SNCF RAIL SAFETY AND THE FOURTH INDUSTRIAL REVOLUTION

AUTONOMOUS TRAIN VERSUS INTERMEDIATE DIGITAL SOLUTIONS ?

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SNCF MAIN RESEARCH PRIORITIES FOR THE FUTURE OF RAIL

> NEW TECHNOLOGIES WITH A MAJOR POTENTIAL IMPACT ON ITS BUSINESS

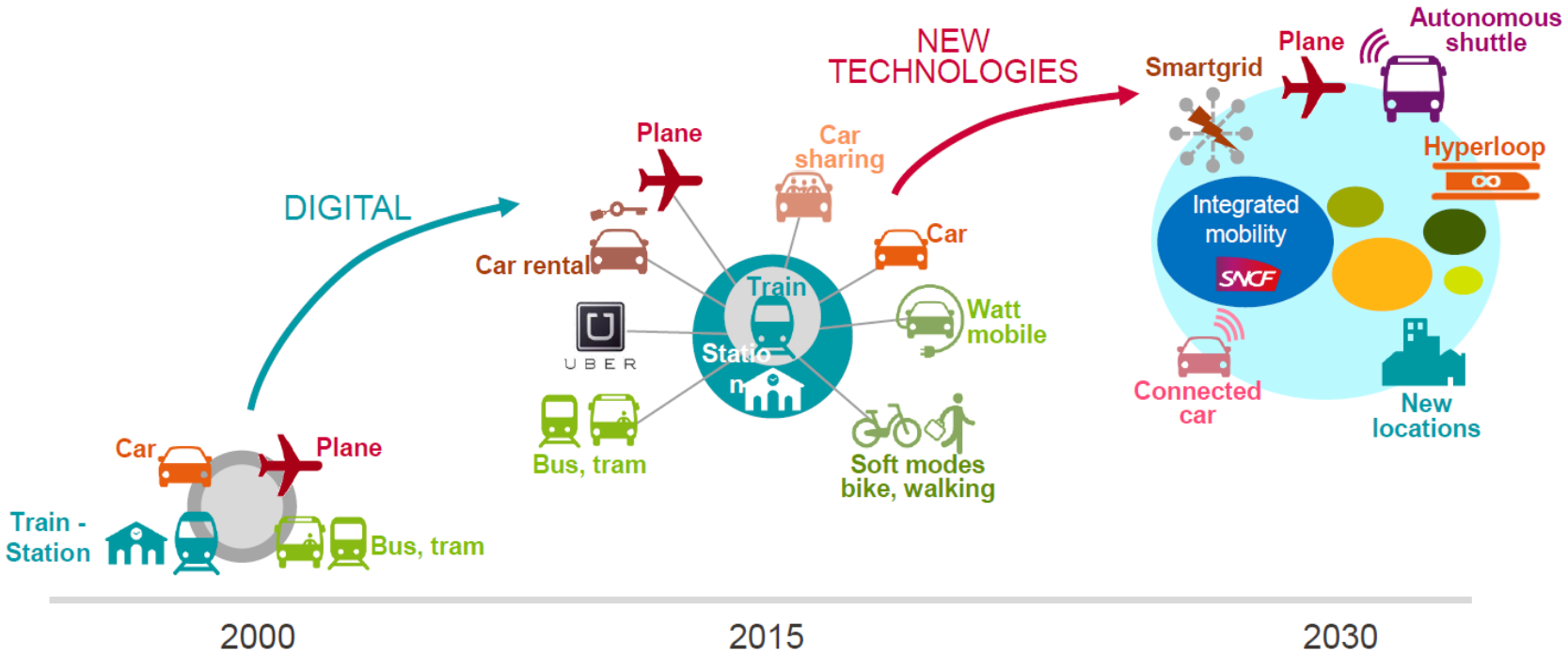
> MASS TRANSIT SYSTEMS

> DIGITAL TRANSFORMATION

> IMPROVEMENTS TO THE SAFETY OF RAIL SYSTEMS

SNCF INNOVATION PROGRAM : TECH4RAIL

FROM DIGITALIZED MOBILITY TO INTEGRATED MOBILITY



DIGITAL INNOVATIVE SOLUTIONS WILL BE DISRUPTIVE FOR SAFETY IMPROVEMENT

LONG TERM :

