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Automation in ATM

Moderated by: Olivia Nunez

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Levels of Automation - an Introduction

Prof. Dr. Peter Hecker

TU Braunschweig

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Automation in Aviation – where are we?

1930s

[1]

[2]

1950s

[3]

[4]

2

[5]

[6]

[7]

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Early Concepts of Automation – a desperate approach to increased demand

- **Challenge**
  - Increased demand in air transportation
  - Recognized KPAs (safety, environment, efficiency, ...)
  - Limitation in resources (human, infrastructure, airspace, ...)
- **Strategy widely followed in 1960s – 90s**
  - Overcome limitations by supporting the human as much as possible through automation
  - Automation driven by technology according to available means
- **Issue**
  - Impact of automation unclear – not always productive
  - Unbalanced use of automation (cockpit vs. ATC)
  - Philosophy of human machine interaction not fully understood

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Flight Guidance - AIRBORNE

Cockpit 70s (B747)

3-4 Pilots & Navigation crew
Analogic display
Mechanical aircraft steering
VHF Radio
Autopilot

Cockpit Today (A380)

1 Pilots crew
Digital & Head-Up Displays
Fly by Wire & Single Cockpit Approach
Satellite communication and data link
Flight Management System

AIR TRAFFIC MANAGEMENT - GROUND

ATC Position 70s

2 Air Traffic Controllers
Analogic display
Paper strips
Phone coordination
VHF Radio Clearance
National radar feed

ATC Position Today

2 Air Traffic Controllers
Digital display
Paper or electronic strips
Phone coordination
VHF Radio Clearance
National radar feed
Multiple support systems in situation assessment, less in decision making

Levels of Automation – categorizing human machine interaction

Early approaches, e.g. :

- Fitts 1951: MABA-MABA lists
- Sheridan & Verplanck 1978: automation is not “all or nothing” instead: assessing the extent of automation per task
- Taxonomy: LoA for decision and action selection: The computer ...

LOW	1	... offers no assistance, human must take all decision & action
	2	... offers a complete set of decision / actions alternatives
	3	... narrows the selction down to a few
	4	... suggests one alternative
	...	
	9	... informs the human only if deemed necessary
HIGH	10	... decides everything, acts autonomously, ignores the human

Levels of Automation – categorizing human machine interaction

- Endsley & Kaber (1999): 10 level taxonomy

	Monitoring	Generating	Selecting	Implementing
(1) Manual Control	H	H	H	H
(2) Action Support	H	H	H	H/C
(3) …	H/C	H	H	C
(4) …	H/C	H/C	H	H/C
(5) …	H/C	H/C	H	C
(6) …	H/C	H/C	H/C	C
(7) …	H/C	C	H	C
(8) …	H/C	H/C	C	C
(9) Supervisory Ctrl.	H/C	C	C	C
(10) Full automation	C	C	C	C

Levels of Automation – categorizing human machine interaction

- So far most schemes had deficencies in the ATM domain
- SESAR supported the development of a specifically adapted scheme:

LOAT – Levels of Automation Taxonomy

Information Akquisition	Informatio n Analysis	Decision & Action Selection	Action Implement.
A0	B0	C0	D0
A1	B1	C1	D1
A2	B2	C2	D2
A3	B3	C3	D3
A4	B4	C4	D4
A5	B5	C5	D5
		C6	D6
			D7
			D8

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From information to action →

Increasing automation ↓

A INFORMATION ACQUISITION	B INFORMATION ANALYSIS	C DECISION AND ACTION SELECTION	D ACTION IMPLEMENTATION
A0 Manual Information Acquisition	**B0** Working Memory Based Information Analysis	**C0** Human Decision Making	**D0** Manual Action and Control
A1 Artefact-Supported Information Acquisition	**B1** Artefact-Supported Information Analysis	**C1** Artefact-Supported Decision-Making	**D1** Artefact-Supported Action Implementation
A2 Low-Level Automation Support of Information Acquisition	**B2** Low-Level Automation Support of Information Analysis	**C2** Automated Decision Support	**D2** Step-by-Step Action Support
A3 Medium-Level Automation Support of Information Acquisition	**B3** Medium-Level Automation Support of Information Analysis	**C3** Rigid Automated Decision Support	**D3** Low-Level Support of Action Sequence Execution
A4 High-Level Automation Support of Information Acquisition	**B4** High-Level Automation Support of Information Analysis	**C4** Low-Level Automatic Decision Making	**D4** High-Level Support of Action Sequence Execution
A5 Full Automation Support of Information Acquisition	**B5** Full Automation Support of Information Analysis	**C5** High-Level Automatic Decision Making	**D5** Low-Level Automation of Action Sequence Execution
		C6 Full Automatic Decision Making	**D6** Medium-Level Automation of Action Sequence Execution
			D7 High-Level Automation of Action Sequence Execution
			D8 Full Automation of Action Sequence Execution

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LOAT – Level of Automation Taxonomy a new approach tailored for ATM

Advantage:

- Multiple LOA per system possible
- Automation assessed in relation to human performance

Example: TCAS autopilot / flight director coupling

- SESAR solution 105, R1
- Conventional TCAS:

  C4: generates options, decides on actions, informs human

  D2: assists human in execution
- AP/ FD TCAS :

