



FEDERATION INTERNATIONALE DE L'AUTOMOBILE



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# FIA REGIONAL RALLY TRACKING SYSTEM SPECIFICATIONS

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## Revision History

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<b>20-10-2021</b>	1.0	First published version
<b>06-12-2022</b>	1.1	Increased wireless 2.2.4 Communication Requirements: Required network stage coverage per event above 90% Coverage maps mandatory to be shared with the event organizer



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## 1. Introduction

### 1.1. Purpose

The purpose of this document is to provide a technical specification for car tracking and reconnaissance systems which are intended for use in the events of the following FIA Championships (together the "FIA Championships") according to the applicable Sporting Regulations:

- FIA Regional Rally Championships
- FIA European Historic Rally Championship

Overviews of a tracking system and a reconnaissance system are provided, along with specifications for components of both systems. This document is intended for use by technical personnel and assumes a reasonable level of technical skill and familiarity with both rally motor sport and data applications.

Note that there is no requirement that a single system must fulfil the purposes of both a tracking and a reconnaissance system, although this is not prohibited. It is expected that different systems would normally be used for those purposes.

### 1.2. Scope

This document provides an explanation of:

1. How rally tracking systems work through an overview and descriptions
2. How rally reconnaissance systems work through an overview and descriptions
3. What features rally tracking systems can offer
4. The specification of components of tracking systems required in FIA Championship events
5. The specification of components of reconnaissance systems required in FIA Championship events.

### 1.3. Definitions

- **MUST** This word, or the terms "REQUIRED" or "SHALL", means that the definition is an absolute requirement of the specification.
- **MUST NOT** This phrase, or the phrase "SHALL NOT", means that the definition is an absolute prohibition of the specification.
- **SHOULD** This word, or the adjective "RECOMMENDED", means that there may exist valid reasons in particular circumstances to ignore a particular item, but the full implications must be understood and carefully weighed before choosing a different course.
- **SHOULD NOT** This phrase, or the phrase "NOT RECOMMENDED", means that there may exist valid reasons in particular circumstances when the particular behaviour is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behaviour described with this label.
- **MAY** This word, or the adjective "OPTIONAL", means that an item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because the vendor feels that it enhances the product, while another vendor may omit the same item.

## 1.4. Acronyms & Abbreviations

Acronym	Definition
ASCII	American Standard Code for Information Interchange
COC	Clerk of the Course
CSV	Comma Separated Values
GLONASS	GLObal NAVigation Satellite System (Russian)
GNSS	Global Navigation Satellite System
GPS	Global Positioning System (American)
HDOP	Horizontal Dilution of Precision
IP	Ingress Protection
ISM	Industrial, Scientific & Medical
OSI	Open System Interconnection
PDOP	Position Dilution of Precision
RCS	Rally Control Software
RF	Radio Frequency
RTOS	Real Time Operating System
UHF	Ultra High Frequency (Radio)
VHF	Very High Frequency (Radio)

## 2. System Overview & Specifications

An overview of a rally tracking system, along with specifications, is provided below. The system has been separated into the in-vehicle components, the communication methods and the monitoring system.

### 2.1. In-Vehicle System

The in-vehicle system comprises sensors, computing, memory, inputs and outputs and communication components, together with cases, antennas and mounting fittings. A main box can house the electronic components, with power supplied from an internal battery and a 12v feed from the vehicle. In most systems, sensor and communication antennas will be fitted on the outside of the vehicle, with leads running along the inside of the rollcage to where the main system is located.

#### 2.1.1. Computation

Computation components include processors and memory (both volatile and non-volatile) in the main system. The role of the components is to process information from sensors and inputs, to control outputs (displays, lights, etc.) and to send/receive information over communication channels.

The firmware powering the tracking system should be as simple as possible for operation by the crew. Any enhanced safety features, e.g. on stage/on transport, should happen automatically without crew input. Any safety features which should normally, from the perspective of Race Control, be attributed to crew action (OK/SOS) must only ever be activated through manual input. In other words, the system must never activate an OK/SOS signal without input from the crew.



The firmware should follow safety-critical software engineering principles; component failure should be easy to diagnose and no combination of external inputs or error states should ever cause a firmware lockup/reboot.

The system must have a processor capable of processing all possible interrupts/logic without either loop exhaustion or RTOS scheduling issues (tasks not given enough time to run).

The system must have non-volatile storage capable of storing all the logged information for a rally. Table 2-1 shows the logging requirements. For some types of information logging is mandatory, while for others it depends on whether or not the tracking device contains that sensor.

**Table 2-1 Logging Requirements**

Item	CSV Header	Unit/Format	Requirement
<b>Date/Time</b>	DateTime	DD/MM/YYYY HH:MM:SS	Mandatory
<b>Latitude</b>	Latitude	Decimal degrees	Mandatory
<b>Longitude</b>	Longitude	Decimal degrees	Mandatory
<b>Velocity</b>	Velocity	Kph	Mandatory
<b>Bearing</b>	Bearing	Degrees	Mandatory
<b>X-axis acceleration</b>	XAccel	G-force	Mandatory
<b>Y-axis acceleration</b>	YAccel	G-force	Mandatory
<b>Z-axis acceleration</b>	ZAccel	G-force	Mandatory
<b>Altitude</b>	Altitude	Metres	If possible
<b>Internal Temperature</b>	TempInternal	Degrees Celsius	If internal temp sensor is fitted
<b>External Temperature</b>	TempExternal	Degrees Celsius	If external temp sensor is fitted
<b>Device Voltage</b>	VoltageDevice	Volts	Mandatory
<b>Rally Car Voltage</b>	VoltageSupply	Volts	Mandatory

For the purposes of clarity; the system may internally log the information in whatever format is most convenient, but when the data is retrieved it must be available in the above format. It may then be formatted differently for human readability purposes, i.e. GPS coordinates may be formatted as Degrees Minutes Seconds instead of Decimal Degrees, or velocity may be formatted as Miles per Hour.

The system must log all of the data every 1s while on stage or on road section. If on transport, and the vehicle is stopped, it may reduce the period to 1 minute.