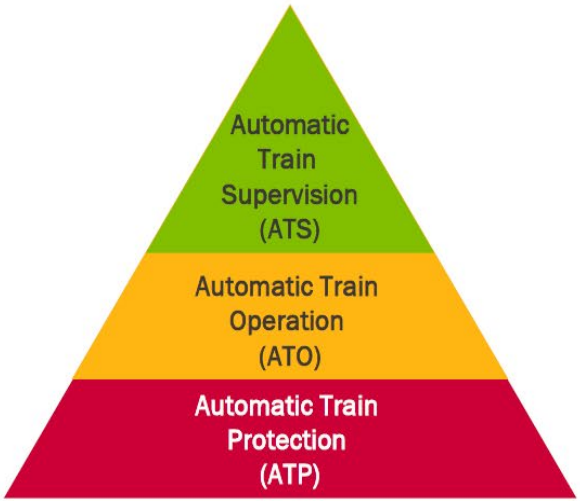
AUTONOMOUS TRAIN

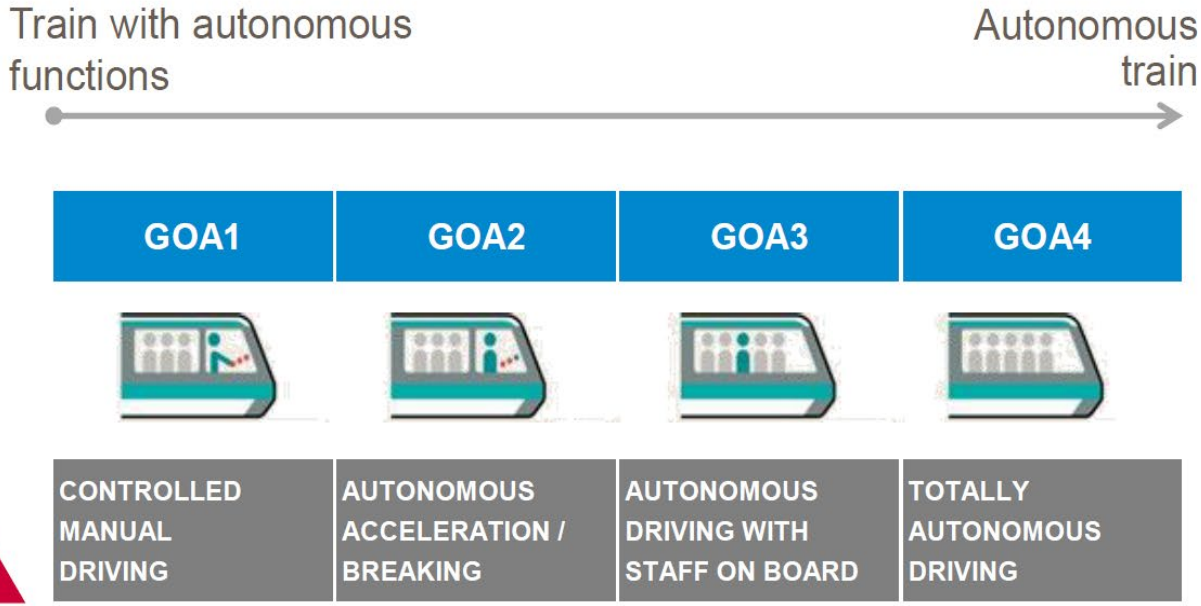
SHORT TERM :

INTERMEDIATE SOLUTIONS

(e.g. Lateral signal recognition)

