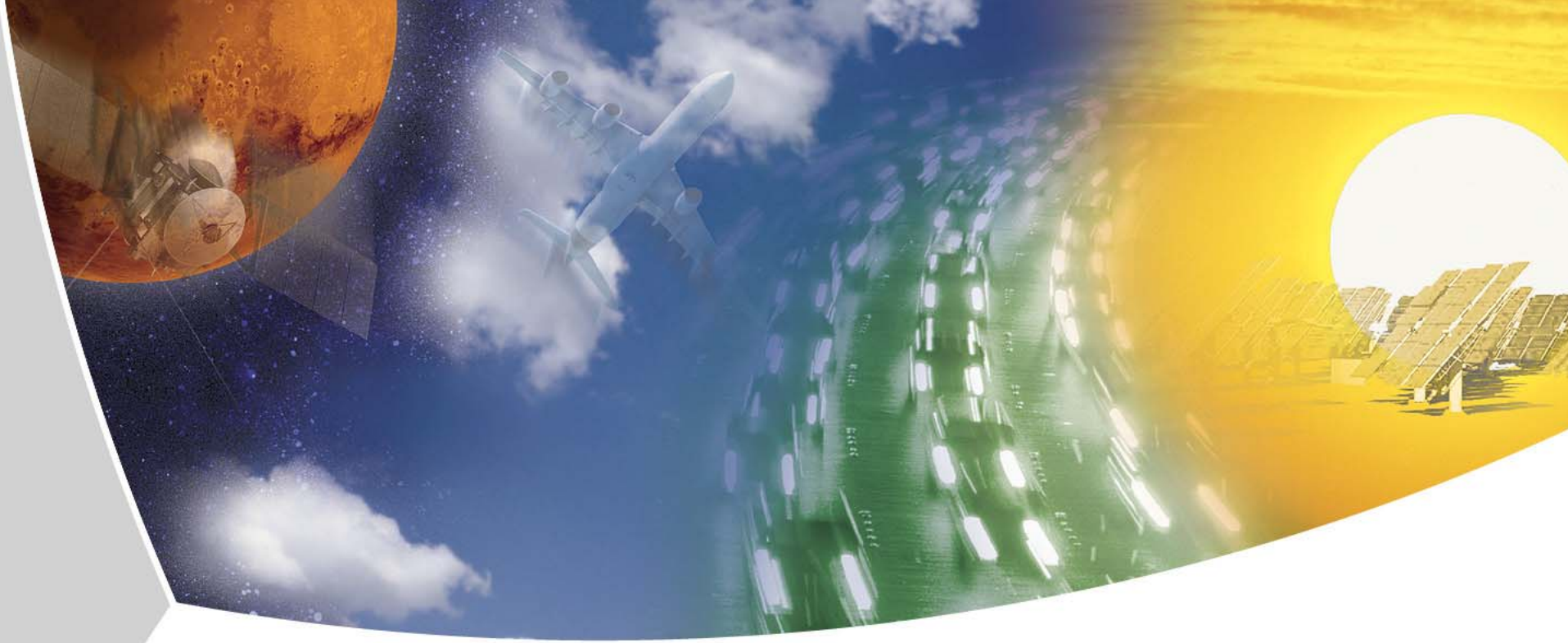

Operational Concept for a complete A-SMGCS

An Output of conceptual work in the European Project EMMA

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Background

- EMMA aims to prepare the concept for higher implementation levels of A-SMGCS that will be built up in EMMA2
- Difficulties with existing ICAO, EUOCONTROL, and EUROCAE levels of implementation when describing new services:
  - Currently, 4 A-SMGCS levels
    - But with routing, guidance, and onboard survices the system gets more complex (there are more than 2 evolution levels)
    - 4 A-SMGCS functions can hardly be matched to the services received by ATCOs, Pilots, and Vehicles Drivers
  - No care for technical enablers and procedures
  - No evolutionary steps with ICAO requirments

EMMA Approach

- 4 Work Shops with Partners from
  - **Industry** (Airbus, PAS, TATM, SELEX)
  - **R&D** (DLR, NLR, EUROCONTROL)
  - **Users**
    - ANSPs (ANS_CR, AENA, DSNA, ENAV, DFS)
    - Airlines (DLH, CSA)
    - Airports (CSL, AENA)

- D131 EMMA OSED-update Document

Definition of Services proposed by EMMA

- Service Description is allocated to the user who receives it and not to a primary function
- 3 main users:
  - **ATCOs** receive
    - Surveillance
    - Routing
    - Control
    - Guidance (ground based guidance) service
  - **Pilots** receive an onboard service enabled by A-SMGCS
  - **Vehicle Drivers** receive an onboard service enabled by A-SMGCS

Definition of Services proposed by EMMA

- When defining a service, **technical functions and their technical enablers** have to be regarded
- It is an iterative process
  - Service ⟷ technical Enablers

Definition of Steps of Implementation

- Different steps of implementation for each individual service that depends on following criteria:

  (1) Development status of the technical enabler (standardised, on the market or to be developed yet)

  (2) Development status of the service (already validated or only at the stage of a concept)

  (3) Degree of interrelations to other functions (complexity)

  (4) Quality of the enabling equipment (needed reliability, safety)