The system must provide a quick and easy method of data retrieval, in the event of a stewards' inquiry or inquest. The data files may be split up into multiple files for ease of use. The splitting of files is left to the provider's discretion; however, the naming of the files should indicate their use, i.e. Stage1, 2021-08-02, etc. The filenames should not contain any characters reserved for popular file systems/operating systems (Windows/Mac OS/Linux).

The data retrieved must be able to be provided in CSV format, adhering to RFC 4180 (UK/USA CSV), with the following header line details, so as to not require a proprietary program for analysis.



The header line should be customised as per the information being logged; should optional sensors not be included on the system, then no record should be written in the header line. Fractional numbers may be used for all fields, including date/time, i.e. DD/MM/YYYY HH:MM:SS.FFF.

For example, a header line could read:

DateTime,Latitude,Longitude,Velocity,Bearing,XAccel,YAccel,ZAccel,Altitude,TempInternal,TempExternal,VoltageDevice,VoltageSupply

### 2.1.2. Sensors

Tracking systems are able to be equipped with many sensors. The most important sensor for a tracking application is GNSS (more frequently referred to as GPS). Modern GNSS modules have greater sensitivity and can receive signals from more satellites and more satellite constellations simultaneously, greatly increasing accuracy. An accelerometer is also an important sensor for rally tracking applications, as it enables the detection of accidents and is a way to indicate their severity; and as such one must be included with a tracking system.

The tracking system may be equipped with other sensors, some of which are listed in Table 2-2.

Table 2-2 Sensors

Sensor	Inclusion	Use Case
<b>GNSS</b>	Required	Global position, altitude, bearing, velocity
<b>Accelerometer</b>	Required	Change in acceleration/deceleration
<b>Gyroscope</b>	Optional	Angular (rotational) velocity
<b>Magnetometer</b>	Optional	Geo-magnetic field (compass bearing)
<b>Barometer</b>	Optional	Atmospheric pressure (altitude)
<b>Internal Thermometer</b>	Optional	Temperature inside the tracking device
<b>External Thermometer</b>	Optional	Temperature inside the rally car
<b>Battery Voltage</b>	Required	Tracking device battery voltage
<b>System Voltage</b>	Required	Rally car system voltage

### 2.1.3. GNSS

The GNSS module used must be of very good quality; it must be able to accurately position the vehicle despite the extremities of the environment – mountainous terrain, valleys, urban environments and forests. There are different technical requirements for the GNSS update rate for tracking and slow zones, to allow separate GNSS modules to be used for each function.

**Table 2-3 Tracking GNSS Requirements**

Metric	Requirement
Search channels	66
Track channels	20
Cold start time	40s
Hot start time	10s
Tracking sensitivity	-165 dBm
Navigation sensitivity	-165 dBm
Reacquisition sensitivity	-160 dBm
Update rate (Tracking)	1Hz
Update rate (Slow Zone)	10 Hz Single Constellation, 5Hz Multi Constellation
Horizontal position accuracy	3.0 m
Altitude accuracy	5.0 m

#### 2.1.4. Accelerometer

**Table 2-4 Accelerometer Requirements**

Metric	Requirement
Measurement range	±16 g
Sensitivity (calibrated)	1024 LSB/g
Output data rate	250 Hz
Zero-g offset	±40 mg

For logging purposes, the system should record the min/max g-force readings (using an 8ms rolling window) on each axis each second, and use this value in the log.

More details on accelerometer-triggered impact detection is provided in Section 2.4.2.

#### 2.1.5. Other Sensors Specifications

Other sensors may be used on the tracking system; however, as they are optional, no specific requirements are given. If a sensor is to be used, it should be of acceptable quality and suited to a rally vehicle environment, such that the information retrieved from it can be trusted and utilised by operators.

#### 2.1.6. Wireless Communications

Wireless communications enable a vehicle to transmit information to the outside world, and receive information into the vehicle from the outside world. As wireless communications are so integral to a rally tracking system, a detailed overview of the main types is provided in Section 2.2.

#### 2.1.7. Wired Communications

Wired communications enable the tracking system to communicate to other systems inside the vehicle or to peripheral systems. There is a variety of protocols, wires and methodologies available, each suiting a particular purpose.



The tracking system may receive information from the CAN bus about the state of internal vehicle sensors, or could use Ethernet or USB to enable downloading of log files.

#### 2.1.8. CAN Bus

If the system is connected to the CAN bus, it must not transmit any information on the CAN bus without FIA approval.

#### 2.1.9. Power

The tracking system must not have an on/off switch, i.e. the crew should not be able to disable the tracking system.

The tracking system must include an internal battery to enable operation in a critical situation. The battery must be capable of powering the tracking system independently for two hours. To enable the battery to stay charged, the system should draw power from the main vehicle system when possible, but must not draw more than 1000mA continuously.

At any time, the system may be in any one of the three states below:

##### 2.1.9.1. Powered On

In this state, the system is fully operational. The system must stay powered on until the battery is depleted or the conditions for another power state are met.

##### 2.1.9.2. Sleep Mode

In order to prevent draining of the battery; the system may switch to a sleep mode state if the following conditions are met for a continuous period of 10 minutes:

- The system is aware it is on a liaison section
- The GNSS reads no movement
- No button pressed

The system must re-enter the powered On state if movement is detected or any button is pressed.

##### 2.1.9.3. Powered Off

The system may power down if, in addition to the sleep conditions above, the following conditions are met for a continuous period of 15 minutes:

- No external power is being supplied to the system
- The system is aware it is on a liaison section
- The GNSS reads no movement
- No button pressed

The system must power back up as soon as external power is supplied to the system.

#### 2.1.10. Input

User input to the system may take the form of buttons, switches or touch panels.



The emergency functions of the system must be accessible to both driver and co-driver without unbuckling their seat belts.

The manual SOS function must require a confirmation action to prevent accidental activation, e.g. multiple presses of a button, or a toggle switch with cover.

#### **2.1.11. Output**

Output of the system may take the form of audible warnings, lights or displays.

If audible warnings are used, they must be used in conjunction with a visual warning.

When visual warnings are used, they must be visible to both the driver and co-driver.

#### **2.1.12. Enclosure**

The enclosure of the system provides a hard shell to protect the internal components. There may be one or more enclosures depending on the system design.

The enclosure or enclosures must be at least IP55 rated.

