"A big risk, but I don't believe you should just try to replicate what's already done"

Is the world ready for another driverless race series? The Abu Dhabi Autonomous Racing League believes so. By **Chris Pickering**

RIGHT A2RL will harness an automated version of Dallara's SF23

THERE'S a branch of motorsport that sits right at the cutting edge of automotive technology. It's arguably more relevant to current road car development than any other discipline in the sport. And yet few people even realise it exists.

That category is autonomous racing, and although it's largely been the preserve of technology companies and academic institutions so far, it is very much a reality. The Indy Autonomous Challenge (IAC), for instance, is now entering its fourth year, with modified Indy Lights cars passing each other at well over 150 mph and touching 180 mph down the straights. Elsewhere, the now-defunct Roborace series ran for two seasons between 2019 and 2021, with seven teams and 12 races in its final year.

Is the world ready for another driverless race series? The engineers and promoters behind the Abu Dhabi Autonomous Racing League (neatly abbreviated to A2RL) think so.

The series will use an automated version of the Dallara SF23. Originally designed for the Japanese Super Formula series, the SF23 is generally recognised as the fastest single-seater outside of Formula 1. Unlike the all-electric Roborace car, it retains a conventional combustion engine, developed by Indianapolis-based 4Piston Racing, along with a sequential transmission.

"One of the things we've learned from previous autonomous series was not to reinvent the wheel where we didn't have to do so," comments Dr Tom McCarthy, chief technology officer for A2RL's parent organisation, ASPIRE. "We're taking the driver out of the car, which is a huge step in itself. We didn't want to lose the noise – that gut-wrenching excitement when you hear the car coming down the straight. That's part of motorsport."

Creating an autonomous race series from scratch is a hugely ambitious target, but there's a sense of pragmatism here that bodes well for A2RL. McCarthy is also refreshingly upfront about its remit as a technology-led formula that's primarily designed to stimulate R&D and inspire the next generation of engineers.

"The idea came about when some of my colleagues in the artificial intelligence centre and the autonomous robotics centre at the Technology Innovation Institute were looking into ways to get involved in motorsport," he explains.

"A number of them have a very strong 'motorsport gene', having grown up in the universities along Italy's Motor Valley. The aim was to create a platform for real-time experiments, which would also involve the public by demonstrating the use of science in a sporting context. We wanted to get kids involved, but we also wanted to get the industry involved, so their use cases could be translated into race formats." ▶

> *"The mistake Formula E made was trying to be a sustainable version of Formula 1. We want to be a different type of sport"*

Hands-on experience

Alongside developing an autonomous variant of the SF23, the team at ASPIRE were keen to ensure that there was a complete infrastructure around the series. They're currently in talks with Yas Marina circuit, for instance, to ensure the communications infrastructure is adequate for the vast amount of telemetry data the series plans to transmit. This may require parts of the 5G network to be blocked off exclusively for A2RL or it could even see the installation of a dedicated wireless network. Parts supply, trackside support and logistics would also be handled centrally through the series, taking that burden away from the individual teams.

Careful consideration has also been paid to selecting the teams themselves, McCarthy explains: "We didn't want to say, 'Send us a white paper so we can establish your technical competency'. We spent six months building relationships with organisations where that capability would be a given.

He points to the IAC as an example: "They have lots of teams from very prestigious US universities without much hands-on motorsport experience, but it's the teams from the Technical University of Munich and the Polytechnic of Milan that have emerged as the ones to beat, both of which have a very strong motorsport heritage. Our takeaway from that was that it's not good enough just to have great computer scientists, you need to make sure that the teams have that broad range of capabilities if they're going to have a realistic chance."

It's perhaps no coincidence that the Politecnico di Milano and the Technical University of Munich are among the 10 international teams so far selected. Others vying for the $2.25 million prize include the University of Modena and Reggio Emilia, the Beijing Institute of Technology with Khalifa University, the University of California, Berkeley with the University of Hawaii, and Code19 Racing with Indiana University.