  (5) Impact on current operational procedures and size of the changes

  (6) Cost/benefit considerations

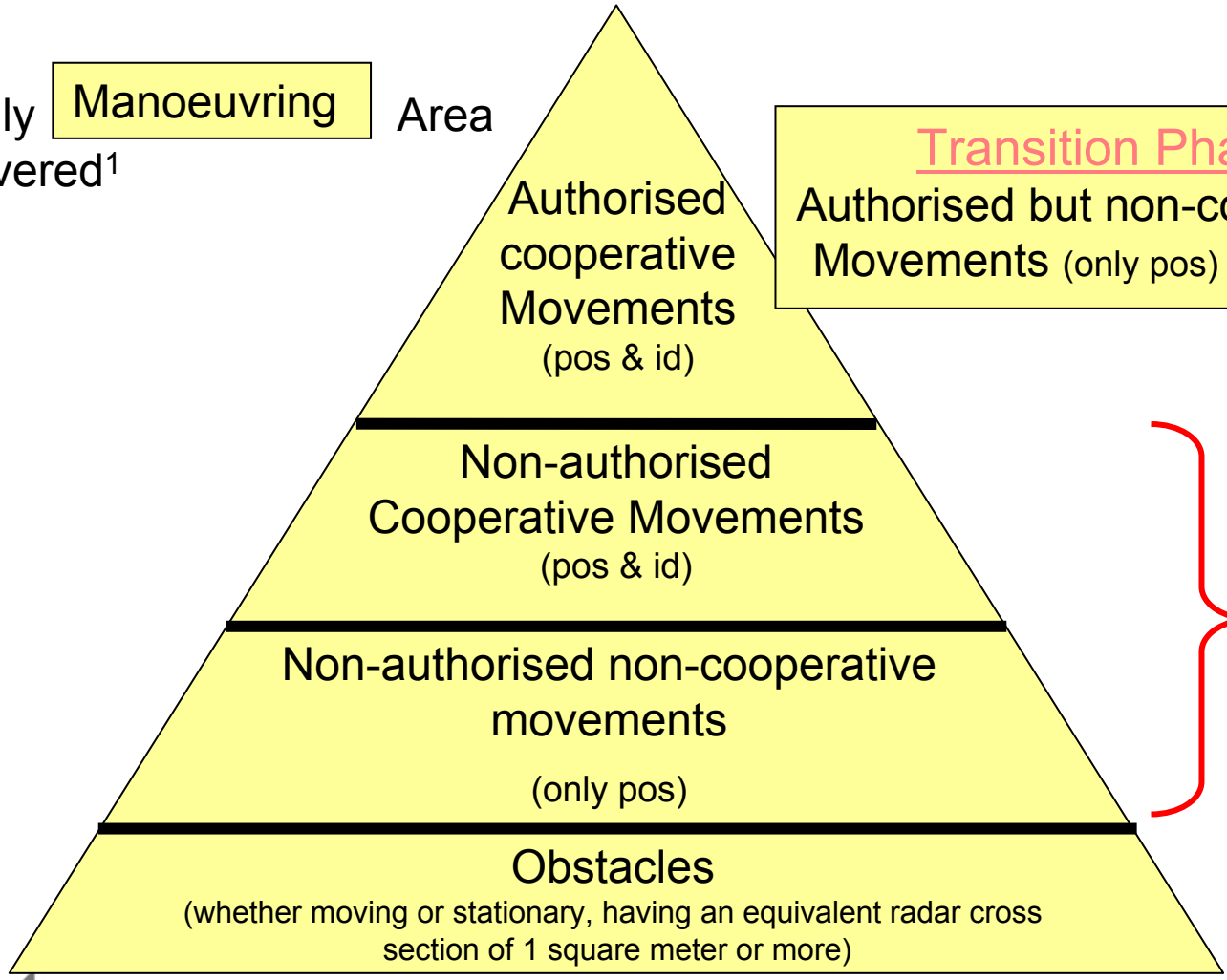
Definition of Functions and Technical Enablers

ATCO - Surveillance

Function	On-board Enabler	Ground Enabler
Provide traffic information	•ADS-out or mode S transponder	•Cooperative sensors (SSR Mode-S, ADS-B, GNSS) •Non-cooperative sensors (SMR) •Sensor data fusion •Flight information •Vehicle information
Provide traffic context		•Aeronautical info server •Meteo data
Interface with ATCOs		•HMI component

EMMA Surveillance – Service Step 1

Only covered[1] Manoeuvring Area

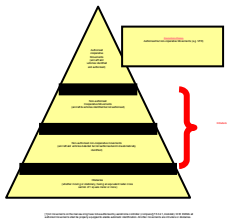


Transition Phase:
Authorised but non-cooperative Movements (only pos) (e.g. GA)

Intruders

EMMA Surveillance – Service Step 2

Manoeuvering + Apron area

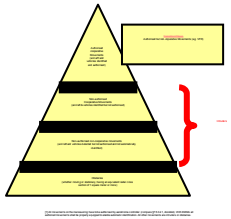


Authorised cooperative Aircraft (pos & id)

Transition Phase:
Authorised but non-cooperative Aircraft (only pos) (e.g. GA)

EMMA Surveillance – Service Step 3 (+VIS3)

Manoeuvering + Apron area



+

Authorised cooperative Aircraft
(pos & id)

Authorised Cooperative Vehicles[2]
((pos & id)
within designated areas where vehicles can conflict withaircraft

Non-authorised Vehicles[2]
(to be detected within designated areas where vehicles can conflict aircraft movements)

Obstacles
(whether moving or stationary, having an equivalent radar cross section of 1 square meter or more within designated area where obstacles can conflict aircraft movements [taxi lanes, active stands])

Intruder

Transition Phase:
Authorised but non-cooperative Aircraft (e.g. GA)

[2] In low visibility conditions, when movements are not able to avoid each other, parts of the apron area (taxi lanes, active stands) are used exclusively for authorised movements. In LVO Vehicles operating in these areas must be authorised and equipped. In good visibility conditions vehicles do not have to be controlled on the Apron (compare also ICAO doc 9830 §3.5.16.3).

Definition of Services Steps

ATCO - Surveillance

Service Steps	Description	Comments
Step 1	• Detection and accurate position of all aircraft, all vehicles, and obstacles • Identification of all cooperative aircraft and vehicles	Manoeuvring area
Step 2	• Step1 + Detection and identification of **all aircrafts**	Movement area
Step 3	• Step2 + • Detection and identification of **all vehicles** • Detection of **Obstacles**	Movement area •Vis3 - where manoeuvring a/c may come into conflict with each other or with vehicles ICAO doc 9830 §3.5.16.3

Definition of Functions and Technical Enablers

ATCO - Control

Function	On-board Enabler	Ground Enabler
Conflict and Incursion Detection and Alerting		•Surveillance function + alerting algorithm
Conflict Resolution		•Resolution algorithm
Support to Communication	•Data Link (point to point) •Onboard HMI component	•Data Link •Ground HMI component
Support to coordination between ATCOs		•Flight Data Management •Electronic Flight Strips

Definition of Service Steps

ATCO - Control

Service Step	Description	Comments
Step 1	•**Runway** Conflict/Incursion detection and alerting	Implementation of **conflict resolution** advisory may be initiated at any step
Step 2	•**Taxiway** Conflict/Incursion detection and alerting	
Step 3	•Detection of plan / route deviation •Support to Communication (CPDLC) •ATCO coordination (EFS)	
Step 4	•Conflict/Incursion detection and alerting of **apron/stand/gate** conflicts	

Definition of Functions and Technical Enablers

ATCO - Routing

Function	On-board Enabler	Ground Enabler
Manual Routing	None	•Input Devices + •simple routing algorithm
Semi-automatic Routing	None	•Routing algorithm + •Interfaces to external data
Automatic Routing	None	•Routing algorithm + •Interfaces to external data •Planning algorithm (SU-time, DMAN)

Definition of Service Steps

ATCO - Routing

Service Steps	Description	Comments
Step 1	Manual Routing	Manual input of a route supported by the shortest taxi route w.r.t. to local standard routes
Step 2	Semi-automatic Routing	Routing service proposes a most suitable route, taking into account control and flight plan information.
Step 3	Automatic Routing	Routing service provides route (track) and time information by aid of a planning function.
Step 4	Automatic Routing + ROP (DMAN)[1]	Planning support is further increased by a departure manager providing optimal runway occupancy times.