#### **2.1.13. Mounting**

The mounting system ensures a firm and solid connection between the vehicle and the enclosure. Vibration dampening systems may be used.

Mountings must be robust enough to ensure that the enclosure does not come loose in the event of an accident, taking into account the extreme environment of a rally (impacts, vibration etc).

Mountings must be easy to fit quickly and accurately to the vehicle.

#### **2.1.14. Antennas**

The antennas provide the sensors/communication systems' connection to the outside world. Their size and placement depend on the individual system. Multiple antennas may, if their provider specifications allow for it, be placed in the same enclosure.

If antennas are to be placed outside the vehicle, they must pass through a hole drilled in the bodyshell. To prevent the cables from being crushed, they must not travel on the outside of the vehicle or through a window, a door, the boot or the bonnet.

Antenna cables must travel alongside the interior of the rollcage wherever possible, but never between the rollcage and the bodyshell.

The length of the antenna cable and the material used must not create signal loss greater than the provider's specification for the modem/module connected.



### 2.1.15. Environment

The system must be designed using componentry and design principles suitable for the rally environment in which it will be used. In particular, temperature tolerances must be taken into account for the rallies where the system will be used.

All components should have a temperature tolerance of -40/60 °C.

All components must be able to withstand the vibration of a rally environment.

## 2.2. Wireless Communication

The main role of wireless communications is to transmit the information about the rally vehicle to the outside world, or to receive signals from the outside world. In addition, wireless communications may be used to communicate between vehicles (collision avoidance, backup communication path, etc.), or between the tracking system and a peripheral (timing system, mobile phone, etc.).

Most wireless communications systems use the RF portion of the electromagnetic spectrum to transfer information between a transmitter and a receiver. The three most common options for rally tracking are explained below.

RF spectrum allocation is decided by the appropriate regulatory body worldwide (usually one per country). The spectrum is allocated in blocks for specific purposes (cellular, WiFi, military use, etc.), and as each authority sets their own rules, there is not a lot of commonality between them, apart from very widespread technologies such as WiFi. Most authorities allocate parts of the spectrum for licence-free data radio use, including ISM bands, RADIOLOCATION, etc. Using frequencies outside of the licence-free allocations requires the purchase from the relevant body of a licence for a particular frequency/location/time.

In addition to this, some regulatory bodies have banned the use of particular frequencies in their area, blocking the use of some technologies (e.g. Iridium satellite phones/modems cannot be used in India).

### 2.2.1. Cellular

Cellular networks across the world have expanded a lot over the last decade, enabling low-cost modems to be mounted on tracking devices. Cellular networks use fixed ground stations, to which modems connect using a variety of technologies (CDMA, GSM, GPRS, LTE, etc.) on a variety of frequencies.

The upside of cellular technology is that it is cost-effective, has very high throughput (compared to other options), is a well-understood, mature technology, coverage is continually expanding in most countries, and a network connection can be directly opened from the device to a server on the internet.

The main downside is that the coverage is limited by (close to) line-of-sight to fixed towers, and that as quite often rallies are held on roads away from populated areas, the stages do not have any coverage and, due to low population density in these areas, never will. The other main drawback is that cellular technologies and the networks they run on are public networks, and towers are only designed for a particular amount of traffic. This means they can easily be overloaded by large numbers of spectators, decreasing the tracking systems' reliability.

### 2.2.2. Data Radio

UHF/VHF data radios come in a variety of form factors, sizes, frequency ranges and operational constraints. They all enable one or more transmitters to send information to a remote receiver. They can be broadly broken up into two categories: those utilising licence-free frequencies, and those using licensed frequencies.

In all cases, the radio on a rally vehicle is communicating with a ground station (usually based in rally headquarters). Fixed, ground-based repeaters can form a network to cover the stages, or a radio repeater plane can be flown to get the information back to the ground station. This is necessary because similar to all RF systems, line-of-sight (or close to) is necessary to enable data transmission. Terrains and the curvatures of the Earth limit RF transmission to less than ten kilometres in most cases. The frequency chosen, transmit power, receiver sensitivity, obstacles, antenna heights and antenna design all greatly influence this figure.

Some rallies are already able to utilise a fixed set of ground-based radio repeaters for voice communications, and in many cases these can serve the dual purpose to carry the data radio traffic as well.

The overall benefits of data radios are that they can operate wherever a network can be set up, the networks are semi-private or completely private, they are fairly cheap (the only running costs are the radio licences), and the bandwidth can be reasonable.

The main drawback is that they require either an existing repeater network, or a repeater such as a plane in flight, to operate effectively over large distances. Also, the modems can be effectively locked to certain regions (licence-free bands), they can require quite a lot of expertise to design and operate, the modems themselves can be expensive (prices vary wildly), and they require a ground station to operate.

#### 2.2.2.1. Licence-Free Frequency Radios

Licence-free radios must be developed and configured for a particular region. Once configured, they can be used licence-free, although the licence-free bands are not private channels and so could potentially be disrupted by other users. In practice, as data radios are not a widely used technology, this is unlikely. The regulatory authority imposes strict specifications (transmit power, channel hopping, max transmit time, etc.) on the way radios use these portions of the spectrum, lowering overall bandwidth but making the bandwidth available to all users.

The benefits of these radios are that no licence is required to use them, and many radios can be used in the same area without significant slowdown. The drawbacks are that the lower transmission power lowers their effective range somewhat, compared to licensed radios, the frequencies of the licence-free bands are fixed and cannot be moved, and the licence-free bands are public and can potentially be shared with other users.

#### 2.2.2.2. Licensed Frequency Radios

Licensed frequency modems operate on frequencies which need to be licensed from the regulatory authority. They can operate at higher power and transmit for as long as they want, compared to licence-free radios. The operator also has more freedom to choose which frequency is used.

The benefits include greater transmission power (enabling longer range), potentially better curving around terrain, and the fact that the frequency is a private network. The drawbacks are that the licence must be purchased, and that in most cases the system must operate its own methodology to multiplex separate transmitters on a network efficiently so as to prevent multiple transmitters from trying to talk over one another.

### 2.2.3. Satellite

Satellite communications enable a transmitter on the ground to send information to a satellite orbiting the Earth. The information is then transmitted to a ground station, where it is forwarded to the operator. The physics involved means that satellite communications (depending on orbit) have a fixed latency, which is considerably larger than cellular or data radios.