  C4: generates options, decides on actions, informs human

  D6: initiates and executes action, human monitors & can interrupt

LOAT → A valuable approach to gain deeper understanding of levels of automation

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References

- [1] Photo Credit To Wikipedia Commons/Amelia Earhart, Los Angeles, 1928 X5665 – 1926 "CIT-9 Safety Plane" – California Institute of Technology (CalTech) Aerospace model 9 Merrill-type biplane designed by Albert Adams Merrill (Instructor in Aeronautics); 45hp Kinner engine; wingspan: 24'0"
- [2] FAA/National Archives - http://www.faa.gov/about/media/Archumb.jpg
- [3] Geni - Photo by user:geni, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=19810682
- [4] http://www.island-images.co.uk/ATC/zRon1950s/Preston%20ATCC%20D1.html
- [5] https://commons.wikimedia.org/wiki/Airbus_A380#/media/File:Airbus_A380_cockpit.jpg
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- [7] DFS Deutsche Flugsicherung GmbH

Thank you for your attention

More information:

<p.hecker@tu-bs.de>

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Automation in ATM
SESAR 2020 R&D

Mihail Genchev

EUROCONTROL

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Automated assistance for ATCOs

- **Today's ATM operating method is changing**
  - Towards Trajectory Based Operations (TBO)
- **Cannot afford to sit back and wait for TBO**
  - Especially in increasingly busy / complex environments
- **Need to manage ATCO workload during transition**
  - Keeping them in the loop
  - Ultimately in charge

Automated assistance for ATCOs

- **Routine Controller tasks make ideal subjects to target**
  - Allows resources (ATCO, frequency, etc) to be used efficiently and increase performance
  - Allows ATCOs to concentrate on High Value tasks
- **Following is one example of potential automation**
  - Will be researched / developed in Pj18
  - Preparation / delivery of 'routine' arrival descent clearances 'in advance' (e.g. Descend when Ready)
  - MUAC airspace
  - Others also being considered (e.g. downstream clearances)