Adaptation

Adapting the SF23 has been a gradual process. One manually-driven prototype was followed by two autonomously-driven prototypes. The first priority was what McCarthy refers to as the perception layer, which is effectively the eyes and ears of the car. This combines GPS, LiDAR, radar

LEFT Teams will be issued with a software stack that delivers a basic level of functionality straight out of the box

BELOW ASPIRE's team launched the autonomous Super Formula SF23 in Abu Dhabi

and optical cameras providing a 360-degree view.

Italian firm Danisi Engineering worked with Aspire and Dallara on the development of the hardware stack. Another part of the Danisi group, Meccanica 42, provided help with the actuators and the drive-by-wire system.

"There are lots of simple things that you need to get right before you can think about actually controlling the car autonomously," McCarthy points out. "We looked very carefully at the design of the wiring loom. Likewise, the cooling requirements for the computer."

A number of other organisations involved in the Super Formula series have also contributed knowhow – notably Tokyo-based Team LeMans.

"It was a question of putting together a fairly large team of suppliers and getting them into very much a partnership," comments McCarthy. "I was in Italy when we did the physical checks last September and we had all our suppliers sitting around a table just looking at progress to date, and where we were going for the autumn shakedown. It's a big team and a diverse team, so getting them all onboard was a big deal."

Open source

In addition to the hardware, the cars will be presented to the teams with a software stack that provides them with a basic level of functionality straight out of the box. The teams will be able to ▶

choose whether they build upon this existing framework or substitute their own code right from the start.

Data collected from both the prototype cars – both autonomous and manually driven – will be shared with the teams on an open source basis to help train the AI algorithms. On top of the perception and motion control systems, the teams will have to handle strategic decisions, such as when to go for a passing manoeuvre.

Coders replace drivers

"In Formula 1, you have the race engineers and the strategists looking at monitors and screens, and feeding that information to the driver, who is controlling the car and perceiving their environment. Those elements combined optimise the overall performance. Here, those are effectively different layers of code," comments McCarthy.

The teams will be given the cars at the end of March. After that, they will have a six-week period for development and testing, during which time they will start to optimise the control of the car. Then, in the lead up to the first race on 28th April, there will be two full weeks of practice, with various challenges along the way. The simplest of these will be a single-car time trial, followed by two-car races, as seen in other autonomous competitions, but A2RL wants to push beyond that.

