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AN ATM BASED CONCEPT FOR THE INTEGRATED TRANSPORT OF THE MULTIMEDIA DATA FROM ARTEMIS TELEPRESENCE SYSTEM

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An ATM Based Concept for the Integrated Transport of the Multimedia Data from ARTEMIS Telepresence System


by
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View of the Experimental ARTEMIS Implementation at FZK



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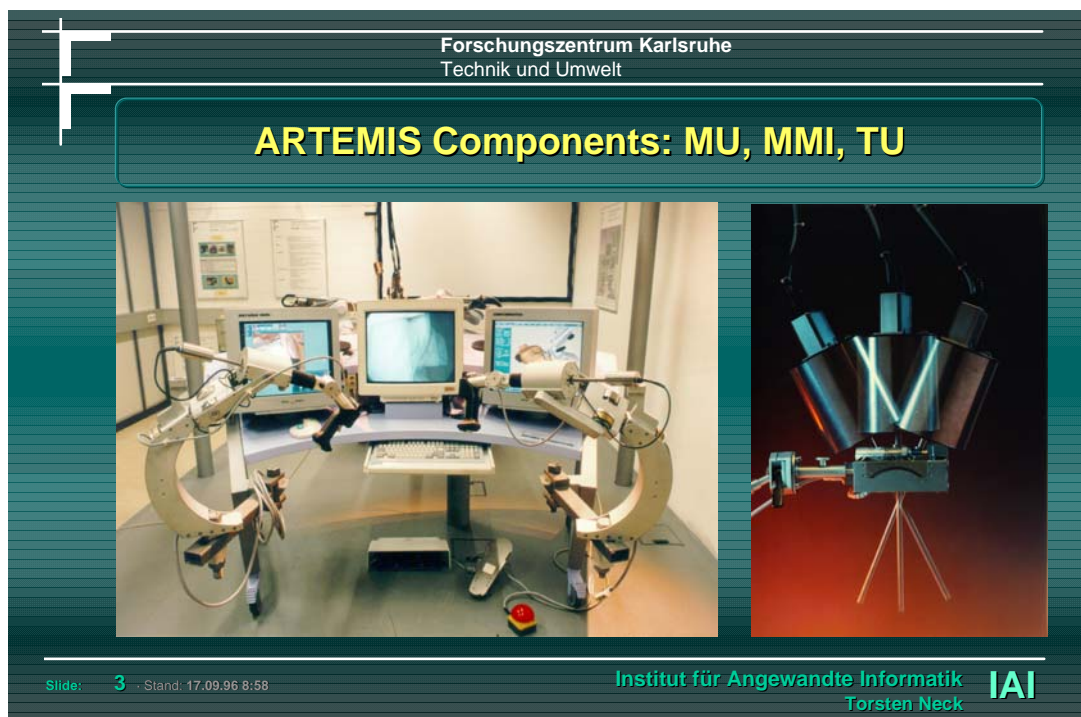
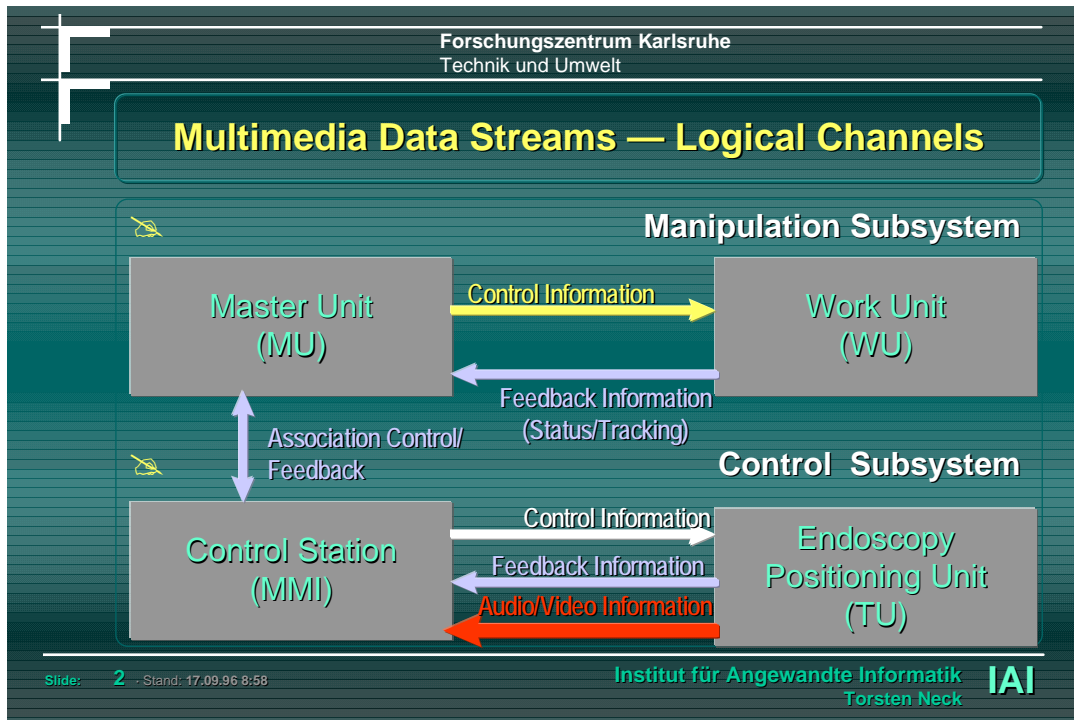
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An ATM Based Concept for the Integrated Transport from ARTEMIS Telepresence System