Satellites are generally either fixed (compared to the ground) in a geostationary orbit, or they move in orbit around the Earth, in either low-earth orbit or medium-earth orbit. Like all RF communications, line-of-sight with the satellite is required. This can pose problems for geostationary systems, as mountains etc. can permanently block the signal to certain locations. The same problem affects moving orbital systems; however, as they move in their orbits, the line-of-sight will change fairly rapidly and line-of-sight will be re-established. Satellite communications can be extremely expensive compared to the other options here, but that cost has been declining over time as new satellites are launched with more modern technology.

The main benefit of satellite connectivity is the range; as they can be used over large areas of the Earth without the need for ground infrastructure.

The drawbacks are lower bandwidth compared to other options, the cost, and line-of-sight issues.

Satellite messages may drop non-critical information that would be transmitted over higher-bandwidth links; for instance, a vendor may choose to omit non-critical information such as vehicle system voltage or altitude, while keeping critical information such as latitude/longitude, velocity, etc.

### 2.2.4. Wireless Communication Requirements

The requirements for each communication method are listed in Table 2-5. Splitting the specification up by method acknowledges that different methods have different use-cases and cannot be specified equally. If multiple methods are used, they must satisfy their own requirements. All values in the table below are averages assuming good conditions.

**Table 2-5 Communication Requirements**

Metric	Cellular	Data Radio	Satellite
<b>Message latency (end to end)</b>	4s	4s	30s
<b>Time between transmissions – on stage</b>	15s	15s	60s
<b>Time between transmissions – on transport</b>	45s	45s	120s
<b>Inactivity warning time</b>	60s	60s	240s

A further amendment to the requirements for transmission is that when a device is in a low power state, pursuant to the requirements in section 2.1.9, it is not required to transmit continually.



Whichever communication methods are chosen, together they must be able to cover at least 90% of the stage areas. In addition to this, before the rally, a communications coverage report must be generated indicating areas of coverage and no coverage. These coverage maps must be generated using the same hardware as will be used during the rally and provided to the event organiser in a simple format. These coverage maps can then be used by the event organizer to mitigate black spots in coverage using more marshals equipped with radio for instance, and by Rally Control to more accurately understand situations – for example, if a vehicle disappears in a coverage black spot, Rally Control know they will not get any information from that vehicle, and must respond accordingly rather than waiting for the tracking system to start working of its own accord.

#### 2.2.5. Car-to-Car Communications

Wireless communications (especially data radios) may also be utilised to transmit information between rally vehicles. Data radios may be used to create on-the-fly mesh networks between vehicles. This can enable a whole host of features, including warnings of stopped cars ahead, overtake request/response systems, information relaying and reverse direction warnings. It is important that while wireless communications can extend existing safety protocols, they must not replace them.

One important application is the relaying of safety critical information. This allows vehicles without direct wireless communications with Rally Control to wirelessly transmit their information to any other vehicles within a short range. Another vehicle may have direct wireless communications and be able to transmit the information to Rally Control. This is especially useful when a car has rolled, damaging or inhibiting long-range antennas. This relaying of safety-critical information is mandatory if the specifications of the system design make it technically possible, i.e., if the system has a suitable short range data radio installed, it must relay safety critical alerts (SOS and detected accidents) to passing cars to relay back to Rally Control.

Whilst car to car communications are an important part of modern tracking systems, it should be noted that some systems and methodologies of transferring information between vehicles are under active patents, so care should be taken, when planning or implementing a system, that no patent or other intellectual property rights are infringed.

#### 2.2.6. Other Wireless Applications

Wireless communications may also be used to transmit information between the vehicle and some other system, e.g. the rally timing system, or a competitor's phone; however, the scope of these applications falls outside of this specification.

### 2.3. Monitoring System

The monitoring system comprises all those components which allow for remote viewing and control of the data generated by the rally tracking devices. In essence, it is every part of the tracking system which is not inside the vehicle.

#### 2.3.1. Messaging Gateways

The messages generated by tracking devices must be decoded and transformed into useful information to be displayed to users. This is achieved differently according to the requirements of the particular communication medium. Some mediums (cellular) are capable of carrying OSI Level 4





traffic (TCP/UDP etc.), enabling remote servers to be used as gateways, while other mediums require the presence of physical infrastructure at the point of reception (VHF/UHF data radios), and others convert proprietary protocols into more common ones for reception (satellite).

The gateway's role is to decode raw messages from the device; to log these message streams to durable storage (database) and update user interfaces with new information. For example, if a gateway receives a new tracking message from a device, it decodes the message (reading the device's unique identifier), finds a database entry relating to this device (finding it is vehicle 20 in a rally), and sends an update over the message streaming service, as well as saving the information to a database.

Messaging gateways should not add more than 500ms of latency to the end-to-end latency of a message; that is, they must take no longer than 500ms to process an individual message.

Messaging gateways must not be publicly accessible.

### 2.3.2. Database

Databases are used to save information and are available to all components of the server system. Incoming messages from tracking devices are logged here, as is all information pertinent to the running of the rally such as entry lists, course information or vehicle positions. Note that all information can be stored in a central database, or multiple databases can be used, as different database technologies lend themselves to different applications (unstructured logging, relational data, etc.).

The database must be secured using best practices to prevent any sensitive data such as g-forces, SOS/OK, or transport speeds from being accessed by the public.

The database must hold the rally entry list.

### 2.3.3. Rally Control Software

The RCS allows operators in Rally Control to interact with the tracking system. The software may be delivered as a web application or a desktop application. A web application is the simplest way to deploy the software to a lot of users, as only a web browser is necessary for operation, but a desktop application may also be used.

The system must be configured for each rally with, at the very minimum, an entry list linking tracking devices to cars, but may also be set up with course information, safety information, rally information, etc.

During the running of the rally the application provides race organisers with ways to view up-to-date information, including the positions and data of vehicles, and ways to issue commands to vehicles, e.g. red flags.

The application should have multiple levels of user access so that critical functionality such as red flags can be issued by the clerk of the course only, while advanced functionality such as the set-up of the system can be done by the appropriate user.

The RCS should be easy to use in all of its functions.