Definition of Functions and Technical Enablers

ATCO – Ground Guidance

Function	On-board Enabler	Ground Enabler
Manual Operation of Ground based Guidance Means	None	•Controller HMI (Switchboard or Lighting Display), •Airfield Lighting Control System, •Selectively switchable Centre Line Lights and Stop Bars
Automatic Operation of Ground based Guidance Means	None	Same as above + •Interfaces to Control and Surveillance Function •Automatic Airfield Lighting Control System

Definition of Services Steps

ATCO – Ground Guidance

Service Steps	Description	Comments
Step 1	Manual Operation of Ground based Guidance Means	Equipment available on the market.
Step 2	Automatic Operation of Ground based Guidance Means	Automatic generation of guidance information, based on the cleared route and the actual position of the aircraft.

Definition of Functions and Technical Enablers

Pilot (Flight Crew)

Function 1/2	On-board Enabler	Ground Enabler
Airport Moving Map	•Own-ship position and state vector •Aeronautical database (airport layout)	
Surface Movement Alerting	•AMM •Conflict and Alerting algorithm	
Ground Traffic Display	•ADS-B-in •AMM	•TIS-B (to see non ADS-B aircraft, vehicles)
Traffic Conflict Detection	•Conflict and Alerting algorithm	•TIS-B
Ground / Air Database Upload	•Aeronautical database	•Airport Mapping Database server •X-NOTAM •D-ATIS

Definition of Functions and Technical Enablers

Pilot (Flight Crew)

Function 2/2	On-board Enabler	Ground Enabler
CPDLC Ground Clearances and Taxi Route Uplink	•CPDLC (DCL, D-Taxi) •Airport Moving Map	•CPDLC •Routing service
Braking and Steering Cues	•Taxi-Route (uplinked or not) •Aeronautical database (airport layout) •B&S algorithm	
HUD Surface Guidance	•Taxi Route (uplinked or not) •Own-ship position and state vector •Aeronautical database	
Automated Steering	•Taxi Route (uplinked or not) •Own-ship position and state vector •Auto-Pilot for taxiing	

Definition of Service Steps

Pilot (Flight Crew)

Service Steps	Description	Comments
Step 1	•Airport Moving Map •Surface Movement Alerting •Braking and Steering Cue (for landing roll)	•Equipment already available
Step 2	•Ground-Air Database Upload •Ground Traffic Display •Traffic Conflict Detection •CPDLC Ground Clearance and Taxi Route Uplink •Braking and Steering Cue (landing roll and taxi)	•Ground TIS-B + DL needed
Step 3	•HUD Surface Guidance	•HUD is already available for approach
Step 4	•Automated Steering	•Major changes in equipments and procedures

Definition of Functions and Technical Enablers

Vehicle Drivers

Function	On-board Enabler	Ground Enabler
Airport Moving Map	•Own-ship position and state vector •Aeronautical database (airport layout)	
Surface Movement Alerting	•AMM •Conflict and Alerting algorithm	
Ground Traffic Display	•ADS-B-in •AMM	•TIS-B
Traffic Conflict Detection	•Conflict and Alerting algorithm	•TIS-B
Support to Vehicles Operations via data link	•Ground/vehicle datalink	•Ground/vehicle datalink

Definition of Services Steps

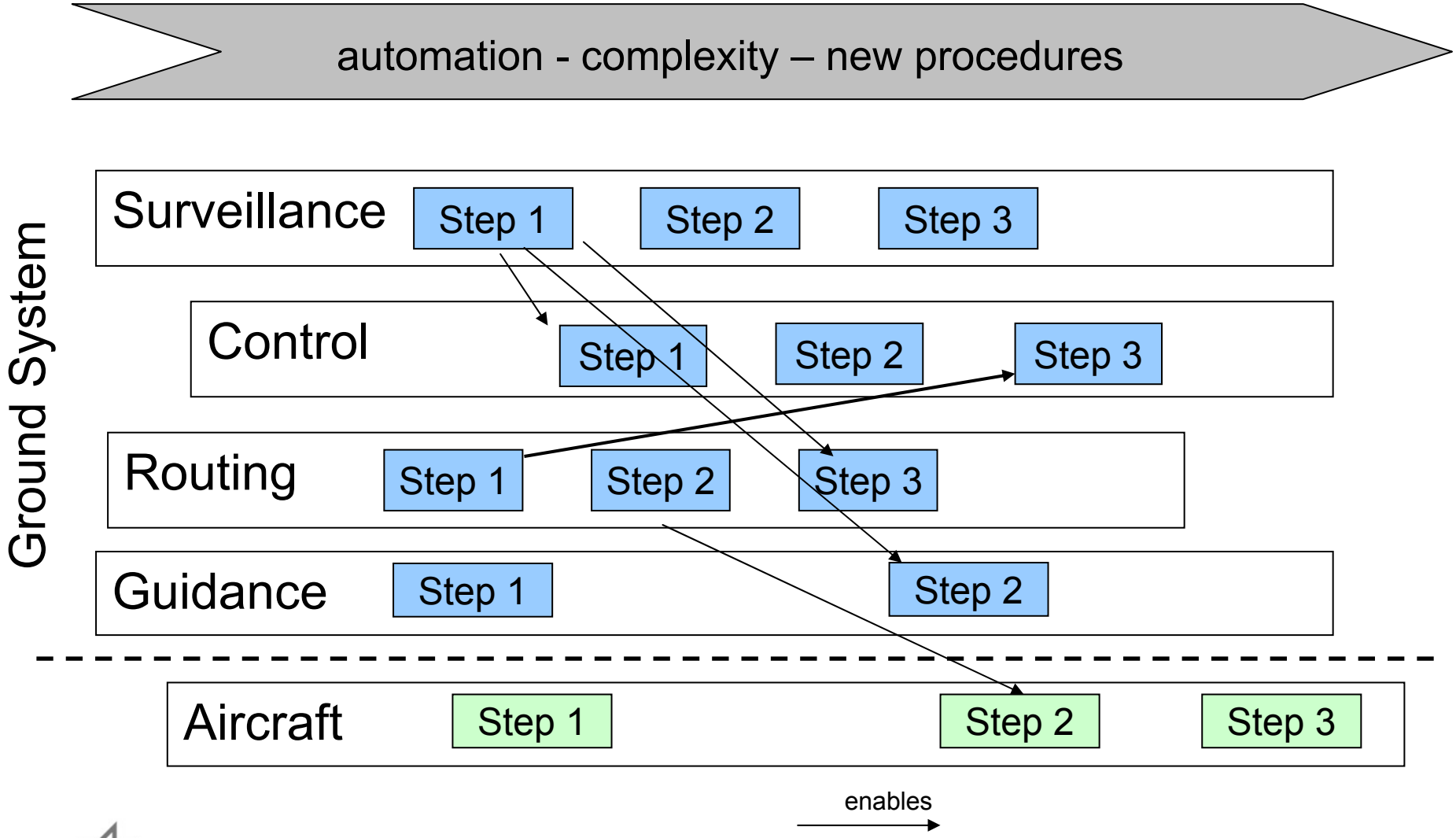
Vehicle Drivers

Service Steps	Description	Comments
Step 1	•Airport Moving Map inlc. alerts	•No ground equipment •Equipment already available
Step 2	•Ground-Air Database Upload •Ground Traffic Display incl. alerts	•Ground TIS-B + DL needed
Step 3	•Dispatch and Guidance via data link	