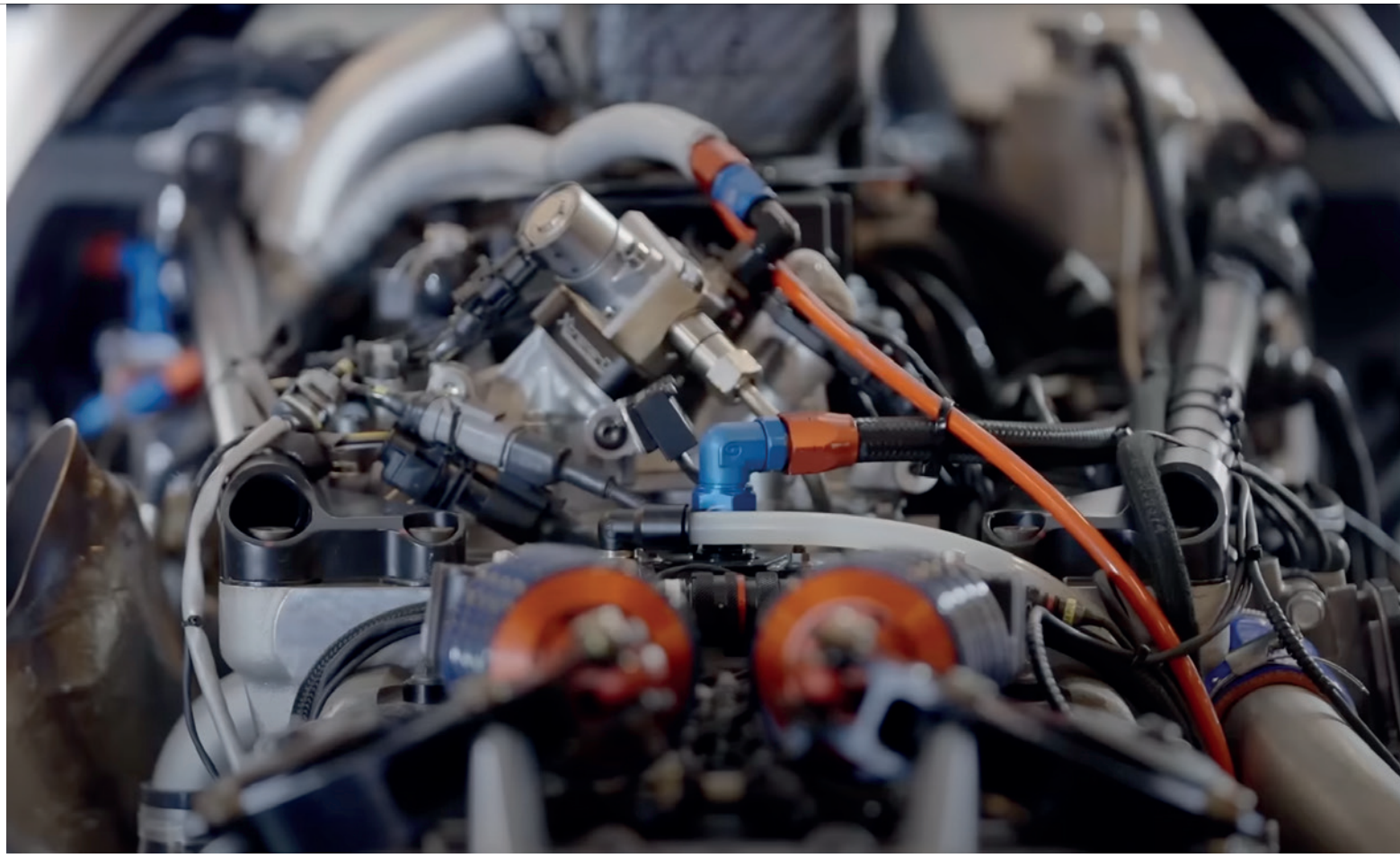
ABOVE With surveys suggesting that public confidence in autonomous technology is currently falling, A2RL hopes to raise awareness and appreciation of ADAS systems

"The current state of the art is to have two cars racing against each other," comments McCarthy. "We want to take that as a baseline and then go further – with [more than two] cars racing simultaneously, initially through simulation [starting in January] and then on the real-world track. Our objective is to have this happen in April. Okay. That's a big risk and a big ask, but I don't believe you should start out with just trying to replicate what's already done."

Wheel-to-wheel

The exact format for these races has yet to be finalised. While Roborace used car-to-car communication to request a pass once the pursuing car got close enough, and the IAC uses a pursuit format where the defending car laps at a fixed speed, ▶

BELOW The Indy Autonomous Challenge succeeded in raising the profile of autonomous racing



A2RL is contemplating a more aggressive approach.

"The ultimate goal is to have cars that can take their own decision on whether they can defend or whether they need to concede the place," says McCarthy. "It's the same judgement call that a human driver makes when they recognise that an opposing car has track position. We can't guarantee that it will always work,

> *"Humans are fallible. AI is also fallible, but it's fundamentally rational"*

any more than we can guarantee that a human driver will always respect the rules, but we'd like to get to the point where the sophistication of the perception system is enough for the car to make that call."

This taps into one of the greatest challenges with automated and partially-automated driving in road cars, which is reacting to unexpected circumstances. Simply navigating along a well-mapped route isn't generally a huge challenge – with racing, as with road driving, things get tricky when you start throwing other variables into the equation.

"We want to allow as much as possible of what you might get in a race between human drivers," notes McCarthy. "Humans are fallible, and there's a sense here that the AI is also fallible, but it's fundamentally rational. Computers don't get the red mist and think 'I'm damned if I'm going to let that other car past'."