AUTONOMOUS TRAINS AS A CHALLENGE FOR DISRUPTIVE RAILWAY TECHNOLOGIES





AUTONOMOUS TRAINS AS A CHALLENGE FOR DISRUPTIVE RAILWAY TECHNOLOGIES

SNCF VISION OF AN AUTONOMOUS TRAIN

> The first use cases

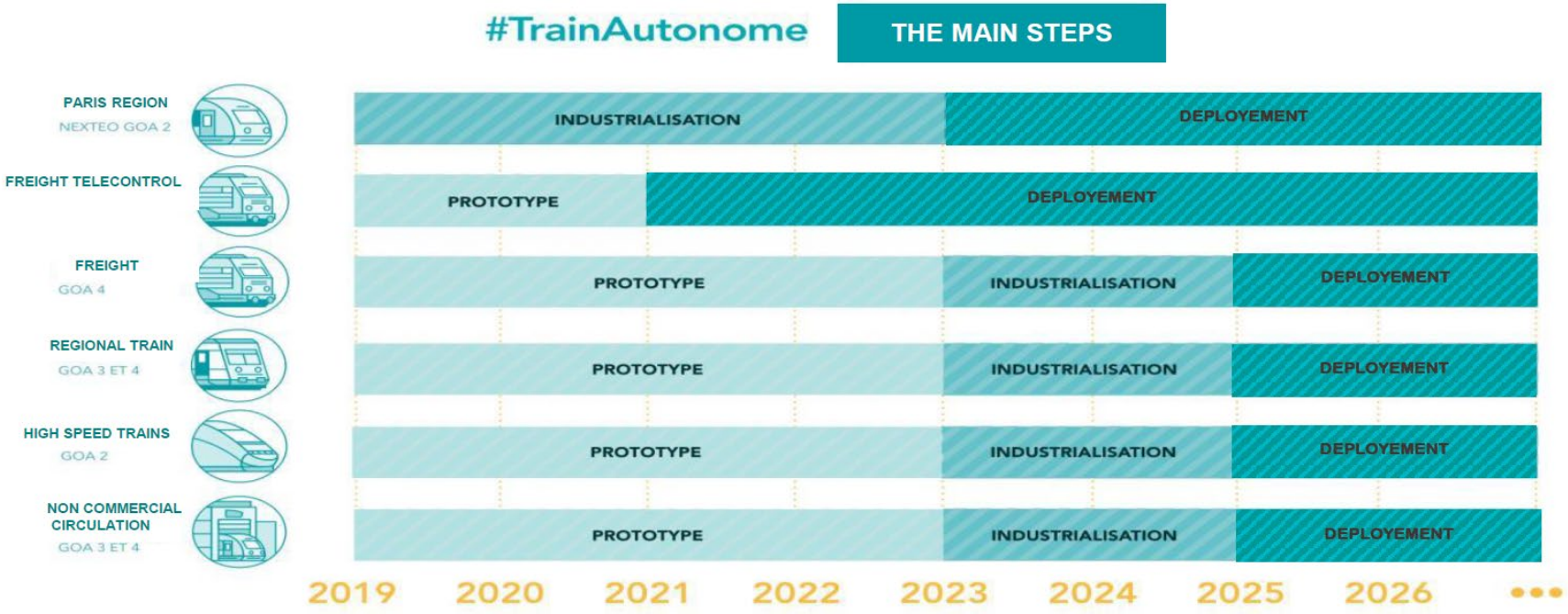
CARGO
GOA2/4 for long routes

PARIS REGION
Remote control on technical trains,
later GOA 4

TGV OF THE FUTURE, "TGV 2020"
GOA2 for commercial high speed Trains.
GOA4 whilst running for maintenance

