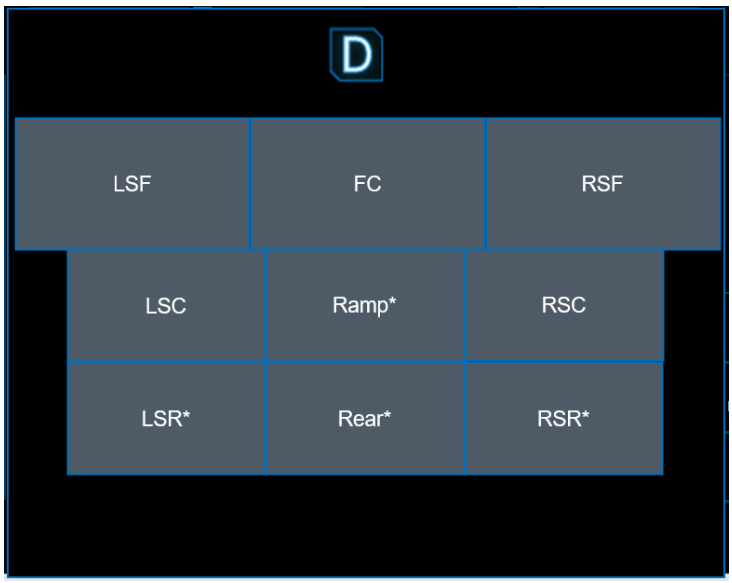


e) Rear Cam

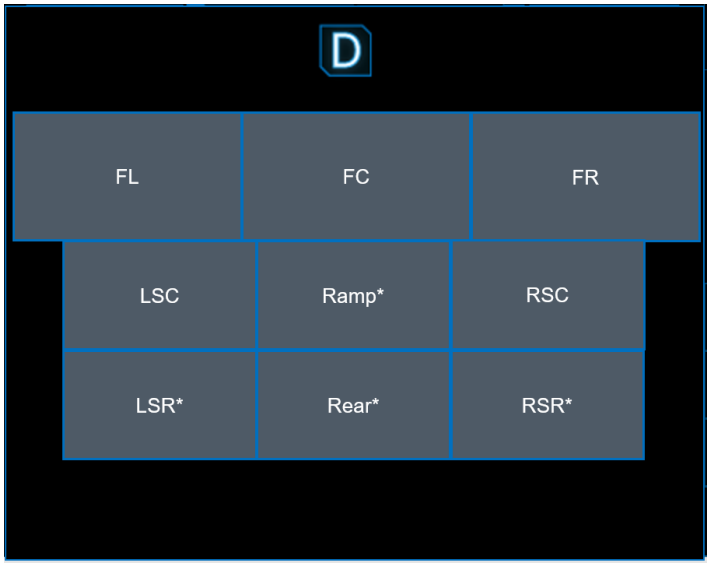


f) Driving Cam

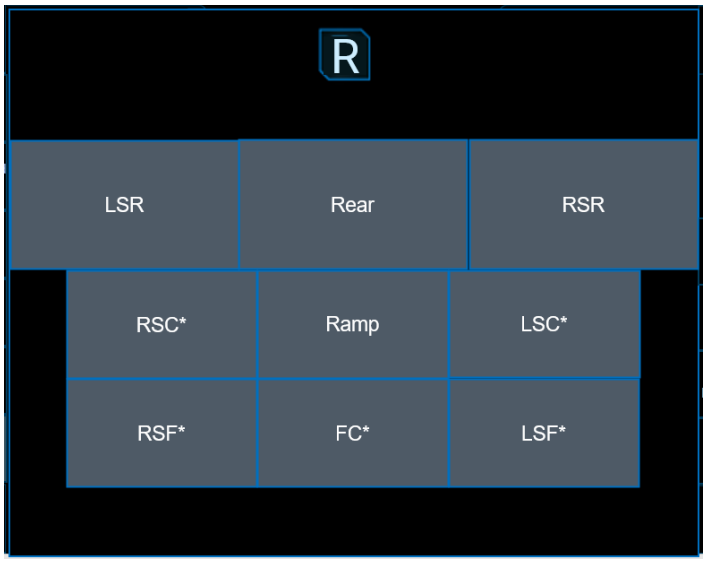
Front Driving Cam 1



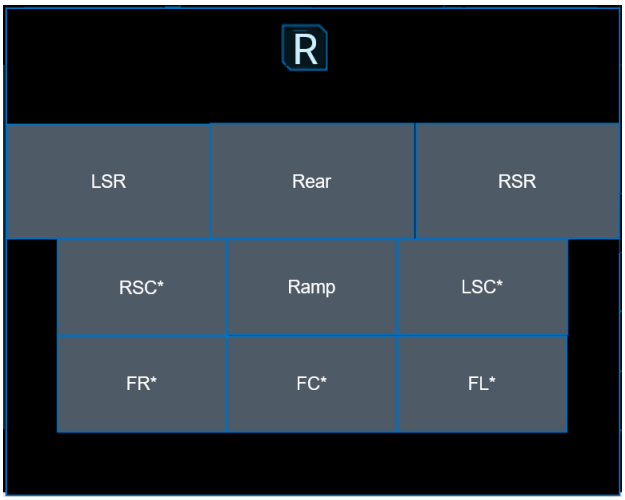
Front Driving Cam 2



Rear Driving Cam 1



Rear Driving Cam 2



4.5.5 Driver Assist System (Provision)

DAS shall consist of various systems to assist driver during driving operation. DAS aid to reduce human error by offering technologies that alerts the driver/operators to dangers/Hazards. Following is the key system required to achieve this:

a) **Stereo Vision** - To enable Depth Perception ability.
b) **Night Vision enhancement -** To enhance visual experience during night operation without Thermal Image (TI) camera.
c) **External System video feed -** equipped driver with the ability to react faster and in an effective approach.
d) **Drive By Wire –** Enable VC with the ability to take over basic driving functions using UIT as driving display. **(Degraded driving mode with higher video latency)**.
e) **Obstacle detection –** Enable objective identification (Human, vehicle, object)

5 REQUIREMENTS

5.1 REQUIRED STATES AND MODES

SSS ID	Description	Remarks
SSS-VIS-MOD-VSR-0001	External LED light to indicate the operating states • Green: Unit is operating normally • Red: Unit is faulty	

SSS ID	Description	Remarks
SSS-VIS-MOD-DDP-0001	Default Power ON mode when power is supplied to DDP	
SSS-VIS-MOD-CAM-0001	Default Power ON mode when power is supplied to camera	
SSS-VIS-MOD-IRL-0001	Default Power OFF mode when power is supplied to vehicle	

5.2 SYSTEM CAPABILITY REQUIREMENTS

SSS ID	Description	Remarks
SSS-VIS-CAP-VSR-0001	Able to encode HD-SDI	
SSS-VIS-CAP-VSR-0002	Able to received HD-SDI	
SSS-VIS-CAP-VSR-0003	Output 1920 x 1080p @30fps for H.264	
SSS-VIS-CAP-VSR-0004	< 50ms video latency for HD-SDI DDP path	
SSS-VIS-CAP-VSR-0005	Able to stitch muitple videos together and output as a single frame.	
SSS-VIS-CAP-VSR-0006	< 100ms video latency for H.264 outputs	
SSS-VIS-CAP-VSR-0007	Able to fused 2 video images together.	
SSS-VIS-CAP-VSR-0008	Able to do heat detection and cut off VCU if it exceed specification.	
SSS-VIS-CAP-VSR-0009	Able to provide health status (BITS) via network	
SSS-VIS-CAP-VSR-0010	<30 secs start up time	
SSS-VIS-CAP-VSR-0011	Able to provide timestamp and relevant video telemetries (frame's area of interest, FOV and position) shall be embedded into the digital video in accordance to Motion Imagery Standards Board (MISB) 0605.6 standard for uncompressed video to enable subsequent processing and/or exploitation of the video frames.	
SSS-VIS-CAP-VSR-0013	Able to decode CANBUS messages	
SSS-VIS-CAP-VSR-0014	Able to decode stereo vision data and display it onto DDP	
SSS-VIS-CAP-VSR-0015	Able to support Night Vision Enhanments	
SSS-VIS-CAP-VSR-0016	Able to support external system wireless video feed, processed and display it onto UITs	
SSS-VIS-CAP-VSR-0017	Able to support Drive-by-wired	
SSS-VIS-CAP-VSR-0018	Able to support Obstacle detection	
SSS-VIS-CAP-VSR-0019	Able to scale HD-SDI(1920 x1080p) output to 1024 x 768	
SSS-VIS-CAP-VSR-0020	Able to communciate with iDDP via RS422	
SSS-VIS-CAP-DDP-0001	Able to decode HD-SDI signal	
SSS-VIS-CAP-DDP-0002	Able to display HD-SDI (1920 x 1080p)	

SSS-VIS-CAP-DDP-0003	< 40ms frames video latency	
SSS-VIS-CAP-DDP-0004	Able to display vehicle information	
SSS-VIS-CAP-DDP-0005	"No signal" image to be displayed when video signal is lost	
SSS-VIS-CAP-DDP-0006	Able to communicate with VCU via RS422	
SSS-VIS-CAP-CAM-0001	Able to output HD-SDI (1920x1080p)	
SSS-VIS-CAP-CAM-0002	Shall be build with hardware trigger	
SSS-VIS-CAP-CAM-0003	Shall come with Low Prarasitic Light sensitity	
SSS-VIS-CAP-CAM-0004	Shall come with Gobal shutter	
SSS-VIS-CAP-CAM-0005	Video output latency shall be <1 frames	

5.3 NETWORK REQUIREMENTS

SSS ID	Description	Remarks
SSS-VSR-NER-001	VSR shall have the capabilities to broadcast up to 20 camera ports RTP streams using 1Gbps and 10 Gbps port	
SSS-VSR-NER-002	User shall be able to configure the RTP stream parameters on 10Gbps port: • Frame rate: 10, 20, 30 FPS • Payload format: H264, YUV422 • Broadcast flag: Enable, Disable The RTP stream parameter shall be configured via canbus/ethernet? Protocol TBD.	
SSS-VSR-NER-003	User shall be able to amend the following via 1Gbps network port: • Creation of Layout • Fliping, mirroring, rotating scaling of the individual video feed. • Broadcasting of system BIT & health status • Configuring of vehicle variant • Amending of OSD, dynamic OSD and the driving status icons (Online calibration method) • Broadcasting of serial number, and Software version	