Definition of Procedures

- Workshop with Users to discuss by which potential procedures the services should be applied
- Procedures defined for higher services but still very pre-matured
- But we need initial procedures to test them in validation activities (EMMA2)
- Initial procedures used to cluster service steps to A-SMGCS implementation packages
- Procedures are the core to enable a service to bring benefit
- EMMA doc D135 - Op. Requirements Doc

Logical Interdependencies between EMMA Service Steps



Logical Interdependencies between EMMA Service Steps

	Expected Steps to each Service									
Surveillance	**S1** id/pos everything manoeuvering		**S2** Step 1 + id/pos a/c in the movement area						**S3** S2 + id/pos vehicles movement area	
Control	**C1** Conflict Rwy		**C2** Conflict Twy		**C3** Plan / Route Deviation				**C4** Conflict Apron	
Guidance	**G1** Manual switched ground guidance (e.g. Heathrow)								**G2** Auto switch	
Routing			**R1** Manual		**R2** Semi-auto		**R3** Auto (planning)		**R4** ROP	
Airborne			**A1** AMM		**A2** Ground traffic + CPDLC				**A3** HUD	**A4** Auto steering
Vehicles			**V1** AMM		**V2** Ground Traffic				**V3** Data link	

ICAO A-SMGCS Categorisation

1. Visibility Conditions
   - Vis 1 — no impact
   - Vis 2 — ATCO cannot see
   - Vis 3 — Pilots cannot see and avoid (400m < Vis 3 < 75m)
   - Vis 4 — Pilots cannot taxi (< 75m)

2. Traffic Density
   - Light (L): 0 < movements < 20
   - Medium (M): 20 < movements < 35
   - Heavy (H): 35 < movements ∞

3. Aerodrome Layout
   - Basic (B): = 1 RWY = 1 TWY = 1 Apron
   - Simple (S): = 1 RWY > 1 TWY ≥ 1 Apron
   - Complex (C): > 1 RWY > 1 TWY ≥ 1 Apron

ICAO implementation levels

Aerodrome Types	User	Surveillance	Control			Routing	Guidance					Level
			Conflict Prediction und/or Detection	Conflict Analysis	Conflict Resolution		Ground				On Board	
							1*	2*	3*	4*		
T-1: 1:(B)(L) T-2: 1:(B)(M) T-3: 1:(B)(H) T-4: 1:(S)(L)	Controller	X	X	X	X	X						I
	Pilot/Vehicle driver						X					
	System											
T-5: 1:(S)(M) T-6: 1:(S)(H) T-7: 1:(C)(L) T-10: 2:(B)(L) T-11: 2:(B)(M) T-13: 2:(S)(L)	Controller	X	X	X	X	X						II
	Pilot/Vehicle driver		X	X	X		X	X				
	System	X	X									
T-8: 1:(C)(M) T-12: 2:(B)(H) T-14: 2:(S)(M) T-16: 2:(C)(L) T-19: 3:(B)(L) T-20: 3:(B)(M) T-22: 3:(S)(L)	Controller		X	X	X				X			III
	Pilot/Vehicle driver		X	X[1)]	X[1)]		X					
	System	X	X	X	X	X						
T-9: 1:(C)(H) T-15: 2:(S)(H) T-17: 2:(C)(M) T-18: 2:(C)(H) T-21: 3:(B)(H) T-23: 3:(S)(M) T-24: 3:(S)(H) T-25: 3:(C)(L) T-26: 3:(C)(M) T-27: 3:(C)(H)	Controller		X	X	X							IV
	Pilot/Vehicle driver		X	X[1)]	X[1)]		X					
	System	X	X	X	X	X				X		
T-28: 4:(B)(L) T-29: 4:(B)(M) T-30: 4:(B)(H) T-31: 4:(S)(L) T-32: 4:(S)(M) T-33: 4:(S)(H) T-34: 4:(C)(L) T-35: 4:(C)(M) T-36: 4:(C)(H)	Controller		X	X	X							V
	Pilot/Vehicle driver						X				X	
	System	X	X	X	X	X				X		