The functions of the RCS should be determined by a user's access level; view-only access should be granted to most users, while those users involved in the set-up or high-level operation of the system should have more access to sensitive functions.

The RCS must not allow any sensitive data, such as g-forces, SOS/OK or transport speeds, to be accessed by the public.

Further details on features are provided in Section 2.4.

#### 2.3.4. Web API

A web-based API provides the same data as is available through the web application but provides it in a machine-readable way. This allows other applications, such as mobile applications, to build views based off the same data.

If a web API is used, it must contain appropriate security mechanisms to prevent the leaking of data to the public.

If a web API is used, it must not allow functions of the system to be controlled without appropriate security access; the same access level restrictions which apply to the RCS must apply to the API, if those functions are implemented in both systems.

If a web API is used, it must not allow any sensitive data, such as g-forces, SOS/OK or transport speeds, to be accessed by the public.

#### 2.3.5. Mobile Applications

With the proliferation of mobile devices in everyday life, mobile applications are becoming more and more common in rally tracking applications. This allows event organisers in the field (stage commanders, marshals, technical delegates, etc.) to also have access to the latest information.

It can also be used for spectators to view a subset of the rally information.

Note that a dedicated mobile application might not be required if the main web application is suitably responsive/performing on mobile devices; however, the user experience may be degraded.

If a mobile application is used, it must not allow any sensitive data, such as g-forces, SOS/OK or transport speeds, to be accessed by the public.

#### 2.3.6. Message Streaming

Web applications and APIs are traditionally updated through a technique known as polling, where an individual client requests fresh information on a timed basis. As an example, each client only updates the position of vehicles on a map every 30 seconds. A message streaming technology or service can reduce this latency by constantly streaming fresh information directly to clients, instead of them waiting to request it.

Message streaming can be implemented directly by servers as a self-hosted technology (websockets, server-sent events), or a cloud-hosted service may be used (Pubnub, Azure SignalR, etc.).

If message streaming is used, the end-to-end latency must be no greater than 10s.

## 2.4. Features

Tracking systems may enable many different safety and management features. As these can cover multiple aspects of the system, they are listed here separately. This specification only covers those most critical to safety.

### 2.4.1. Tracking

The main function of the tracking system is to accurately locate each rally vehicle at all times. Whilst tracking information can be displayed in many ways, the most common is a top-down map view, with indicators on it for each vehicle, and other information highlighted (stages, regroup, remote refuels, alternative routes, etc.).

The RCS must contain a main display, consisting of a map (vector, satellite) and icons for each vehicle's position. Each icon must contain the vehicle's number. The system must differentiate between vehicles on stage and those on transport sections.

The colour of the vehicle's icon should be based on the vehicle state shown in Table 2-6.

**Table 2-6 Vehicle Icon Colours**

On Stage/Transport	State	Colour
Transport	Moving	White
Transport	Stopped	Grey
Stage	Moving	Black
Stage	Stopped, no button pressed	Yellow
Stage	OK	Green
Stage	SOS	Red

The map should include clearly marked polylines or similar to display the stage and transport routes.

The map should include clearly marked indicators for the stage starts, finishes and time controls. If a timed refresh is used to update the map, the timing interval must be 20s or less.

### 2.4.2. Accident Detection

One of the most critical functions of the tracking system is to report the state of the vehicle to Rally Control, so that event officials can make appropriate decisions on safety responses. To that end, the entire accident detection and reporting system should be designed to be clear, robust and reliable; all the way from the rally vehicle to the Rally Control interface.

In particular, the wireless communications between the vehicle and the outside world should be designed in a reliable way; the design should continually attempt transmission until it receives acknowledgement that the data has been successfully delivered to the destination.

Table 2-6 shows the states about a stopped vehicle with which the system needs to concern itself the most:

- Stopped, no button pressed
- Stopped, OK pressed
- Stopped, SOS pressed

For the purposes of clarity, the impact detection function of the system does not modify the above states, but is a separate piece of information.

If a vehicle has stopped on a competitive stage, and no buttons have yet been pressed, the information should be relayed to the RCS, and the vehicle icon should update accordingly as per Table 2-6. It is highly recommended that any supplementary information about the stop (vehicle orientation, max g-force) is transmitted at this time.

When the vehicle has stopped on a competitive stage, the system must allow the competitors to signal their state to Rally Control.

The competitor must be able to press an OK button, indicating to Rally Control that they do not need help. The system may allow the competitor to send more information to clarify the situation i.e. road blocked or road clear.

The competitor must be able to press an SOS button, indicating to Rally Control that they need help in the event of an emergency. The system may allow the competitor to send more information to clarify the situation i.e. fire or medical.

For clarity, there are two required safety states – OK & SOS, each with two recommended sub-states, as shown below:

- **OK**
  - OK – Road Blocked
  - OK – Road Clear
- **SOS**
  - SOS – Fire
  - SOS – Medical

The sub-state should only be able to be selected after the OK or SOS has been selected. The sub-state provides extra information to Rally Control about the nature of the incident and allows them to respond accordingly.

The SOS feature must include anti-mistake functionality; that is, a process must be required to activate the SOS which precludes accidental activation. Various methods can be used, either in hardware or software, such as a 'missile-style' toggle switch cover, a long press of a button, two presses of a button, etc.

When an SOS is received by the RCS, the user interface must immediately display a prominent visual indication, and should also provide an auditory indication. The map indicator for the vehicle must change to red to indicate the SOS in a clear manner.



If any other information has been received about the situation (fire, medical, blocked road, or g-forces), this information should be easily accessible.

If the system is fitted with an accelerometer and an impact is detected by the in-car system (defined below), the RCS must immediately display a prominent visual indication and should also provide an auditory indication. Any other information about the incident (g-force etc.) should be easily accessible. The visual/auditory indicators should not be able to be confused with an SOS from the crew.

For the purposes of impact detection, the system should perform a rolling average over 8ms of samples. An impact should be triggered when any axis reads over 15g for 5ms of consecutive samples.

In addition to the above, the RCS must display if no message has been received from a vehicle for the periods defined in Section 2.2.4, and the vehicle icon should update accordingly as per Table 2-6.

Additionally, between the flying finish and the stop point, all safety features should be active just as they are on a competitive stage; however, cars stopping normally at the stop point should not trigger any safety alerts.