	The individual 1 Gbps network port shall be able to broadcast the video feed to individual external device/display.	
SSS-VSR-NER-004	When H264 is selected, it shall be encoded with the following compression parameters: TBD	
SSS-VSR-NER-005	When YUV422 is selected, VSR shall immediately transfer the image to be packaged to RTP and broadcast out to ensure minimal latency	
SSS-VSR-NER-006	VSR shall maintain one global timestamp within its 4 internal CPUs. Upon startup, VSR shall use IEEE PTP1588 to sync with the master clock provided by Platform Server in the 1Gbps network. With the global timestamp, VSR shall embed timestamp according to all the broadcasted video feeds	
SSS-VSR-NER-007	All arriving video streams shall be timestamped and have a running sequence number embedded in the RTP header so that the consumer is able to synchronize the video feeds for processing	

5.4 SYSTEM EXTERNAL INTERFACE REQUIREMENTS

SSS ID	Description	Remarks
SSS-VIS-INT-VCU-0001	Shall have 20 x HD-SDI video inputs	
SSS-VIS-INT-VCU-0002	Shall have 3x ultra low latency HD-SDI video outputs	
SSS-VIS-INT-VCU-0003	Shall have 3 x ultra low latency HD-SDI video outputs	
SSS-VIS-INT-VCU-0004	Shall have a in-build network switch that consist of :2 x 10Gb and 8 x 1Gb	
SSS-VIS-INT-VCU-0005	Shall have 4 x RS422 ports	
SSS-VIS-INT-VCU-0006	Shall have 20 x 12V@1A dc power outputs	
SSS-VIS-INT-VCU-0007	Shall have 8x discrete Inuts and 4 x discrete output	
SSS-VIS-INT-VCU-0008	VCU shall have a grounding boss. There shall be no DC connection between the chassis and electronics within the unit. The DC resistance between the chassis and the earth boss shall be >1MΩ.	
SSS-VIS-INT-VCU-0009	Shall have an easy to operate system diagnostic and firmware update interface.	
SSS-VIS-INT-VCU-0010	Shall have 1 x Ethernet I/O interfaces for inbuild GPU	

SSS-VIS-INT-VCU-0011	Shall have 2 x CANBUS port	
SSS-VIS-INT-DDP-0001	Shall have 3x HD-SDI video inputs	
SSS-VIS-INT-DDP-0002	Shall have 1 x 1Gb ethernet port	
SSS-VIS-INT-DDP-0003	Shall have 8 x buttons	
SSS-VIS-INT-DDP-0004	DDP shall have a grounding boss. There shall be no DC connection between the chassis and electronics within the unit. The DC resistance between the chassis and the earth boss shall be >1MΩ.	
SSS-VIS-INT-DDP-0005	Shall have a system diagnostic and firmware update interface.	
SSS-VIS-INT-CAM-0001	Shall have AWG #12 coaxial contact for indvidual video feed	
SSS-VIS-INT-CAM-0002	Shall have 1 x hardware trigger contact	
SSS-VIS-INT-CAM-0003	Camera shall have a grounding boss. There shall be no DC connection between the chassis and electronics within the unit. The DC resistance between the chassis and the earth boss shall be >1MΩ.	
SSS-VIS-INT-IRL-0001	Shall have 24V DC power	
SSS-VIS-INT-IRL-0002	IR illuminator shall have a grounding boss. There shall be no DC connection between the chassis and electronics within the unit. The DC resistance between the chassis and the earth boss shall be >1MΩ.	

5.5 SAFTEY REQUIREMENTS

SSS ID	Description	Remarks
SSS-VIS-SAF-VCU-0001	Shall have a bypass circuit to route the camera HD-SDI signal directly to the DDP HD-SDI output when fault is detected in the Emergency mode.	
SSS-VIS-SAF-VCU-0002	No freeze images shall be output to DDP	
SSS-VIS-SAF-DDP-0001	No freeze images shall be displayed	

5.6 SECURITY AND PRIVACY REQUIREMENTS

SSS ID	Description	Remarks

5.7 SYSTEM AND ENVIRONMENTAL REQUIREMENTS

SSS ID	Description	Remarks

5.1 ENVIRONMENTAL AND ELECTRICAL REQUIREMENTS

SSS ID	Description	Remarks

5.2 COMPUTER HARDWARE REQUIREMENTS

SSS ID	Description	Remarks

5.3 COMPUTER SOFTWARE REQUIREMENTS

SSS ID	Description	Remarks

5.4 PACKAGING REQUIREMENTS

SSS ID	Description	Remarks

5.5 HUMAN INTERFACE REQUIREMENTS

SSS ID	Description	Remarks

6 APPENDIX