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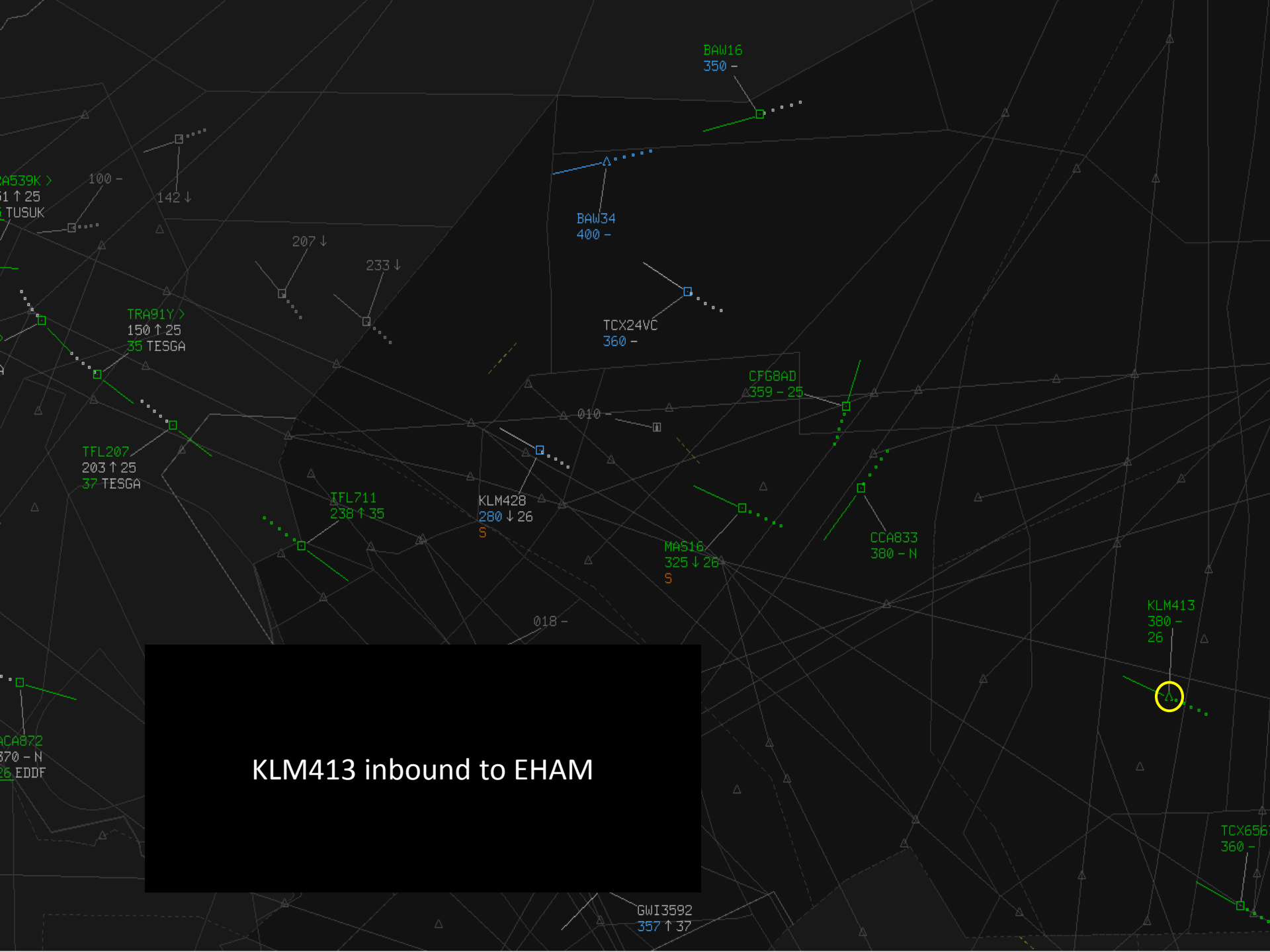