#### 2.4.3. Red Flag

The Red Flag functionality is as critical as Accident Detection, and should be designed to be clear, robust and reliable, all the way from the Rally Control interface to the rally vehicle.

In particular, the wireless communications between the outside world and the vehicle should be designed in a reliable way; the design should continually attempt transmission until it receives acknowledgement that the data has been successfully delivered to the destination.

The red flag feature allows the COC to activate the red flag on a selected stage up to a selected distance. Upon activation of a red flag, a command is sent to every vehicle currently on that stage up until the selected distance. Upon receipt of the red flag, the in-vehicle system activates lights/screens/sirens as appropriate. The competitor should be able to signal acknowledgement of the flag, through the press of a button or similar, to give Rally Control a complete picture of the safety situation on the stage.

A red flag must not be able to be sent by anyone other than the COC or an authorised representative.

Activation of the red flag must be through a simple interface, allowing the COC to activate the flag under strenuous circumstances with little effort and low likelihood of making a mistake.

A red flag must not be sent to any vehicles other than those on the selected stage who have travelled less than the selected distance.

Upon activation of the red flag, the main display must update to show the COC which cars have been sent the red flag.

The display should further update to show which vehicles have received the red flag, to allow the operators to know when it is being shown to the crew.

The RCS must make available logs of when a Red Flag was activated, the details of the flag (distance, stage, which user activated the flag), and when the flag was de-activated.

#### 2.4.4. Slow zone management

A slow zone is an area of the stage that the competitors must cover while driving below a set speed limit (normally 50 kph). The zone is defined by a 200 m warning board, an entry board and an exit board. The purpose of a slow zone is to allow event organisers to control the speed of cars through dangerous sections of the stage without physical barriers such as chicanes.

The system must be capable of automatically recognising when it is in a slow zone, and recording and transmitting information pertaining to that slow zone. A report must be able to be generated containing a list of infractions recorded in that zone. For accurate recording of data, a GNSS module with an update rate of at least 10Hz must be used, as specified in Section 2.1.3.

The system should not attempt to send the detailed 10Hz logs of information, as the amount of data collected will be relatively large (for rally wireless communications), but should collate the information on the fly and generate a small report at the end of the zone to transmit to rally HQ. The aim is to provide the slow zone report for each vehicle within minutes of passing the zone, rather than hours later.

A report must contain:

- Entry time (tenth of a second)
- Exit time (tenth of a second)
- Entry speed (tenth of kph)
- Exit speed (tenth of kph)
- Maximum speed (tenth of kph)
- Minimum speed (tenth of kph)
- Time overspeeding (tenths of a second)
- Min. number of satellites used in calculations by the GNSS receiver
- Max. PDOP or HDOP

In order to account for inaccuracies in both the technology involved and the placement of the physical boards, two buffers will be applied to the slow zones.

The first is that the system must only start recording slow zone data 20 m after the entry coordinate, and must stop recording data 20 m before the exit coordinate; that is, the electronic system considers the virtual slow zone to be 40 m shorter than its coordinates (and hence the physical zone).

The second is that the system should only increment the tenths of a second overspeeding when the speed is greater than the configured speed limit + 5%; that is, the speed limit of 50 kph becomes 52.5 kph, 100 kph becomes 105 kph.

If the system is capable of displaying speed (i.e. if it contains an LCD or similar display), the speed must be displayed to the crew. It should be prominent and not employ any smoothing or filtering of the raw data.



The detailed 10Hz logs should be able to be collected some time later if needed for a Stewards' inquiry, e.g. wirelessly when bandwidth is not an issue, or when a cable can be connected to the device in the service park.

One feature of speed management zones that is useful for event organisers is a variable speed limit, which the event organisers can choose. This allows for speed management at very low speeds through sensitive areas in reconnaissance or in transit, or for higher speed slow zones during a live stage.

#### 2.4.5. Bi-directional Messaging

An optional feature, messaging functionality can allow Rally Control to ask short, variable questions of the crew, and receive simple responses. Due to the limited input/output of most tracking systems, the responses should be limited to Yes/No, which can be achieved through the press of a button.

The text encoding scheme used for transmission and display in the vehicle must meet or exceed the standard ASCII character set; more advanced encoding schemes may be used at the provider's discretion. The message length must be 25 characters or more.

### 2.5. Other

#### 2.5.1. Regulation Compliance

The tracking system must be compliant with any and all applicable personal data protection laws and regulations.

#### 2.5.2. User Guide Production

The provider must create a user guide intended for:

- Team mechanics (mounting, correct connection and installation)
- Competitor crews (explanation of user interface and functionalities)
- Rally Control people (explanation of user interface and functionalities)

#### 2.5.3. Amendments

The FIA reserves the right to make any change to the content of this technical specification, subject to publication and/or written notification, by whatever means it considers appropriate, to the providers and to any interested parties. Any change thus made will come into effect immediately on publication and/or notification as mentioned above.

## 3. Reconnaissance System Overview & Specifications

An overview of a rally reconnaissance system is given below, along with specifications of components. Unlike the main rally tracking system, the main aim of the reconnaissance system is only to provide organisers with a means to check competitors' compliance with the reconnaissance regulations – namely the amount of passes, direction of passes, and speed whilst on stage.

To satisfy the requirements of reconnaissance logging, a dedicated device – such as a GNSS logger – or a mobile phone application may be used. If a mobile phone application is to be used, diagnostic





information from the user's device should be collected to ensure that the GNSS sensor meets the requirements below.

The system has been separated into the in-vehicle system and the monitoring system.

### 3.1. In-Vehicle System

The in-vehicle system comprises a GNSS sensor, battery, computing and memory, together in a case, antennas and mounting fittings. Ideally, a single box houses all antennas and electronic components together, quickly fitted to the dash of a vehicle with high-strength Velcro or a similar fitting.

#### 3.1.1. Logging

The system must have non-volatile storage capable of storing all the logged information for reconnaissance – typically 2 or 3 days. Table 3-1 shows the logging requirements. It is mandatory to log all information.