Mr. Chairman, thank you very much for your introduction.

Dear Sirs, ladies and gentlemen,

[Slides 0 and 1] I would like to present you an ATM based concept, which allows to control our telepresence system ARTEMIS in the usual manner – using MONSUN – but which is also capable of integrating the necessary audio and video information originated by surrounding cameras and especially the endoscope. May we have the next slides, please.



[Slides 2 and 3] As you already know the ARTEMIS system consists of at least **4 units**:

- the **master unit (MU)** which controls [slide 3 left picture]
- the **telemanipulator or work unit (WU)**. [slide 3 left picture in the background]

Together, they build the **telemanipulation subsystem**. In addition there exists – important for the feedback – what I call the **control subsystem**, consisting of the

- **control station**, called **Man Machine Interface (MMI)** [slide 3 left picture foreground] and
- the **endoscopy positioning unit** with the endoscope camera which – in terms of the MONSUN control concept – is a **Tracking Unit (TU)** [slide 3 right picture]

Between these units the typical **MONSUN information channels** are established **independently** [slide 2]:

- first of all: the most important **control channel** which makes up the **telemanipulation itself**
- and there is some **feedback information** (actual position for tracking purposes, or force reflection) from the WU to the Master.

In the **control subsystem** you can see

- an **additional control information channel** for the positioning actions of the endoscopy positioning unit
- the **correspondent feedback channel** carrying the actual position and
- most important in this subsystem: **the audio video information from the endoscope itself**.
- You will also find the association control and feedback channel which makes the link between the two subsystems.

With respect to the different **types** of information

- **discrete information** in the control context and
- **continuous audio and video** information

we are confronted with a typical **MULTIMEDIA SYSTEM**.

Please, let me show you some more detailed characteristics of those multimedia data channels with the next slides – may we have them, please.