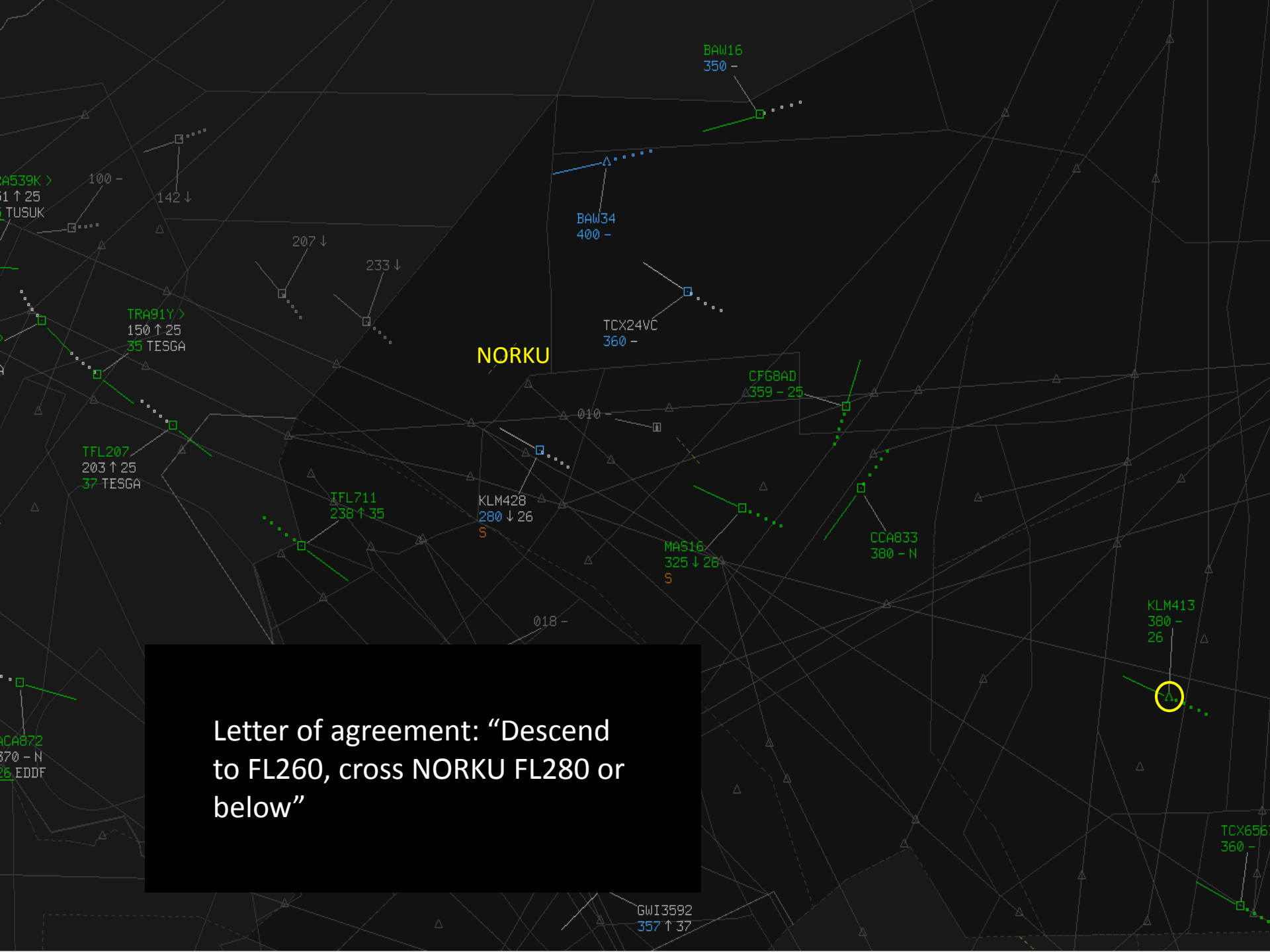
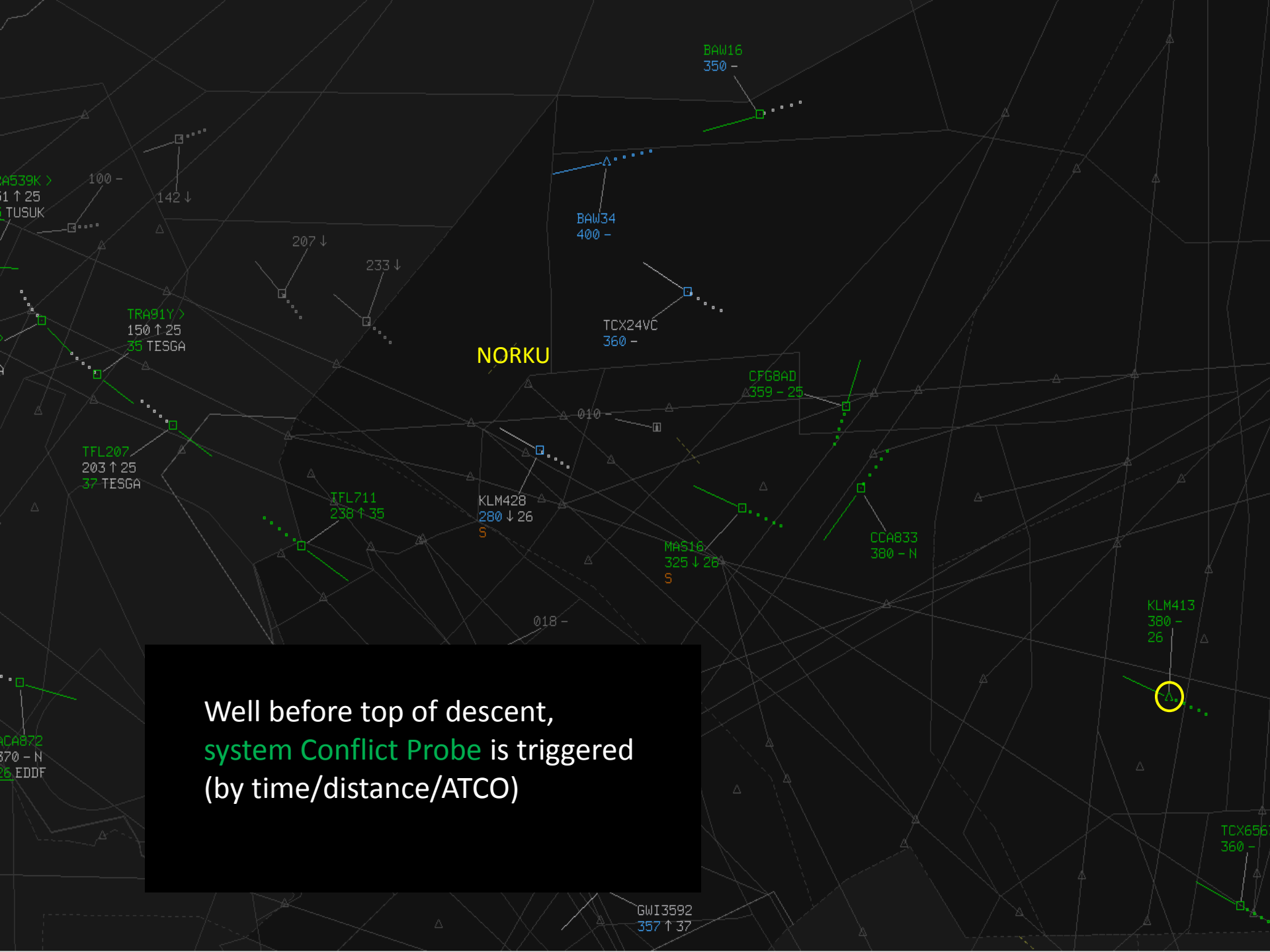