ABOVE The car will retain a conventional combustion engine. As with the IAC, it will be developed by Indianapolis-based 4Piston Racing

BELOW Dallara's SF23 base car, raced in the Japanese Super Formula series, is to join the autonomous ranks

Despite the sophistication of the sensors – no less than seven Sony IMX728 cameras, combined with four AF ProWave RADAR sensors and three Innovusion Falcon Kinetic FK1 LIDAR sensors – it's accepted that the learning curve will most likely be steep. As well as running in daylight, the series hopes to compete at night under artificial light, adding an extra dimension to the spectacle, as well as confronting a use case that road cars will have to deal with too.

There are no plans to restrict the performance of the car. While the teams will have to take their own decisions on how hard they're comfortable pushing, the full performance of the car will be available right from the start for those who are able to utilise it. ▶

Super Formula

A different model

The series hopes to appeal to fans as a racing spectacle, but McCarthy accepts that it may have to adopt a different model to conventional racing.

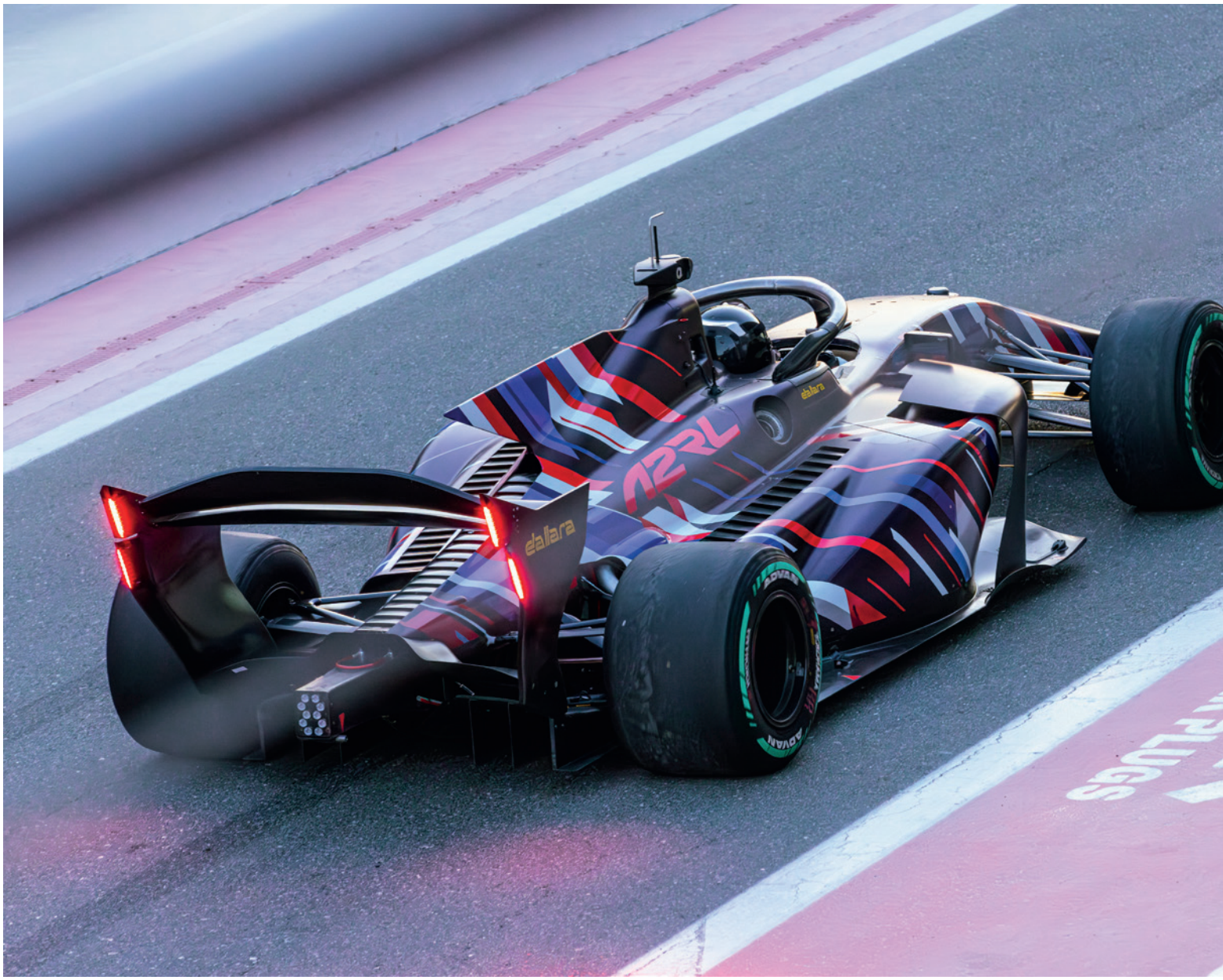
"I'm very conscious that there's the potential for autonomous racing to be boring as hell unless you're doing the coding," he says. "We really want to create a spectacle, but we're aware that this is likely to be an audience that is built online more than at the track. That's why we're putting a lot of work into app development and ghost car development, so the audience both at the track and online can really enhance their experience."