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Quality of Service (QoS) Requirements of the ARTEMIS Communications Channels

Channel	OoS	Band- width	Traffic charact.	Propag. delay	Media charact.	Iso- chronity	Data loss sensitivity
Primary control		◆	ABR	◆◆◆	shared	○	◆◆◆
TU control		◆	ABR	◆◆	shared	○	◆
WU feedback		◆	ABR	◆◆◆	shared	○	◆◆
TU feedback		◆	ABR	◆◆	shared	○	◆
A/V feedback		◆◆◆	CBR/VBR	◆◆◆	dedicated	◆◆◆	◆◆
Association control		◆	ABR	◆	shared	○	◆

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Main Quality Parameters for Multimedia Communications

✂ Bandwidth requirements	
☞ Data rate requirements	[bit/s]
☞ Traffic characteristics	“CBR”/“VBR”/“ABR”
✂ Delay requirements	
☞ Propagation delays	“signal speed”, “switching delay”
☞ Media characteristics	“shared”/“dedicated”
✂ Needs for isochronous service	“jitter”
✂ Sensitivity for data loss	“bit error rate”/“cell loss rate”

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[Slides 4 and 5] This matrix lists up all the independent information channels which I have introduced. They are arranged in the lines of the matrix. The columns show some Quality of Service parameters which are explained by the right slide.

I only want to point out the most important details:

- As you can see in the bandwidth column, telemanipulation is not a problem of high bandwidth,
- the only bandwidth consuming information in the whole system is the A/V channel.

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- The A/V channel is a **completely different** type of data flow compared to control and feedback channels.
This is due to the fact, that A/V represents the **continuous medium** whereas all other channels are of the **discrete** type.

What else is to be underlined? It is: The **propagation delay** is the **determining quality parameter** for the whole telepresence system, for all types of channels!

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Realization Alternatives: Conventional LANs and ATM-Networks

- **Conventional local area network (LAN)**
 - ☞ based on "CSMA/CD" or "Token Passing"
 - ☞ ☹ shared medium → **unpredictable delays**
no bandwidth guarantee, only unisynchronous service
 - ☞ ☺ entirely standardized, low costs
- **Integrated Broadband Communications Network (IBCN)**
 - ☞ based on "Asynchronous Transfer Mode" (ATM)
 - ☞ ☺ all QoS requirements supported,
high bandwidth available, tolerable and constant delays
 - ☞ ☹ not wide spread, very high costs

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[Slide 6] So let us have a look at the different network candidates for the realization of the ARTEMIS multimedia system:

- First, we have the **conventional local area networks** like Ethernet or FDDI: their benefits are, that they are **entirely standardized** and **available all over the world** at **low costs**, but, as I have put it down on the slide, their **disadvantages** are the **shared media** which lead to **unpredictable delays**, and the **absence of bandwidth guarantees**, which only allow an **un-isochronous** communication service.

Though, with adequate restrictions, they are **acceptable for the control** channels, they are **not suitable for the continuous media** audio and video.

- For these media we should use ATM networks like the IBCN or B-ISDN: With them we can **provide the corresponding data services** in a very **flexible manner**, with them **high bandwidths** are available and there are **short delays** (in the range of microseconds) and these short delays are **deterministic and constant!**

The **disadvantage** of ATM is that it is a new technology which is not very wide spread up to now, and only available at expensive costs!

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Additional Alternatives for Long Distances: Narrowband ISDN and Satellite Links

✎ ISDN — Integrated Services Digital Network

- ☞ 😊 all QoS requirements supported, **tolerable delay**
- ☞ 😞 **low bandwidth** (standard: 64 kbps)
- ☞ 😊 very wide spread, affordable costs

✎ Satellite link with relay stations (remember SMIT 1994!)

- ☞ 😞 proprietary codecs (coder-decoder), no data link services
- ☞ 😞 medium bandwidth, **untolerable delay (up to 2sec)**
- ☞ 😞 **untolerable error rates**
- ☞ 😞 very high costs

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[Slide 7] Let's take a glance at the long distance alternatives, too:

If we look for a wide spread **long distance network** which may be used for a multimedia telepresence system (for **teleconsultation** or **virtual reality teletraining**) at the moment the **only acceptable candidate** (besides ATM) might be the **narrowband ISDN**.