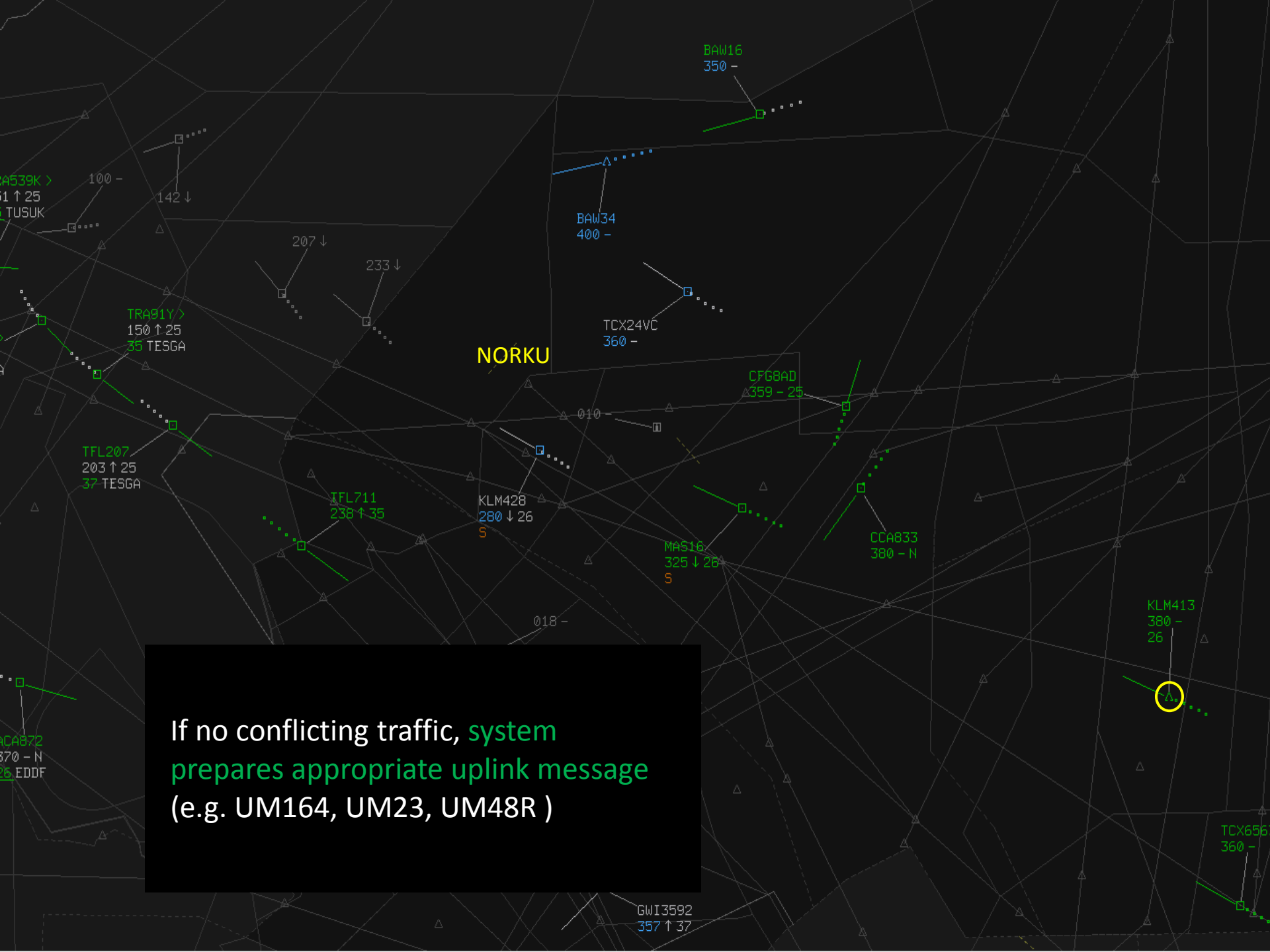
KLM413 inbound to EHAM



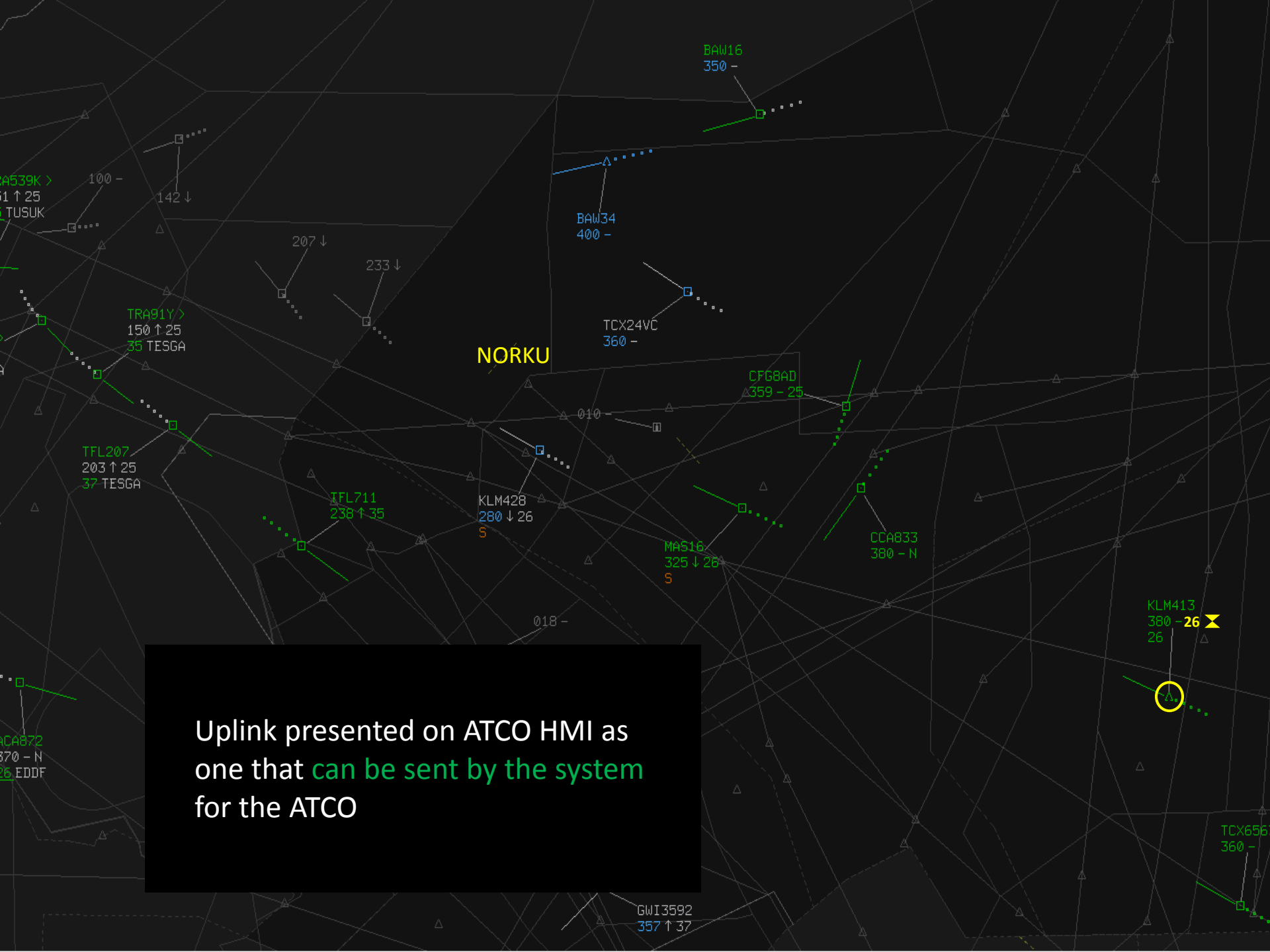
Letter of agreement: “Descend to FL260, cross NORKU FL280 or below”