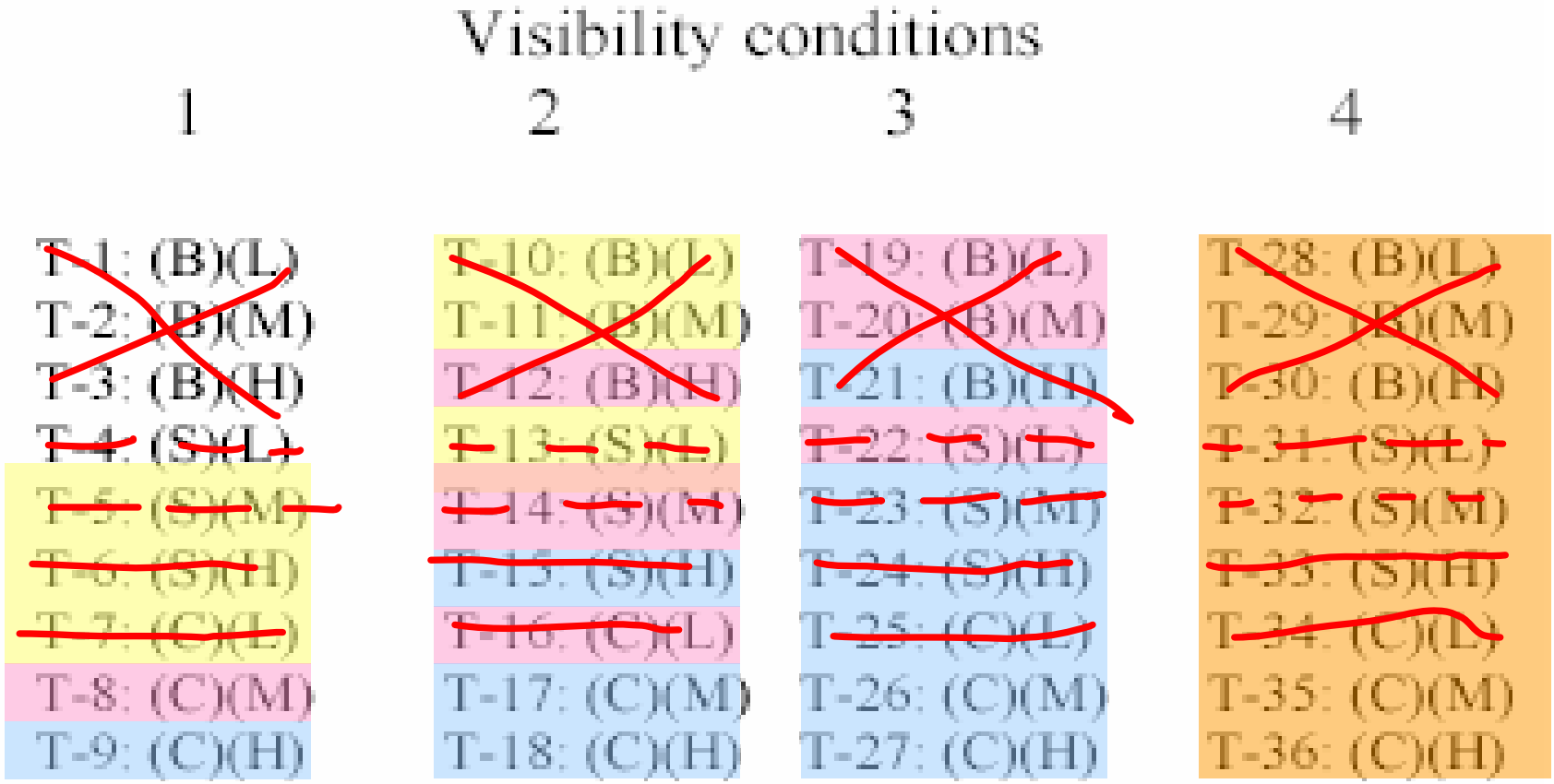
SMGCS

ICAO A-SMGCS Categorisation T1 – T36

Visibility conditions 1	2	3	4	
T-1: (B)(L)	T-10: (B)(L)	T-19: (B)(L)	T-28: (B)(L)	**Level I**
T-2: (B)(M)	T-11: (B)(M)	T-20: (B)(M)	T-29: (B)(M)	
T-3: (B)(H)	T-12: (B)(H)	T-21: (B)(H)	T-30: (B)(H)	
T-4: (S)(L)	T-13: (S)(L)	T-22: (S)(L)	T-31: (S)(L)	**Level II**
T-5: (S)(M)	T-14: (S)(M)	T-23: (S)(M)	T-32: (S)(M)	
T-6: (S)(H)	T-15: (S)(H)	T-24: (S)(H)	T-33: (S)(H)	**Level III**
T-7: (C)(L)	T-16: (C)(L)	T-25: (C)(L)	T-34: (C)(L)	
T-8: (C)(M)	T-17: (C)(M)	T-26: (C)(M)	T-35: (C)(M)	**Level IV**
T-9: (C)(H)	T-18: (C)(H)	T-27: (C)(H)	T-36: (C)(H)	
				Level V

Source: TATM, FHA WS, 2005-04-05

ICAO A-SMGCS Categorisation T1 – T36



EMMA Matrix for Implementation Packages

LAYOUT	TRAFFIC DENSITY	VISIBILITY			
		Vis 1	Vis 2	Vis 3	Vis 4
COMPLEX	Medium	Implementation Package (IP) 1	IP2	IP3	IP4
	Heavy	IP5	IP6	IP7	IP8

ICAO A-SMGCS Definition

A system providing routing, guidance and surveillance for the control of aircraft and vehicles in order to maintain the declared surface movement rate under all weather conditions within the aerodrome visibility operational level (AVOL) while maintaining the required level of safety.

- SAFETY
- THROUGHPUT

EMMA Matrix for Implementation Packages

Traffic Density	Vis 1	Vis 2	Vis 3	Vis 4
Medium optional				
Heavy Optional				

Logical Interdependencies between EMMA Service Steps

	Expected Steps to each Service										
Surveillance	**S1** id/pos everything manoeuvring	**S2** S1 + id/pos a/c in the movement area								**S3** S2 + id/pos vehicles movement area	
Control	**C1** Conflict Rwy		**C2** Conflict Twy		**C3** Plan Deviation					**C4** Conflict Apron	
Guidance	**G1** Manual switched ground guidance (e.g. Heathrow)								**G2** Auto switch		
Routing			**R1** Manual	**R2** Semi-auto		**R3** Auto (planning)			**R4** ROP		
Airborne		**A1** AMM			**A2** Ground traffic + CPDLC					**A3** HUD	**A4** Auto steering
Vehicles		**V1** AMM		**V2** Ground Traffic				**V3** Data link			

Proposed Initial Implementation Packages

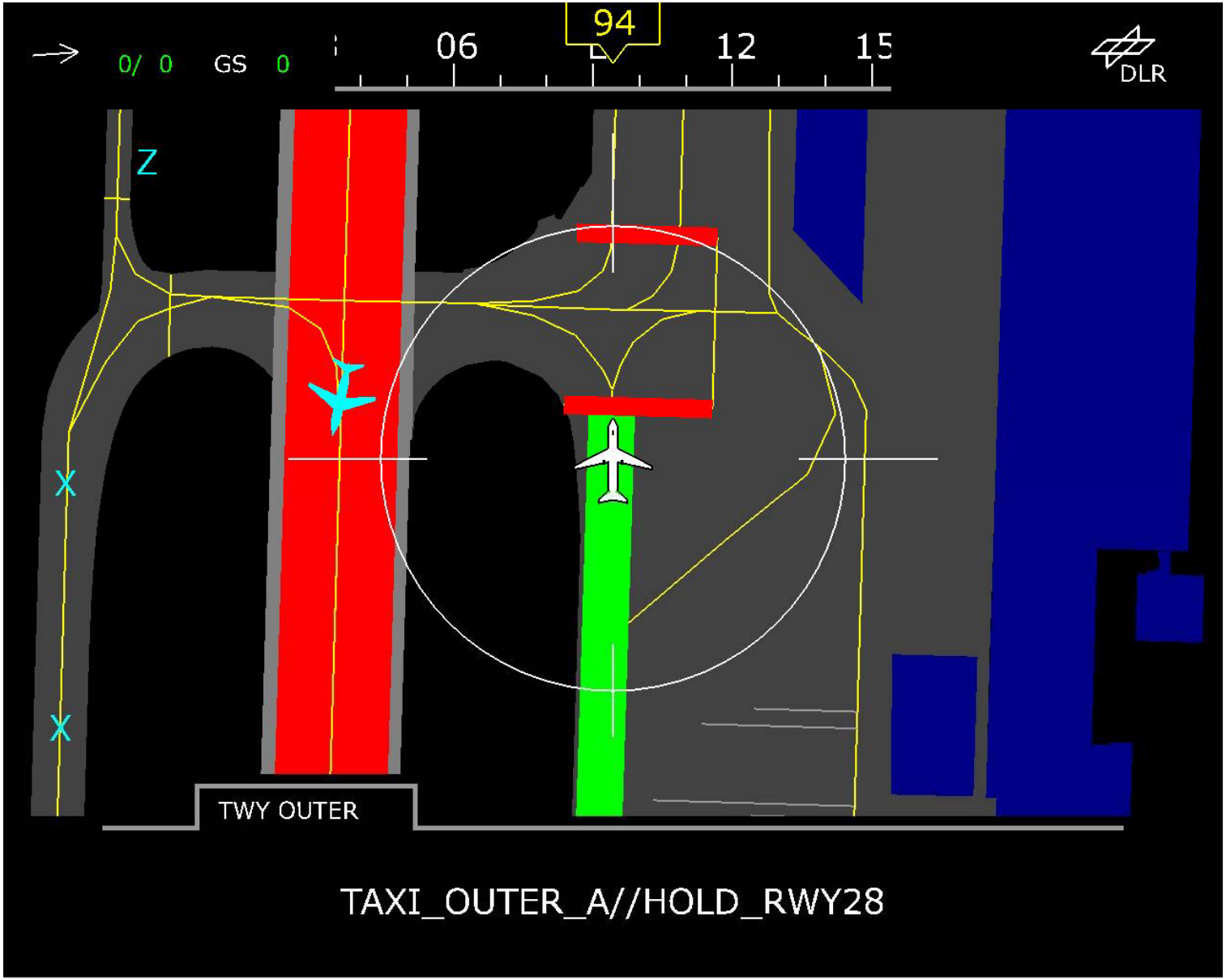
Traffic Density	Vis 1	Vis 2	Vis 3	Vis 4
Medium optional	S1 + C1			
Heavy Optional				