REGIONAL TRAINS
GOA 3 on shuttles

AUTONOMOUS TRAINS AS A CHALLENGE FOR DISRUPTIVE RAILWAY TECHNOLOGIES



SAFETY CHALLENGES OF AUTONOMOUS TRAIN

> AUTONOMOUS TRAIN WILL INCREASE THE RAILWAY SYSTEM SAFETY LEVEL

> AUTOMATION COULD BRING NEW RISKS, ACCORDING TO GOA AND ATP

> RISKS MUST BE TAKEN INTO ACCOUNT TO DEFINE PROCESS FOR GRADUALLY INTRODUCING AUTOMATED DRIVING

> OTHER CHALLENGES : SOCIAL ASPECTS, CYBER SECURITY, MIGRATION TIME BETWEEN THE CURRENT AND FUTURE SYSTEMS …

SAFETY DEMONSTRATION PROCESS FOR NEW SYSTEMS

COMBINATION OF SEVERAL ELEMENTS OF PROOF FOR THE NEW SYSTEMS :

> FORMAL DEMONSTRATION OF THE SOFTWARE INVOLVED IN THE SAFETY FUNCTION

> TESTS ON THE OPERATIONAL NETWORK OR IN RAIL TEST CENTRES

> DIGITAL SIMULATIONS IN CONJUCTION WITH PHYSICAL TESTS

➔ **INTENSIVE COLLABORATION BETWEEN THE PROPOSERS OF THE NEW SOLUTIONS AND THE SUPERVISORY AUTHORITIES RESPONSIBLE FOR VALIDATING THEM.**

OPPORTUNITIES : INTERMEDIATE DIGITAL SOLUTIONS FOR NEW SAFETY LOOPS

3 EXAMPLES

OPPORTUNITIES : INTERMEDIATE DIGITAL SOLUTIONS FOR NEW SAFETY LOOPS

COMMON FEATURES :

> PURPOSE : REDUCE CONSEQUENCES OF A HUMAN ERROR

> SAFETY INTERGRITY LEVEL (SIL) = 0

> REDUCE RISK BY AT LEAST 100

> STATUS TO BE DEFINED, INCLUDING ON A LEGAL BASIS

OPPORTUNITIES : INTERMEDIATE DIGITAL SOLUTIONS FOR NEW SAFETY LOOPS

1 – SIGNAL DETECTION TO REDUCE SPADS :

OPPORTUNITIES : INTERMEDIATE DIGITAL SOLUTIONS FOR NEW SAFETY LOOPS

1 – SIGNAL DETECTION TO REDUCE SPADS :

	 **IMAGE ACQUISITION**	 **EXTRACTION ZONE**	 **SIGNAL COLOR ANALYSIS**
STEP 1 : SIL 0 VERSION	FRONT CAMERA SOLUTION	IT SOLUTION IA (DEEP LEARNING)	IA SOLUTION (DEEP LEARNING) AND ANALYTIC SOLUTION
STEP 2 : SAFE GEOLOCALISATION		ACCURATE SAFE GEOLOCALISATION	
STEP 3 : CERTIFIED SOLUTION	SAFE SOLUTION COMPILE WITH GOA 2, 3, 4	REINFORCED SAFE GEOLOCALISATION	SAFE SOLUTION (SEVERAL PARALLEL CONTROL SOFTWARES)

OPPORTUNITIES: INTERMEDIATE DIGITAL SOLUTIONS FOR NEW SAFETY LOOPS

2- SYSTEM FOR REAR-END COLLISION ON SINGLE TRACKS (SRVU)

REQUIREMENT 1:

"...TO IMPLEMENT A PROCEDURE OR A TOOL, ABLE TO RAISE AN ALARM WHEN DETECTING INCONSISTENCIES THAT COULD LEAD TO A TRAIN COLLISION ON A SINGLE TRACK"