**Table 3-1 Reconnaissance Logging Requirements**

Item	CSV Header	Unit/Format
<b>Date/Time</b>	DateTime	DD/MM/YYYY HH:MM:SS
<b>Latitude</b>	Latitude	Decimal degrees
<b>Longitude</b>	Longitude	Decimal degrees
<b>Velocity</b>	Velocity	Kph
<b>Bearing</b>	Bearing	Degrees

Note that the logging requirements and formatting are identical to the tracking system logging requirements, except that some fields have been omitted.

For the purposes of clarity; the system may internally log the information in whatever format is most convenient, but when the data is retrieved it must be available in the above format. It may then be formatted differently for human readability purposes, i.e. GPS coordinates may be formatted as Degrees Minutes Seconds instead of Decimal Degrees, or velocity may be formatted as Miles per Hour.

The system must log all of the data every 1s.

The data files may be split up into multiple files for ease of use. The splitting of files is left to the provider's discretion; however, the naming of the files should indicate their use, i.e. Stage1, 2021-08-02, etc. The filenames should not contain any characters reserved for popular file systems/operating systems (Windows/Mac OS/Linux).

The data retrieved must be able to be provided in CSV format, adhering to RFC 4180 (UK/USA CSV), with the following header line details, so as to not require a proprietary program for analysis.

Fractional numbers may be used for all fields, including date/time, i.e. DD/MM/YYYY HH:MM:SS.FFF.

The header line should be as follows:

DateTime,Latitude,Longitude,Velocity,Bearing





### 3.1.2. GNSS

The GNSS module used must be of very good quality; it must be able to accurately position the vehicle despite the extremities of the environment – mountainous terrain, valleys, urban environments and forests.

**Table 3-2 Reconnaissance GNSS Requirements**

Metric	Requirement
Search channels	66
Track channels	20
Cold start time	40s
Hot start time	10s
Tracking sensitivity	-165 dBm
Navigation sensitivity	-165 dBm
Reacquisition sensitivity	-160 dBm
Update rate	1Hz
Horizontal position accuracy	5.0 m
Altitude accuracy	10.0 m

### 3.1.3. Status Check

The in-vehicle system should provide a quick and easy way for an event marshal to check that the system is operating nominally. This could be as simple as a status LED, or some status text on a mobile application user interface.

### 3.1.4. Output to Competitors

There is no requirement to display any details which are being logged – especially speed – to competitors.

## 3.2. Monitoring System

The monitoring system for reconnaissance is any part of the system not inside the vehicle.

### 3.2.1. Infringement Report

The system must be capable of producing an infringement report for the Stewards/CoC. Reports may be split up by day. The reporting should summarise any infringements belonging to the three categories below:

#### 3.2.1.1. Overspeeding on stage

Each overspeed event should be listed, with detailed information as per the table below:

**Table 3-3 Overspeed Reporting Requirements**

Metric	Unit
Vehicle Number	String
Stage Name	String
Date/Time	DD/MM/YYYY HH:MM:SS
Maximum Speed	Kph
Time Over Speed	Seconds
Latitude	Decimal degrees
Longitude	Decimal degrees

For the time, latitude and longitude fields, the end of the overspeeding event should be given. Fractional units, such as kph in tenths, may be used.

### 3.2.1.2. Excess runs of stage

Any runs in excess of the reconnaissance rules – usually two runs per stage – should be listed, with detailed information as per the table below:

**Table 3-4 Excess Runs Reporting Requirements**

Metric	Unit
Vehicle Number	String
Stage Name	String
Number of runs	Integer
Date/Time of each run start	DD/MM/YYYY HH:MM:SS

### 3.2.1.3. Reverse runs of stage

Any runs of a stage completed in reverse direction to the rally route should be listed, with detailed information as per the table below:

**Table 3-4 Reverse Runs Reporting Requirements**

Metric	Unit
Vehicle Number	String
Stage Name	String
Date/Time of run start	DD/MM/YYYY HH:MM:SS

## 4. Roadmap for future implementations

These specifications will be revised on a yearly basis and incorporate changes to available technology. The table below gives an indication of planned additions to the specifications, in order to facilitate future system design. Items listed in this roadmap will become mandatory in the year indicated. This roadmap is not exhaustive and may be updated.

**Table 4-1 Roadmap for future implementations**

Item	2024	2025	2026
High Contrast Screen Display	X		
Speed display during Slow Zone passing	X		
Bi-Directional Messaging	X		
Advanced Car to Car communication		X	
High speed CAN communication ISO 11898-2	X		



## APPENDIX I

### 1. FIA Certification process

This document provides guidelines for interested parties wishing to apply for a Rally Car Tracking System certification by submitting a certification application dossier.

Any provider applying for such a certification agrees to comply with the corresponding FIA Rally Car Tracking Systems Specifications.

#### 1.1. Certification Application Dossier

In order to apply for FIA certification, the provider shall send an application dossier to the FIA at the following Email address: [rally.safety@fia.com](mailto:rally.safety@fia.com)

It is the responsibility of the provider to ensure that – and by applying for an FIA certification the provider represents and warrants that – its application does not infringe any third party intellectual property rights, including but not limited to patents and trademarks.

The FIA may request evidence of a licence to use a third party's trademark and/or trade name. If the FIA considers that such licence has not been validly obtained, it may at its sole discretion request that changes be made to the application or may refuse the application.

For reasons of clarity and to avoid confusion amongst consumers, the FIA reserves the right not to assign a certification for an FIA Rally Car Tracking System to an entity that is trading under a name that is confusingly similar or identical to the name of a different legal entity that already holds a certification for the same safety equipment.

#### 1.2. Certification Application Procedure

Upon receipt of the certification application dossier, the FIA will check the application to see whether it is correct, complete and meets the requirements for certification in accordance with the FIA Rally Car Tracking Systems Specifications. Only complete certification application dossiers will be taken into consideration and it is the responsibility of each provider to ensure that all relevant information and documentation is provided. The FIA Safety Department may request any further information it deems necessary. Providers shall respond to any such request in due course. The FIA reserves the right to refuse the certification if the product is deemed – at the sole discretion of the FIA – non-compliant with the FIA Rally Car Tracking Systems Specifications.

#### 1.3. Certification Assignment Procedure

When the FIA is satisfied that the request for certification can be granted, which remains at the sole discretion of the FIA, the FIA will inform the provider accordingly.