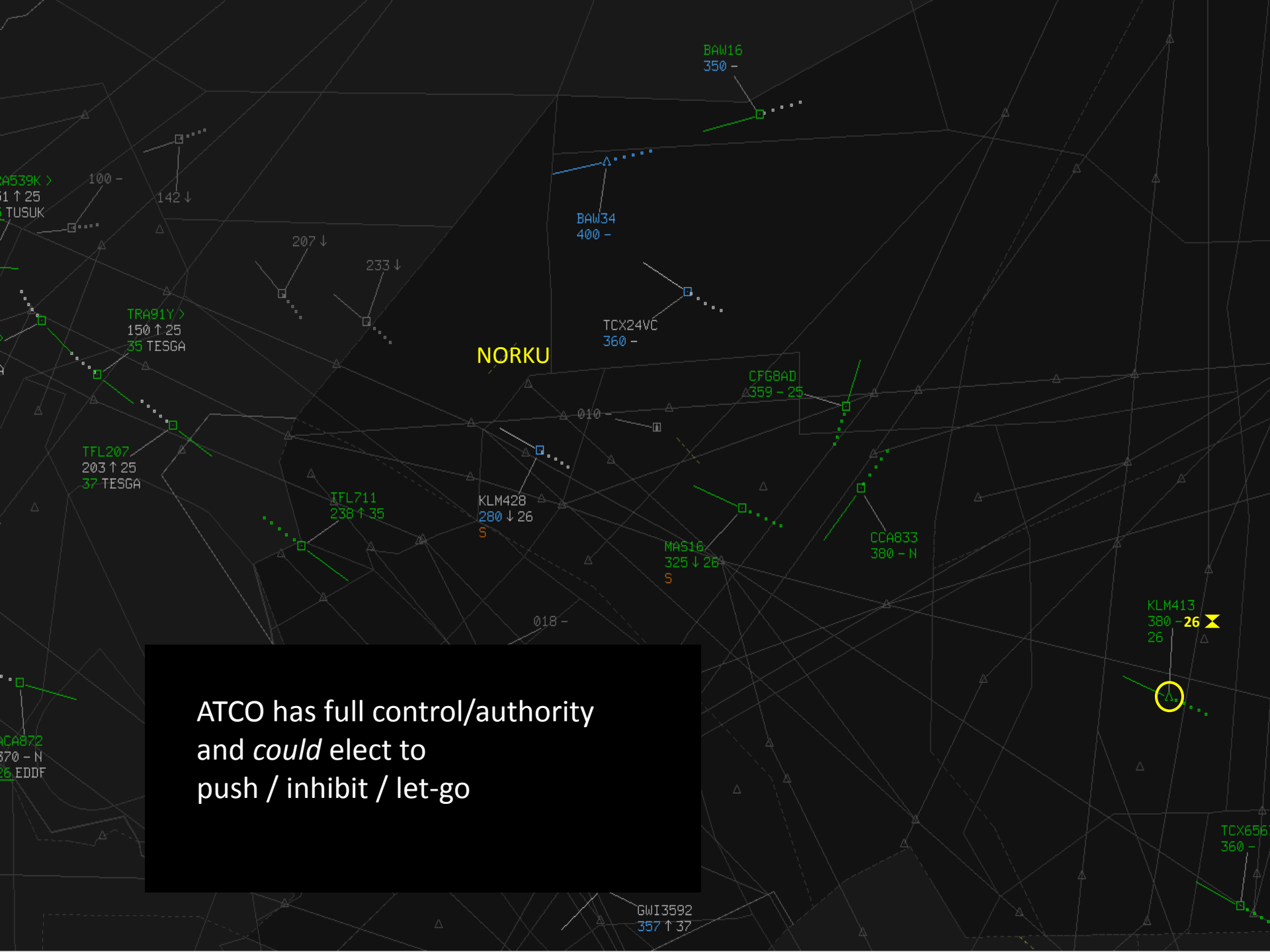
Well before top of descent,
system Conflict Probe is triggered
(by time/distance/ATCO)