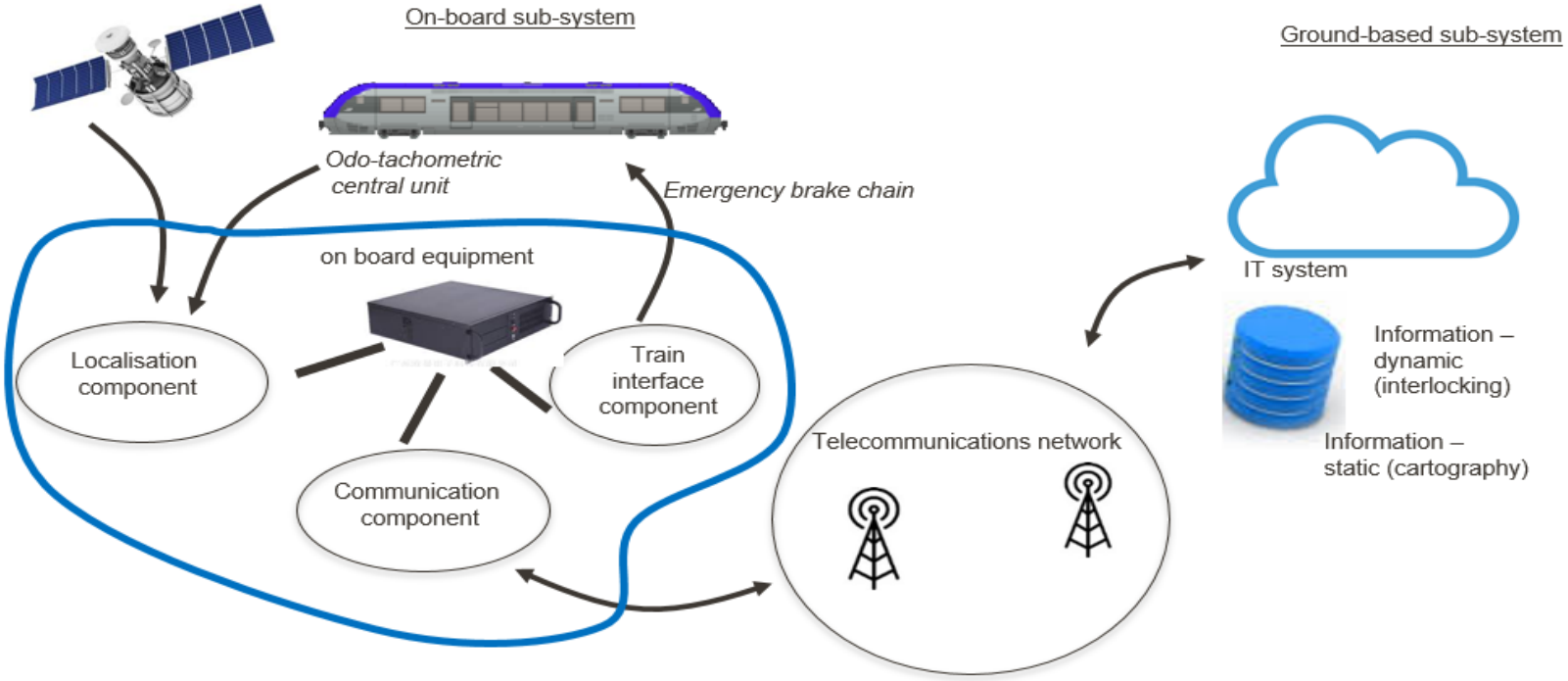
REQUIREMENT 2:

"...TO RAISE AN ALARM: AS A FIRST STEP, IT IS A QUESTION OF HAVING A "PARACHUTE" SYSTEM ON SINGLE TRACKS."