- The most important disadvantage of ISDN however is the lack of bandwidth, so that you are urged to cumulate up to 4 or 5 network endpoints.
- As you can read from the **sadly looking faces** in front of the **satellite characteristics** this **definitely is no adequate solution!** (Especially due to the fact that the main quality requirement for a telepresence system is the guarantee of short delays, and that is what is worst when you use a satellite: up to 3 secs roundtrip time!)

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Basic MONSUN Implementation of ARTEMIS

Non integrated solution: LAN and analogue network

Characteristics:

- ☞ Unpredictable but acceptable delay (due to local restrictions of LAN)
- ☞ Connectionless services, fault sensitive (due to shared medium)
- ☞ Separate digital and analogue lines

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[Slides 8, 10, 12] In the ARTEMIS test bed we have started with a **non integrated** solution using Ethernet as the digital control network (shown by the light line) and carrying the audio video information separately over analogue lines (the red arrow).

The delay problem is arbitrated by restricting the network access: on the ethernet segment only participants in the telepresence scenario are admitted.

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Semi Integrated Implementation of ARTEMIS

Semi integrated multimedia: LAN and digitized A/V

Characteristics:

- ☞ Integrability of A/V into MMI (due to digital transport over ATM)
- ☞ Availability of wide range scenarios (due to standardized transports)

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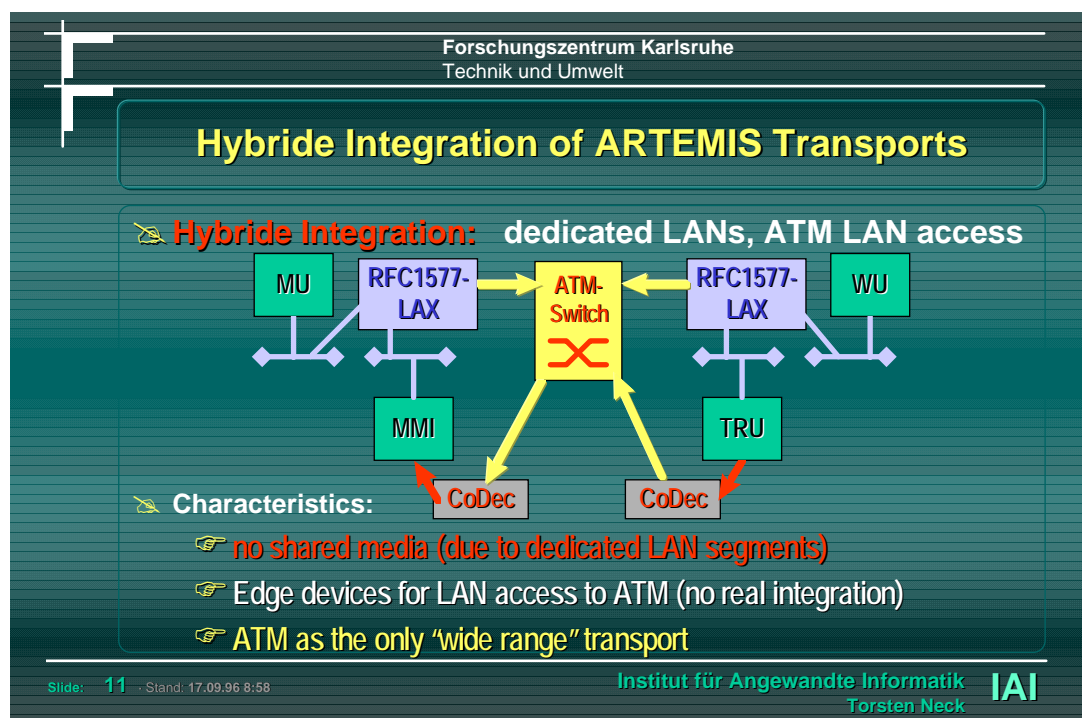
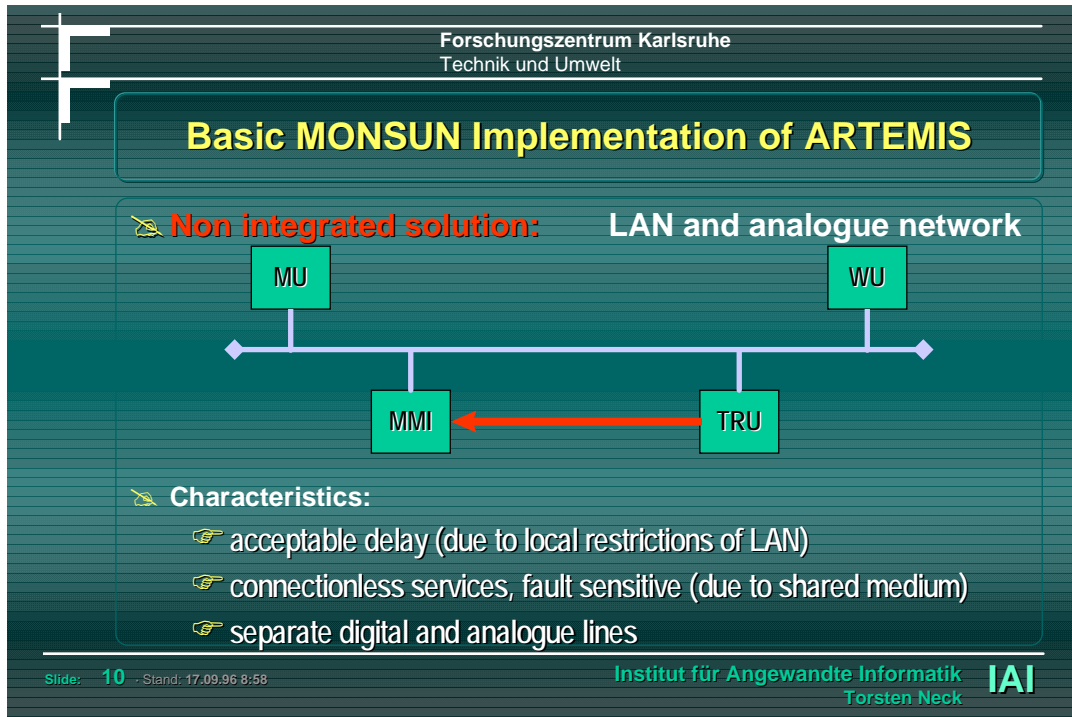
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[Slide 9] Our first step towards integration was the **digitization** of the audio video information by the use of special ATM coders and decoders (you call them shortly CODECS).