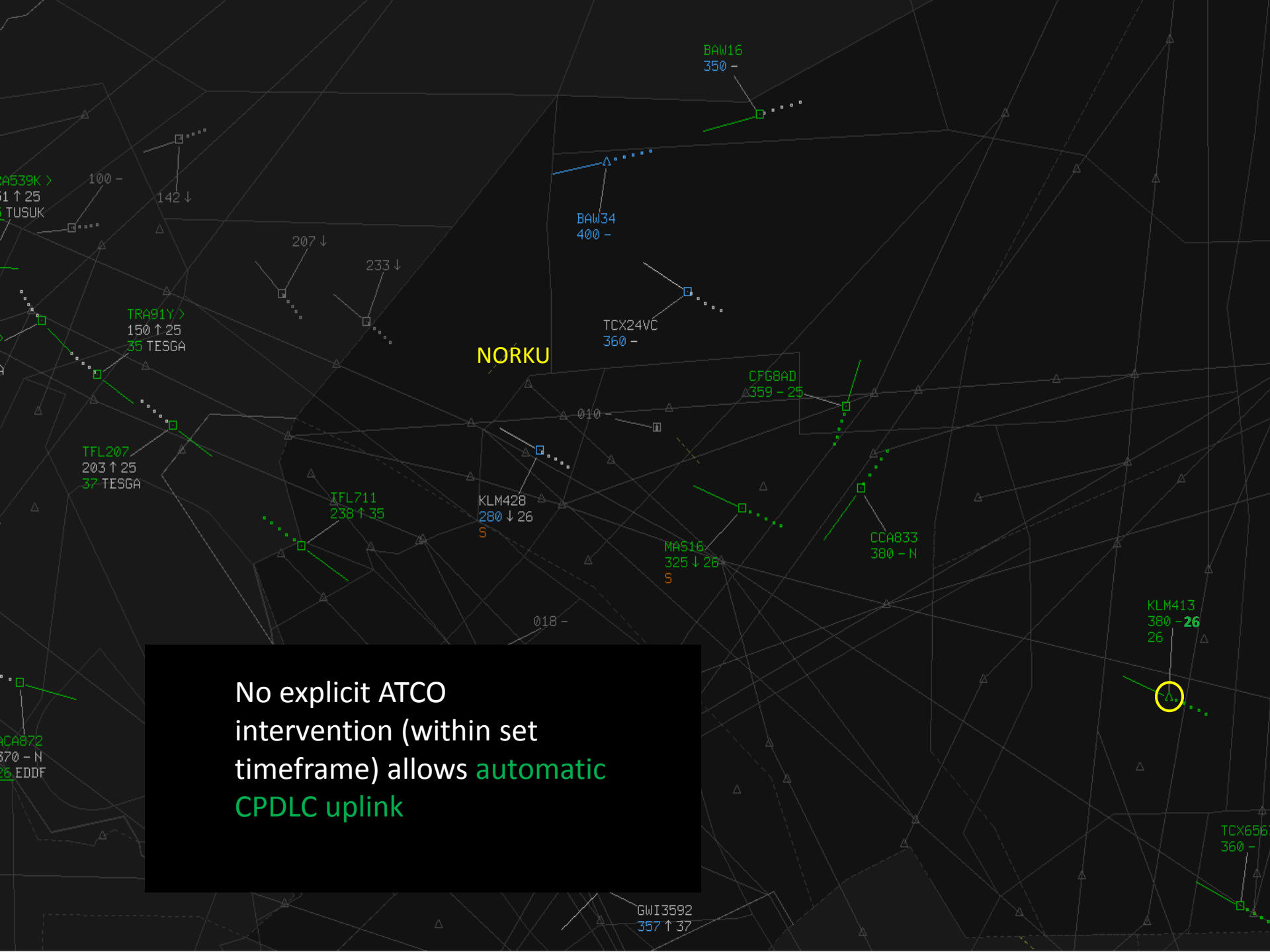
If no conflicting traffic, system prepares appropriate uplink message (e.g. UM164, UM23, UM48R)



Uplink presented on ATCO HMI as one that can be sent by the system for the ATCO



ATCO has full control/authority
and *could* elect to
push / inhibit / let-go



No explicit ATCO intervention (within set timeframe) allows automatic CPDLC uplink

Research will . . .

- **Identify and Address Safety Aspects**
  - Confirm selected tasks are good and can help - in a safe way
- **Address Appropriate Procedures**
  - On the Ground and Airborne side
- **Identify Appropriate Messages**
  - Identify correct messages to use (and/or any potential gaps)
- **Define Trigger Parameters**
  - Time / Distance / ATCO
- **Develop appropriate HMI**
  - Albeit within a local context

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Thank you for your attention

More information:

mihail.genchev@eurocontrol.int

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Ensuring safety in an increasingly automated ATM environment

Bryan Jolly

EASA

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Emergent behaviours in automation

The system is not always a sum of its parts

Mode S Selected Flight Level downlink

On SIDs/STARs, MCP/FCU is not always controlling the next level—off (depends on navigation mode)

Airborne architecture not uniform across aircraft

Procedures not the same for different airspace users

Improvement may result in false alerts and increase workload for both flight crews and ATC.

The regulator perspective

- **Safety needs to be ensured at all times**
  - Human Performance must be taken into account from the start
  - But not all potential issues will be pre-empted
  - In-service monitoring is needed to identify emergent behaviours
  - Theses monitoring processes are part of the ATM Safety Management Systems (SMS)

Thank you for your attention

More information:

<bryan.jolly@easa.europa.eu>

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Automation & IFATCA

Patrik Peters

President & CEO, IFATCA

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Automation in ATM – its nothing new

Automation

Standing agreements

Radar

FDP

Code Callsign conversion

Secondary Radar – Mode A/C

Labelled displays

RDP

STCA

IRVR

OLDI

EFD

Monopulse

SSR

MODE S

HIPS

PHARE

MODE S DAPS

AMAN

MTCA

CPDLC

MTCD/TP

TBS

1951 | 1960 | 1970 | 1980 | 1990 | 2000 | 2010

Automation 'Theory' & Research findings

The 'Fitts' List

'Ironies of Automation'

Brittle systems

Function allocation

Cognitive Work

Mode awareness

Clumsy automation

Automation as a Team player

Automation Surprises

Levels of automation

Data Overload

'Work"

Joint Cognitive systems

Complex systems Co-agency

Resilience

Laws of cognitive work

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What can be learnt from the flight deck?

- You need clear expectations of the role and what human and pilot actually do
  - The 2012 CAST-PARC report, itself a second look at automation on the flight deck – Finding 10
- Integrate human and automation
  - Work… The nature of Work..
  - NATS iFACTS AP15 Website
- *"We have reduced training and increased automation" (Airbus, 2013)*
  - *There is a problem'*

Has ATM Learnt these lessons?