The FIA will also update the corresponding Technical List published on the FIA website to include the newly certified model of product at the next possible occasion. The Technical Lists are updated on the first and third Tuesday of each month.



The provider of a newly certified model of product may request that the FIA updates the Technical List on a different date, subject always to the FIA's availability to take on the request and to the provider's providing a reasonable period of advance notice for said request.

#### 1.4. Certification of a tracking system under new brand name

In order to request a change of the name of an already certified Rally Car Tracking System to a new brand name, the request shall be sent to the FIA.

#### 1.5. Provider Commitments

The provider commits to submit for certification a sample which is consistent with the mass-produced product.

The provider undertakes not to modify the design, materials, software, hardware and fundamental method of production of the product. If such modification is required by the provider, it shall apply for a new certification of the product.

If the provider becomes aware at any time of any non-compliance with the FIA Rally Car Tracking Systems Specifications to which the tracking system sample is certified, the provider shall inform the FIA of such non-compliance without delay.

#### 1.6. Post-Certification Controls Applied to the Products Certified by the FIA

The product's stability and conformity with the FIA Rally Car Tracking Systems Specifications may be checked within the framework of the FIA post-certification procedure set out in Chapter 2.

## 2. Post-certification controls applied to the products certified by the FIA

### 2.1. Provider's acceptance of post-certification controls

In applying for the certification of his product, the provider automatically undertakes to respect the present document and accepts all the control procedures that the FIA might undertake to guarantee the conformity of the certified products.

The post-certification control tests will be carried out in conformity with the conditions set out in the certification process above. The provider therefore undertakes not to contest any differences in the test conditions that may appear between the post-certification test and the initial certification test, insofar as these differences do not exceed the tolerances authorised by the FIA Rally Car Tracking Systems Specifications.

### 2.2. Provider's undertaking for the stability of his product

When applying for the certification, the provider undertakes not to modify the design, materials and fundamental method of production of the product. The only parts that may be modified without consulting the FIA are those explicitly specified in the FIA Rally Car Tracking Systems Specifications.

### 2.3. Organisation of post-certification controls carried out by the FIA: performance test

At its own discretion, the FIA may conduct one or other of the following tests:



**2.3.1.** A sample of the product will be taken by the FIA, or by any other FIA-appointed person, directly at the production site, at an event or via the distribution channels. In the case of a sample taken at the factory, the provider will be contacted beforehand.

**2.3.2.** Performance tests will be carried out in compliance with the FIA Rally Car Tracking Systems Specifications.

**2.3.3.** Following these tests, there are two possible outcomes:

- If the sample passes the test, the provider will be notified that a control has been carried out and that the sample complied with the FIA Rally Car Tracking Systems Specifications.
- If the sample is found not to comply with the FIA Rally Car Tracking Systems Specifications, the non-conformity of the product will be established on the sole grounds that the irregularity of this single sample has been noted. The provider will be notified of the non-conformity of his product by registered letter.

At the request of the provider by registered letter, sent to the FIA within the 20 days following the sending of the notification of non-conformity, the same sample may be re-tested by the FIA. In the case of a destructive test, a new sample will be taken in accordance with Article 2.3.1. The provider will be invited to attend the second test.

If this sample is again found not to comply with the FIA Rally Car Tracking Systems Specifications, the non-conformity of the product will be established on the sole grounds that the irregularity of this single sample has been noted.

If the sample is found to comply with the FIA Rally Car Tracking Systems Specifications, the conformity of the product will be re-established.

#### **2.4. Organisation of post-certification controls carried out by the FIA: comparison test**

**2.4.1.** A sample of the product will be taken by the FIA, or by any other FIA-appointed person, directly at the production site, at an event or via the distribution channels. In the case of a sample taken at the factory, the provider will be contacted beforehand.

**2.4.2.** Comparison tests will consist in a comparison between the sample and the product initially certified in order to check that the provider has respected his commitments as set out in Article 2.2.

**2.4.3** Following these tests, there are two possible outcomes:

- If the sample passes the test, the provider will be notified that a control has been carried out and that the sample complied.
- Should the provider fail to respect his commitments as set out in Article 2.2 and in particular if the sample proves not to be identical to the product initially certified with the FIA, the non-conformity of the product will be established on the sole grounds that the irregularity of this single sample has been noted, it being specified that no performance-related considerations may be put forward in defence. The provider will be notified of the non-conformity of his product by registered letter.



At the request of the provider by registered letter, sent to the FIA within the 20 days following the sending of the notification of non-conformity, the same sample may be re-tested by the FIA. In the case of a destructive test, a new sample will be taken in accordance with Article 2.4.1. The provider will be invited to attend the second test, together with a representative of his ASN.

If it is found that the provider has failed to respect his commitments as set out in Article 2.2, the non-conformity of the product will be established on the sole grounds that the irregularity of this single sample has been noted, it being specified that no performance-related considerations may be put forward in defence.

If it is found that the provider has respected his commitments as set out in Article 2.2, the conformity of the product will be re-established.

### 2.5. Cancellation of the certification

If the non-conformity of the sample is established in accordance with Article 2.3 or 2.4, the certification may be cancelled. However, the FIA will take into account the existence of special circumstances and may impose alternative sanctions which provide the same guarantees in terms of safety as the cancellation of the certification would have done.

The following procedure will be used for the cancellation of the certification:

- The provider will be notified of the cancellation of the FIA certification of the product.
- The provider will be responsible for implementing the FIA's decision at his own expense.

Once the decision to cancel the certification has been made, the certification of the product concerned will immediately be withdrawn. It will therefore no longer be accepted for events governed by the FIA regulations.

At the same time, the FIA will announce the sanction publicly.

### 2.6. Invoicing of the controls

If the non-conformity of the product is established, the FIA will invoice the provider for the full costs occasioned by these control tests. These shall include the costs of purchasing the product, the costs of the tests, and a fixed sum of 2500 CHF for the services of the FIA.

## 3. Amendments

The FIA reserves the right to make any change to the content of this appendix, subject to publication and/or written notification, by whatever means it considers appropriate, to the providers and to any interested parties. Any change thus made will come into effect immediately on publication and/or notification as mentioned above.

If any such amendment is made by the FIA, the provider shall apply for a new certification of the previously certified rally car tracking system.