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Due to the standard coding and compression technique it was possible to partly integrate the video into the MMI workstation.

With the digital transport of control and A/V information – still on two separate but digital networks – the scenario could be extended to non local use.



[Slide 11] The next step – and this is the state of our system at the moment – was to banish the separate digital networks to the periphery and to bundle all the data streams in the one ATM interface transport.

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We introduced so called **EDGE DEVICES** or **LAN ACCESS SWITCHES** which permit separate and independent Ethernet segments to be „BRIDGED OVER“ or „TUNNELLED THROUGH“ ATM.

Thus every unit has got it's own ethernet segment – eliminating 'access conflicts and reducing delay. All segments (and thus all units) are connected to the central ATM high performance network via the LAN ACCESS SWITCHES (LAX).

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Basic MONSUN Implementation of ARTEMIS

Non integrated solution: LAN and analogue network

```

graph TD
    Bus(( )) --- MU
    Bus --- WU
    Bus --- MMI
    Bus --- TRU
    TRU --> MMI
  
```

Characteristics:

- acceptable delay (due to local restrictions of LAN)
- connectionless services, fault sensitive (due to shared medium)
- separate digital and analogue lines

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Future Implementation: ARTEMIS — Fully Integrated with Native ATM

Fully integrated solution: one single network/protocol

```

graph TD
    ATM[ATM-Switch] <--> MU
    ATM <--> WU
    ATM <--> MMI
    ATM <--> TRU
    MMI --- CoDec1[CoDec]
    TRU --- CoDec2[CoDec]
  
```

Characteristics:

- One single network and protocol without range restrictions
- flexible and appropriate QoS parameters
- fully integrated MMI without "dual attachment" to the network

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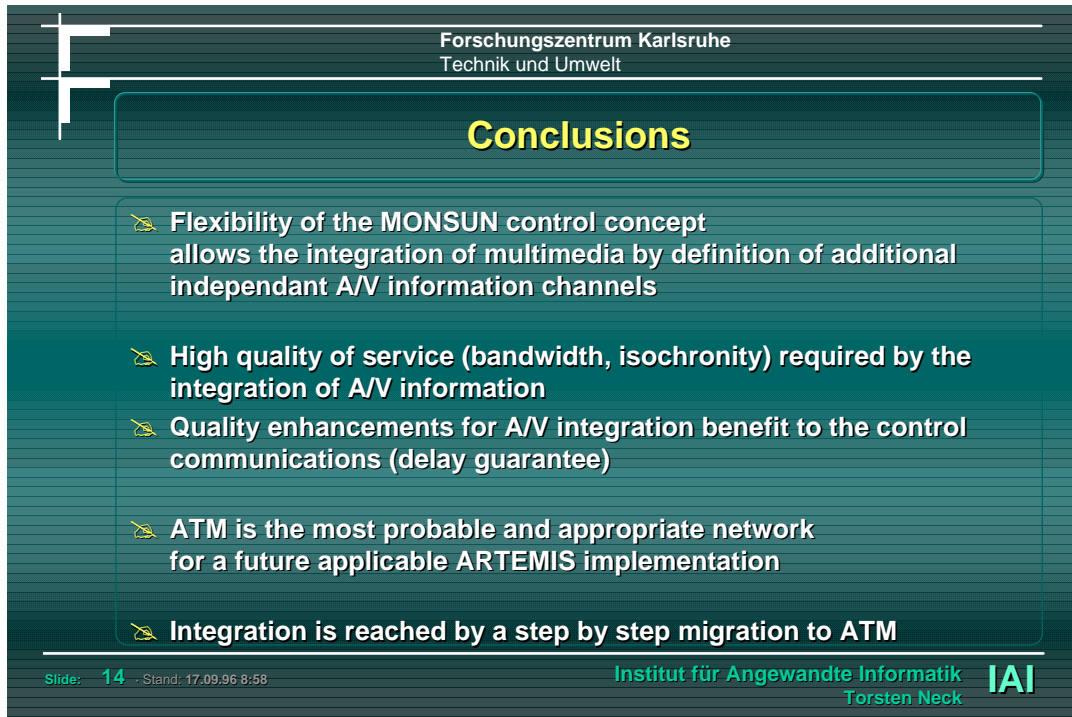
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[Slide 13] And finally: our next step will be the total elimination of edge devices and the only use of ATM - so called **NATIVE ATM** - for all the transport, thus reducing the complexity.

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And – as you can see in comparison to the initial solution – we will have the same complexity but with a changed TOPOLOGY: no more bus or shared medium, but dedicated lines with a single dedicated, parameter controlled protocol.

May we have the last slides please.



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Conclusions

- ✎ Flexibility of the MONSUN control concept allows the integration of multimedia by definition of additional independant A/V information channels
- ✎ High quality of service (bandwidth, isochronity) required by the integration of A/V information
- ✎ Quality enhancements for A/V integration benefit to the control communications (delay guarantee)
- ✎ ATM is the most probable and appropriate network for a future applicable ARTEMIS implementation
- ✎ Integration is reached by a step by step migration to ATM

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[Slides 14 and 15] You can read my conclusions on the left slide. If you have further questions feel free to contact me with the address and numbers presented on the right slide. Thank you very much for your attention.



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Thank you very much for your attention.

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