OPPORTUNITIES: INTERMEDIATE DIGITAL SOLUTIONS FOR NEW SAFETY LOOPS

2- SYSTEM FOR REAR-END COLLISION ON SINGLE TRACKS (SRVU)

SRVU NEEDS ANALYSIS



OPPORTUNITIES: INTERMEDIATE DIGITAL SOLUTIONS FOR NEW SAFETY LOOPS

2- SYSTEM FOR REAR-END COLLISION ON SINGLE TRACKS (SRVU)

SRVU ADVANTAGES

> RE-USE OF THE ALREADY TESTED FUNCTIONS

> REDUCED DEVELOPMENT COSTS

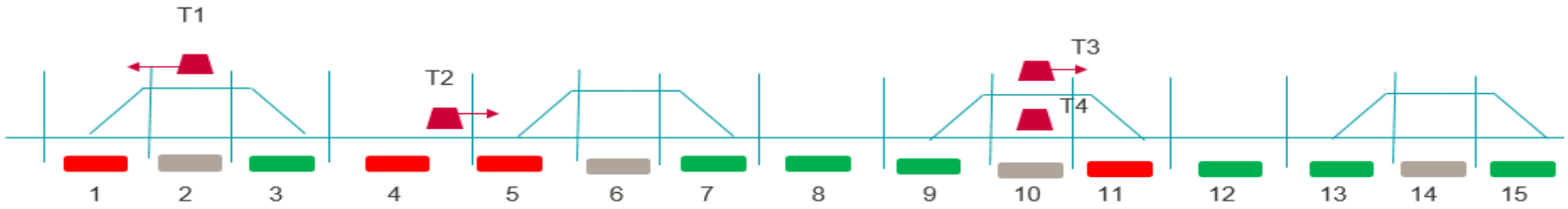
> ABOUT 90% OF THE DISTANCE COVERED

> LOW IMPACT ON ACTUAL OPERATIONS ON SINGLE TRACKS

OPPORTUNITIES: INTERMEDIATE DIGITAL SOLUTIONS FOR NEW SAFETY LOOPS

2- SYSTEM FOR REAR-END COLLISION ON SINGLE TRACKS (SRVU)

SRVU FUNCTIONAL PRINCIPLES



Block	Occupied / Free
1	Occupied T1
2	Not covered
3	Free
4	Occupied T2
5	Occupied T2
6	Not covered
7	Free
8	Free

Block	Occupied / Free
9	Free
10	Not covered
11	Occupied T3
12	Free
13	Free
14	Not covered
15	Free

OPPORTUNITIES: INTERMEDIATE DIGITAL SOLUTIONS FOR NEW SAFETY LOOPS

3- SPEED LIMIT SUPERVISION (ESVE +)