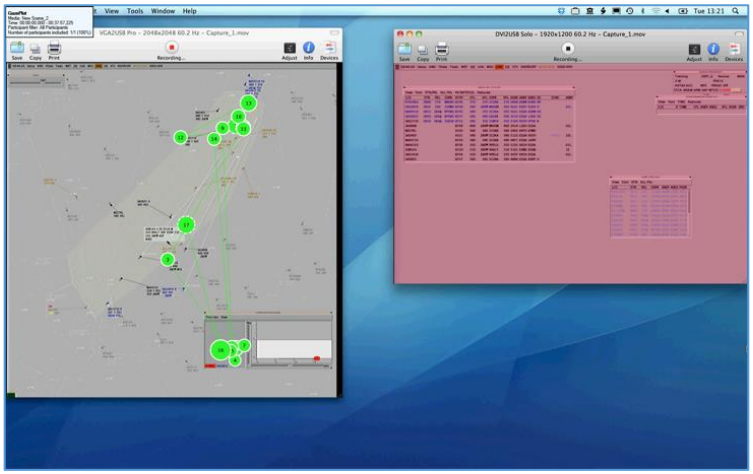
NO

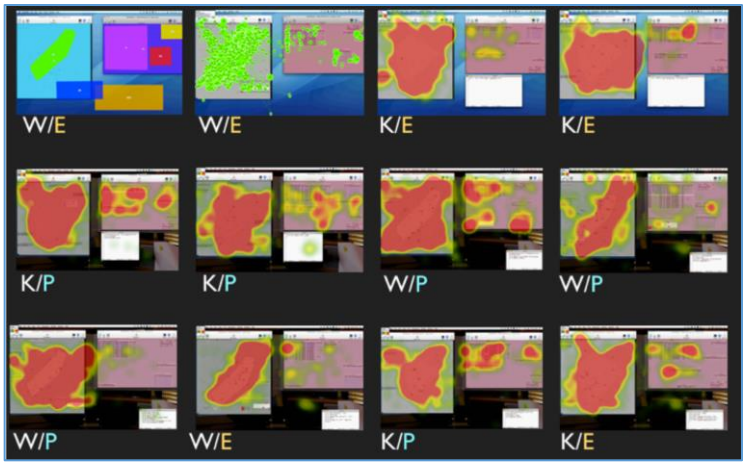
IFATCA Members experience -1

Experience with automation has shown that:

- The nature of work changes – and processes that support work –
  - Example: LFV
- Blurred responsibilities and double binds – who is doing what
- New Complexities
- Less transparent interactions
- Systems fail… etc. etc
- Example:

AP15 - URET





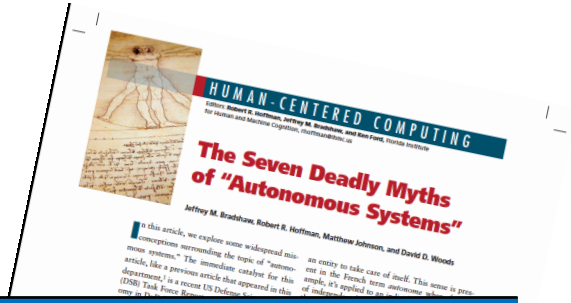
Lundberg, 2012

SO, why should ATCOs believe anything that system designers say….

It is evident that there are numerous misconceptions about the role and place that automation plays in new designs. The consequences, which are experienced by many controllers, pilots and engineers day in and day out often stem directly from these. Bradshaw et al (Bradshaw, 2013) refer to some of these as the "Seven deadly myths of "Autonomous Systems':

Bradshaw, 2013 'The seven deadly myths of autonomous systems

The Fitts' List is alive and well, but… Complexity emerges


HUMAN-CENTERED COMPUTING

The Seven Deadly Myths of "Autonomous Systems"

Jeffrey M. Bradshaw, Robert R. Hoffman, Matthew Johnson, and David D. Woods

Putative benefit	Real complexity
Human Errors are reduced	Machines, humans & cognitive work systems are fallible – errors are systemic
Increased Performance is substituted	Practice is transformed, the roles of people change
Frees up human by offloading work to the machine	Creates new kinds of cognitive work., often at the wrong time
Less human knowledge is required	New knowledge and skills demands are imposed on the human, and can end up out of the loop: automation surprises
Agent will function autonomously	Team play & coordination with other agents is essential – Joint cognitive, or Co-agent systems

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Bradshaw, 2013 'The seven deadly myths of autonomous systems

One way of looking at change of role and work

Change in role	Emergent property
Demanding higher skills and levels of performance	Exceeds human capability
Reducing operating tasks to passive monitoring	Deskilling, tedium, low system comprehension, leading to low morale,
Automating functions	Reduces ability to intervene
Reduces humans ability to deal with the unexpected	

What are we designing our systems for?

A Complex world?

There are good examples that can be drawn from – what IFATCA expects

- **The term 'Automation' is not helpful - lets stop using it**
- **There are examples of good and less than good human-system integration.**
  - Do we understand why they are so?
- **Human-system integration & joint work' is not necessarily 'bad. Change management makes it so, IFATCA argues, where it does not facilitate adapting to a complex world**
- **Neither ATCO nor system designer truly know what the 'new' work looks – good 'joint-cognitive work' follows some rules: lets use them**

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Thank you for your attention

More information:

patrik.peters@ifatca.org

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More information:

<olivia.nunez@sesarju.eu>

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