Proposed Initial Implementation Packages

Traffic Density	Vis 1	Vis 2	Vis 3	Vis 4
Medium	S1 + C1	S2 + C1		
optional				
Heavy				
Optional				

Proposed Initial Implementation Packages

Traffic Density	Vis 1	Vis 2	Vis 3	Vis 4
Medium	S1 + C1	S2 + C1	S2 + C1 + A2 + V2	
optional				
Heavy				
Optional				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GS 0
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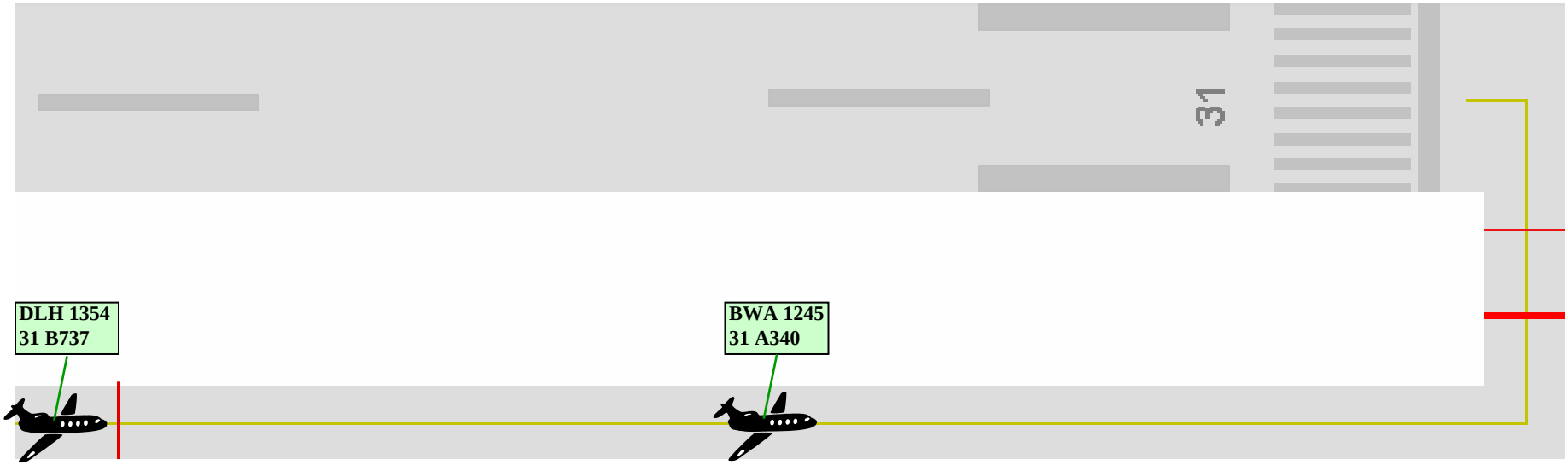
94
12
15
DLR
Z
X
X
TWY OUTER
TAXI_OUTER_A//HOLD_RWY28

Proposed Initial Implementation Packages

Traffic Density	Vis 1	Vis 2	Vis 3	Vis 4
Medium	S1 + C1	S2 + C1	S2 + C1 + A2 + V2 S3 + C4 + R3	
optional				
Heavy				
Optional				

Seperation in Vis 3

- Ground STCA“ or
- Aircraft approaching stationary traffic (ICAO doc 9830, §3.4.5.7 b) 2))



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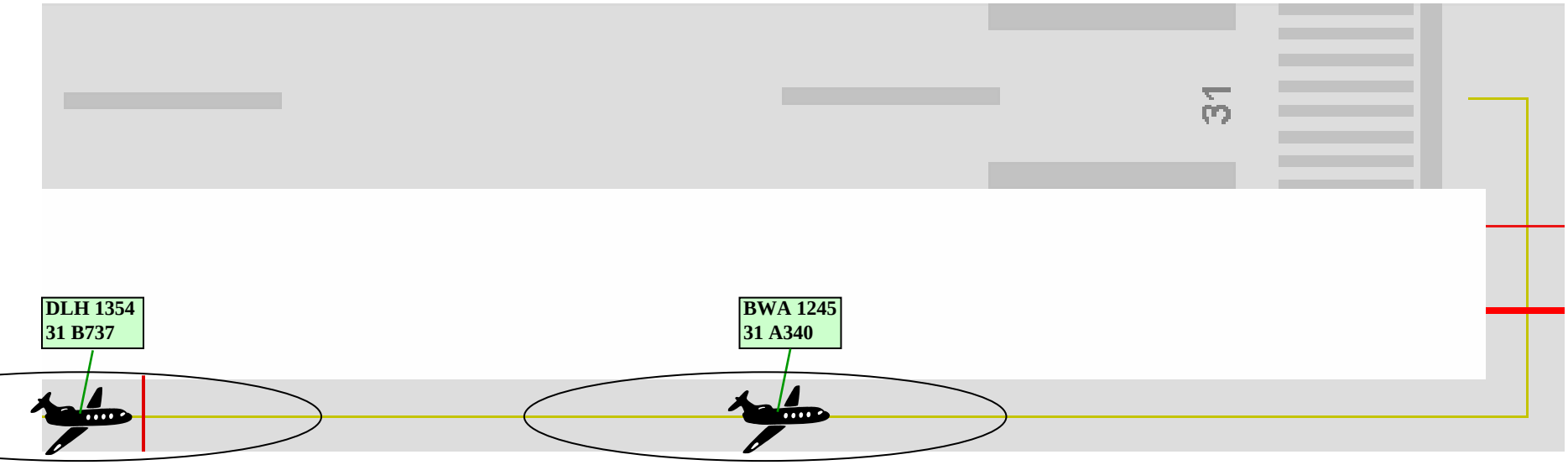