PURPOSE : MONITOR THE RISKS OF TRAINS EXCEEDING THE SPEED LIMIT OF A PARTICULAR LINE

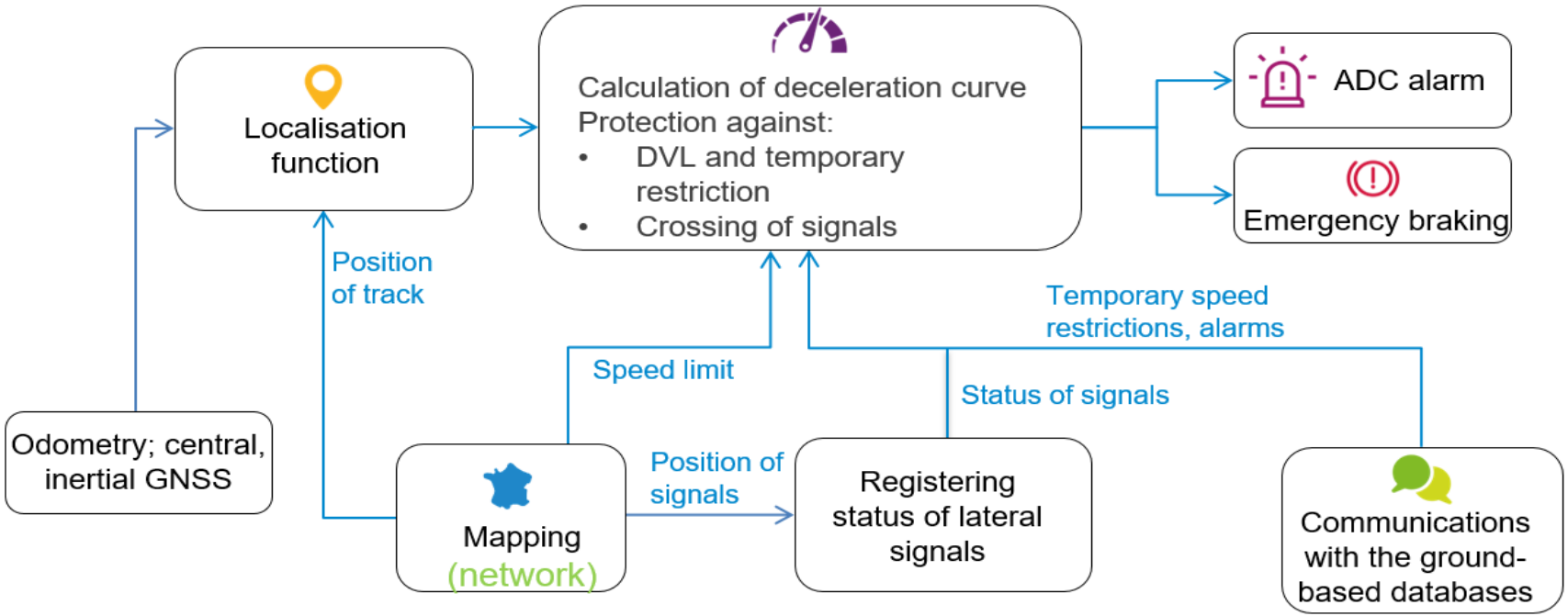
> PRECISE GEOLOCALISATION TO IDENTIFY THE TRACK AND TO DETERMINE THE ACTUAL SPEED

> MAPPING OF THE TRACKS WITH THEIR SPEED LIMITS .

DISPLAY OF THE SPEED ON THE DRIVER'S MAN-MACHINE INTERFACE WITH A SIGNAL/ALARM ISSUED TO THE DRIVER IF THE AUTHORISED SPEED LIMIT IS EXCEEDED

OPPORTUNITIES: INTERMEDIATE DIGITAL SOLUTIONS FOR NEW SAFETY LOOPS

3- SPEED LIMIT SUPERVISION (ESVE +)



OPPORTUNITIES: INTERMEDIATE DIGITAL SOLUTIONS FOR NEW SAFETY LOOPS

3- SPEED LIMIT SUPERVISION (ESVE +)

THE RISK OF CROSSING LATERAL SIGNALS IS ALSO COVERED WITH THESE FUNCTIONS :

> READING OF LATERAL SIGNALS (SUB-SYSTEM OF THE AUTONOMOUS TRAINS OF THE FUTURE)

> GEOLOCALISATION

> CALCULATION OF THE SPEED CURVE

IN THIS CASE A WARNING IS OUTPUT TO THE DRIVER

CONCLUSION

FOR SEVERAL YEARS, WE HAVE BEEN OBSERVING THE EMERGENCE OF DISRUPTIVE TECHNOLOGIES IN OTHER SECTORS WHICH AIM TO IMPROVE THE SAFETY OF OPERATIONS AND MAKE IT POSSIBLE TO VISUALISE ALTERNATIVE SOLUTIONS THAT DO NOT MODIFY THE INFRASTRUCTURE.

SOME OF THESE SOLUTIONS WILL USE INTERMEDIATE SUB-SYSTEMS THAT ARE INDISPENSABLE FOR THE DEVELOPPEMENT OF THE SYSTEMS OF THE FUTURE, ESPECIALLY THE AUTONOMOUS TRAIN.

AS A RESULT THEY DO NOT REPRESENT A “WRONG MOVE” WITH REGARD TO THE LONG-TERM DEVELOPMENTS OF SYSTEMS.

THANK YOU FOR YOUR ATTENTION