The aim here is to blend real and virtual reality. Fans may be given an opportunity to drive the ghost car in a simulation, competing virtually against the real car on track. Likewise, the option of virtual obstacles (similar to those used in Roborace) is under consideration, which would mean that the car might have to negotiate a virtual chicane overlaid into the video footage, with no risk of a collision in the real world if something goes wrong.

> *"The ultimate goal is to have cars that can take their own decision on whether they can defend or concede the place"*

"I don't see it as something people will sit in their living rooms and watch on a Sunday afternoon. But the generation we want to influence won't do that anyway," comments McCarthy. "They will look at something on their handheld device and they will want to interact with it. So we want to ultimately influence a generation of STEM students and people that will be coming into their 20s and driving cars over the next decade. We want to interest OEMs in engaging with this future audience too.

"We realise that taking a person out of the car is a big change straightaway. So we want to offer them something



different to Formula E or Formula 1. In some respects, I think the mistake that Formula E made was trying to be a sustainable version of Formula 1. We want to be a different type of sport. We want to sit side by side with Formula 1, but we want to deliver an enhanced experience in a completely different way, using a different method to reach our online audience."

Digital twin

So far, there has been a lot of data collection with the human-operated car, the autonomous stack has been put through hardware in the loop testing, and a digital twin of the car has successfully lapped the circuit in simulation.

"Over the coming weeks, we're going to be putting the autonomous car through a variety of tests to combine what we've done in the human-operated car and what we've done in simulation," explains McCarthy. "We know we can do it, it's a question of testing the integration and the resilience of the hardware and determining whether we need to change anything. Right now, we're on track, and the testing has yielded good data."

Once the initial shakedown testing has been completed, the hardware will be frozen for the 2024 season, but that may change in the future.

"I would like to see the series almost become a marketplace for sensor companies," comments McCarthy. "As I talk to some of the companies developing LiDAR and radar and cameras, what excites them about this project is that they can perform real world testing at speeds they're not allowed to reach on the roads. In the future, we hope to offer them a chance to demonstrate their technology on our test cars, and possibly win a place on the rig for future races."

Ultimately, A2RL's objective is to establish Abu Dhabi as a hub for high-tech industries. To do so, it's taking an unashamedly academic approach, tapping into the rich seam of engineering talent that's already quietly breaking records in events like the IAC.

Whether or not autonomous driving is ready to break into mainstream motorsport remains to be seen, but it's undoubtedly one of the hottest research topics in the automotive industry. As such, there's a strong demand for fresh talent and bright ideas. RT

ABOVE RIGHT Two Indy Autonomous Challenge front-runners, the Politecnico di Milano and Technical University of Munich, are among the 10 international teams vying for the $2.25 million prize

RIGHT Things don't always go smoothly with autonomous racing. One of Roborace's teams famously hit the pit wall; the series hit the buffers

LEFT The SF23 was given a human shakedown in Abu Dhabi for the engineers to familiarise themselves with the car