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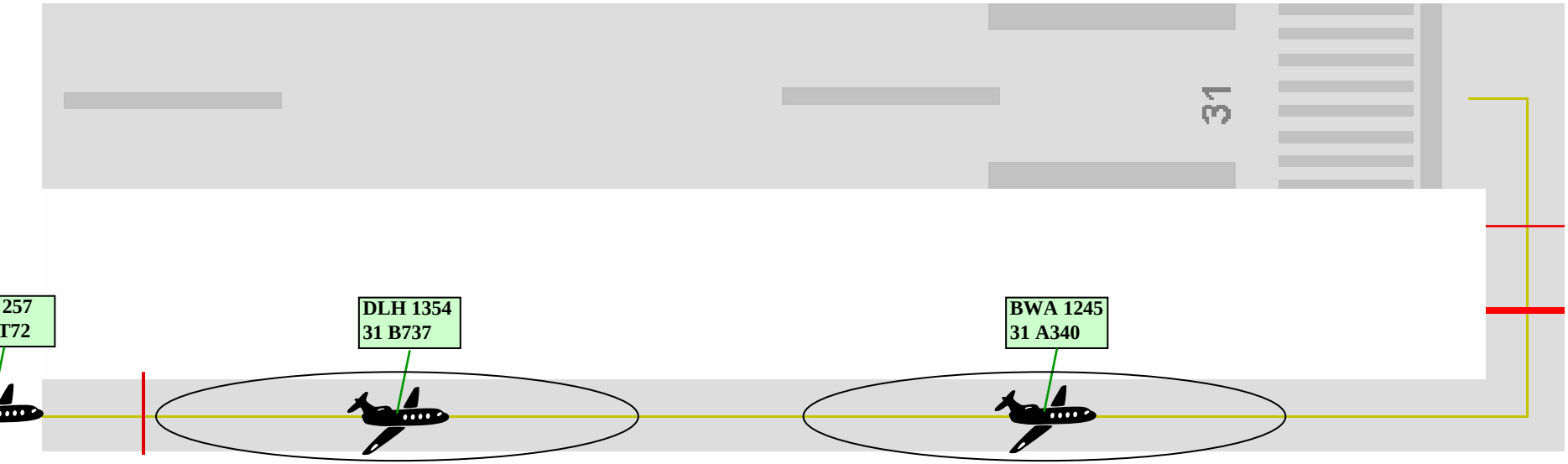

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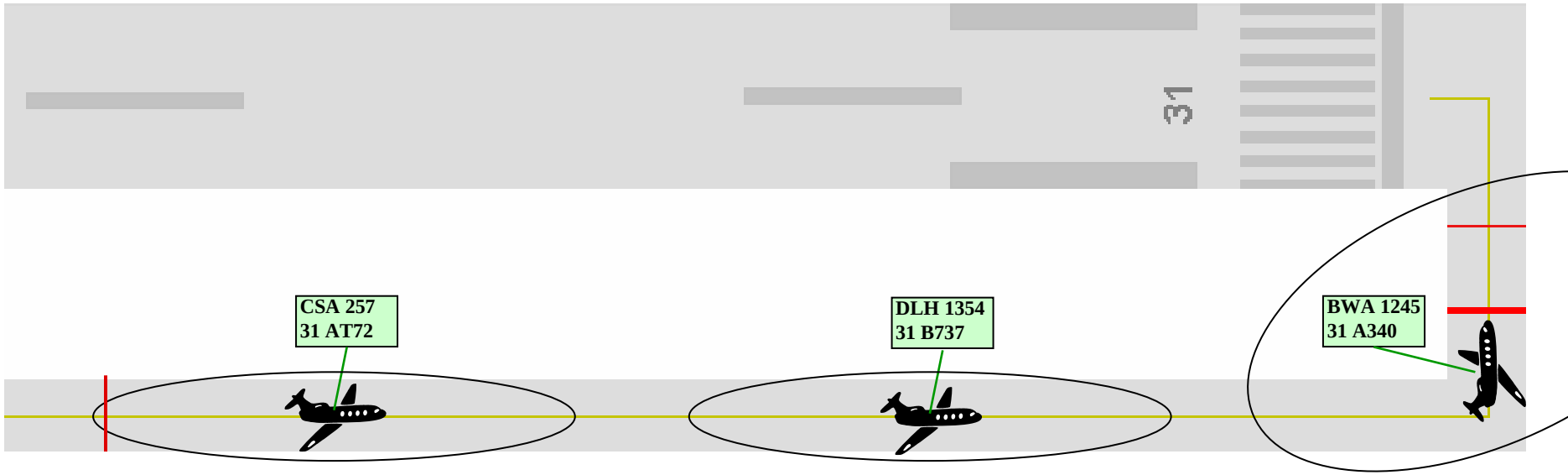

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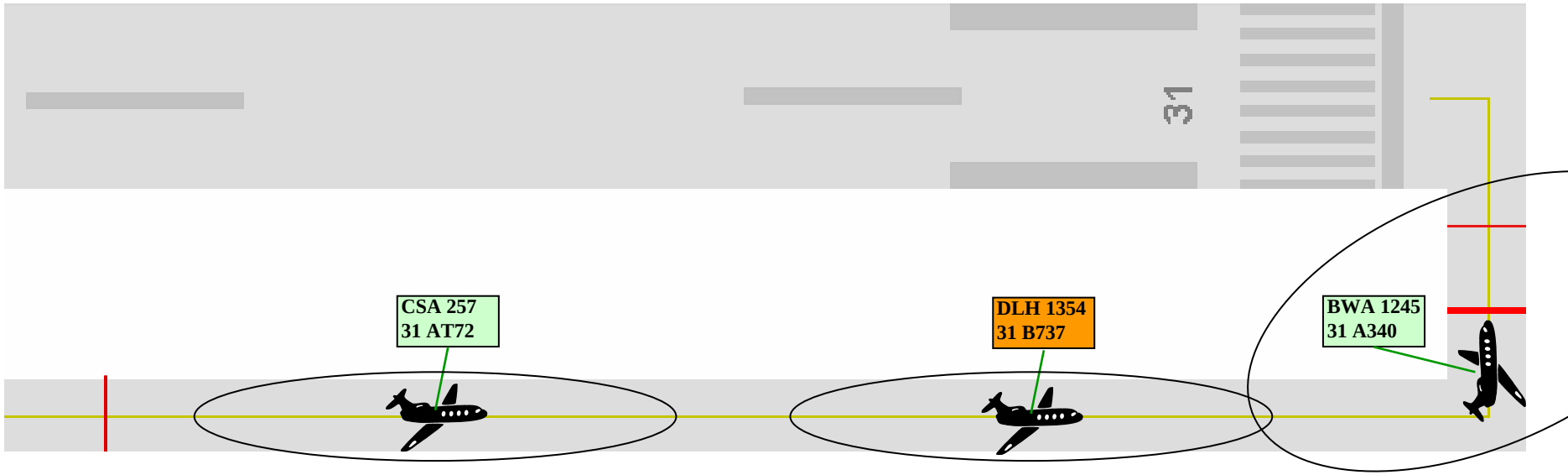
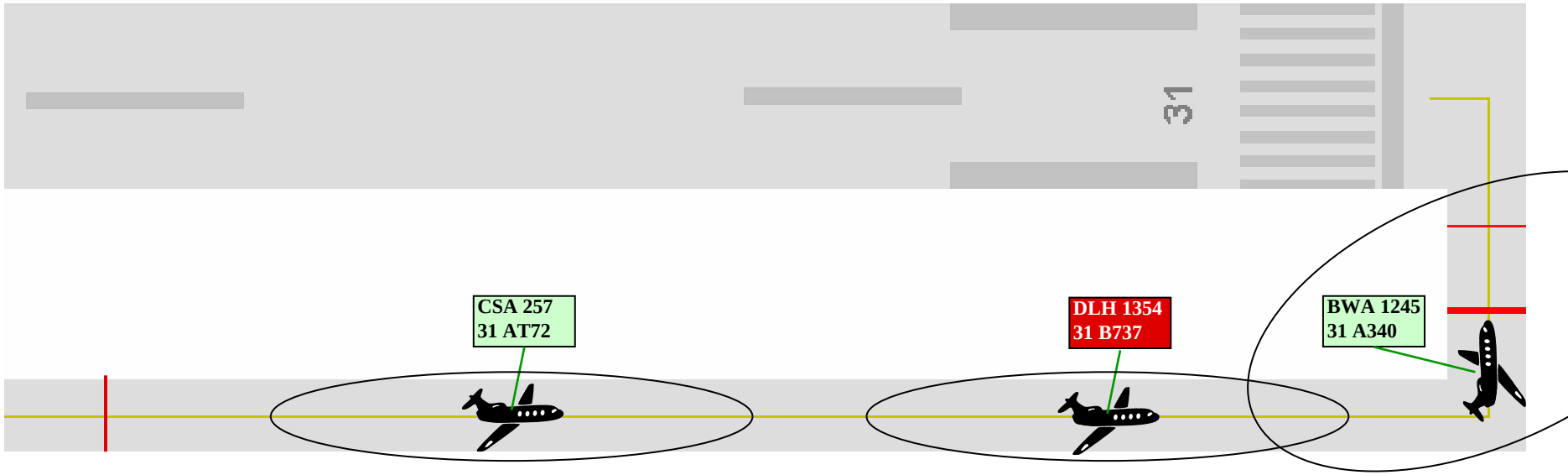


Seperation in Vis 3



Proposed Initial Implementation Packages

Traffic Density	Vis 1	Vis 2	Vis 3	Vis 4
Medium	S1 + C1	S2 + C1	S2 + C1 + A2 + V2 S3 + C4 + R3	
optional				
Heavy				
Optional				

Proposed Initial Implementation Packages

Traffic Density	Vis 1	Vis 2	Vis 3	Vis 4
Medium	S1 + C1	S2 + C1	S2 + C1 + A2 + V2 S3 + C4 + R3 S2 + C4+ V2+ R3	
optional				
Heavy				
Optional				

Proposed Initial Implementation Packages

Traffic Density	Vis 1	Vis 2	Vis 3	Vis 4
Medium	S1 + C1	S2 + C1	S2 + C4+ V2+ R3	S2 + C2 + A3 + V2
optional				
Heavy				
Optional				

Proposed Initial Implementation Packages

Traffic Density	Vis 1	Vis 2	Vis 3	Vis 4
Medium	S1 + C1	S2 + C1	S2 + C4+ V2+ R3	S2 + C2 + A3 + V2
optional	A1 + V1 R3/R4 +A2 +V1	A2 + V2 C2+R3/R4+A2+V1	R4 + A2	C4 + A4 + R3/R4
Heavy				
Optional				

Proposed Initial Implementation Packages

Traffic Density	Vis 1	Vis 2	Vis 3	Vis 4
Medium	S1 + C1	S2 + C1	S2 + C4+ V2+ R3	S2 + C2 + A3 + V2
optional	A1 + V1 R3/R4 +A2 +V1	A2 + V2 C2+R3/R4+A2+V1	R4 + A2	C4 + A4 + R3/R4
Heavy	S2 + C3 + R4	S2 + C3 + R4	S2 + C4 + V2 + R4	S2 + C3 + A3 + V2 + R4
Optional				

Proposed Initial Implementation Packages

Traffic Density	Vis 1	Vis 2	Vis 3	Vis 4
Medium	S1 + C1	S2 + C1	S2 + C4+ V2+ R3	S2 + C2 + A3 + V2
optional	A1 + V1 R3/R4 +A2 +V1	A2 + V2 C2+R3/R4+A2+V1	R4 + A2	C4 + A4 + R3/R4
Heavy	S2 + C3 + R4	S2 + C3 + R4	S2 + C4 + V2 + R4	S2 + C3 + A3 + V2 + R4
Optional	A2 + V2	A2 + V2	A2 + V3	A4 + V3

Proposed Initial Implementation Packages

Traffic Density	Vis 1	Vis 2	Vis 3	Vis 4
Medium	S1 + C1	S2 + C1	S2 + C4+ V2+ R3	S2 + C2 + A3 + V2
optional	A1 + V1 R3/R4 +A2 +V1	A2 + V2 C2+R3/R4+A2+V1	R4 + A2	C4 + A4 + R3/R4
Heavy	S2 + C3 + R4	S2 + C3 + R4	S2 + C4 + V2 + R4	S2 + C3 + A3 + V2 + R4
Optional	A2 + V2	A2 + V2	A2 + V3	A4 + V3

Eurocontrol EMMA

www.dlr.de/EMMA

Questions…?