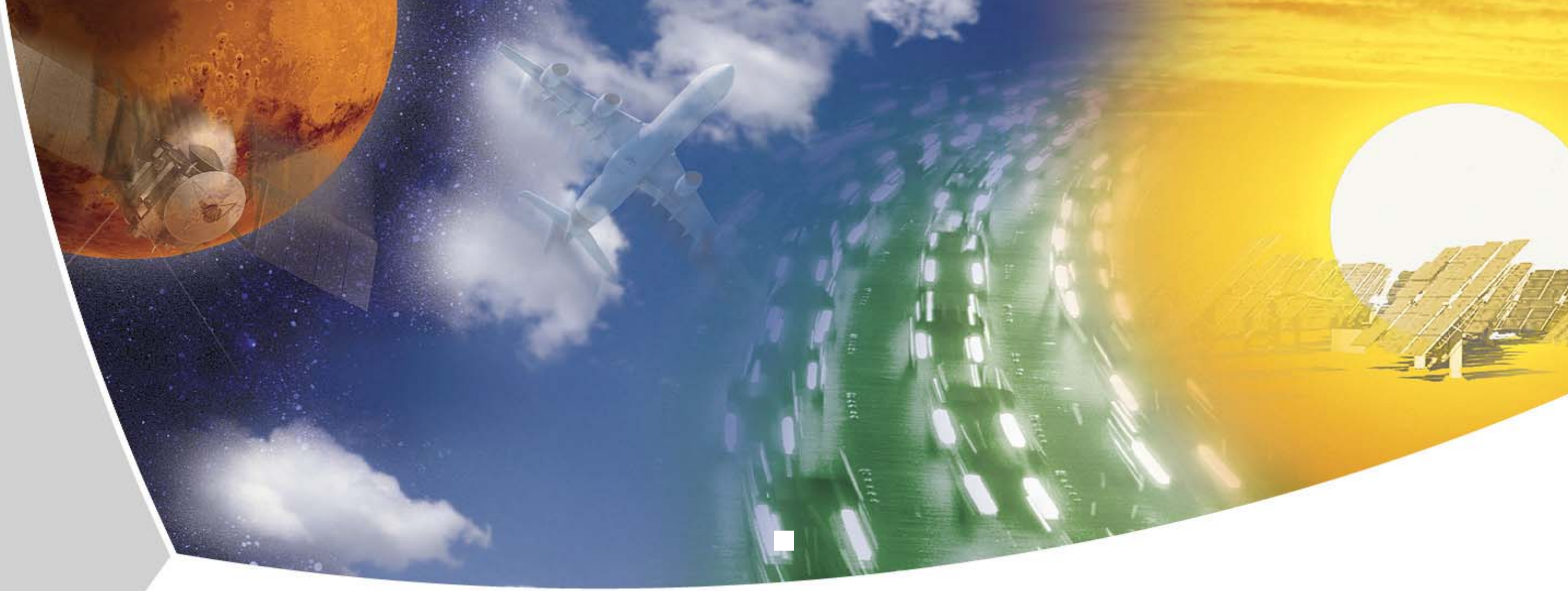

Airport CDM: The Contribution of the XMAN Approach

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Introduction

- Many projects have contributed to the CDM concept
  - DAVINCI
  - LEONARDO
  - Gate to Gate
  - C-ATM
  - Nordic SWIM
  - ...
  - Eurocontrol CDM Project
    - Airport CDM Implementation Manual
    - Airport CDM Applications – Operational Concept Document
    - Airport CDM Applications – Level 1, Functional Requirements
    - The European CDM Portal on the Internet: http://www.euro-cdm.org

Conclusion

Read these documents carefully and you will know everything about CDM !!!

..., but

... there are still some questions that need further consideration, like

- **How to use existing/future decision support systems for collaborative decision making?**
- **How to incorporate preferences of other partners in the decision making process?**
- **How to evaluate an improved predictability of operations, events, necessary resources, etc.?**

Intention and Content of Presentation

Intention of the Presentation

- **Provide an insight in the coordination of XMAN decision support tools and the resulting contribution to CDM**
- **XMAN: Decision Support Tools based on planning algorithms**
  - **AMAN (Arrival Manager)**
  - **DMAN (Departure Manager)**
  - **SMAN (Surface Manager)**
  - **TMAN (Turn-around Manager)**
  - EMAN (En-route Manager)
  - ADCO (Arrival Departure Coordination Layer)

Content

- **Brief overview about the CDM-A objectives, partners and elements**
- **Brief overview about the XMAN approach, its objectives and status**
- **AMAN – TMAN – DMAN coordination and its contribution to Information Sharing and Collaborative Decision Making**
- **Incorporation of Aircraft Priorities of the Airline/Airport**
- **Conclusions**

CDM-A: Objectives, Partners and Elements

Objectives

- ❑ Increase punctuality (TOBT!)
- ❑ Increase predictability
- ❑ Increase efficiency
  - Airport resources
  - Network capacity

Partners

- ❑ Airport Operators
- ❑ Aircraft Operators
- ❑ Ground Handlers
- ❑ Air Navigation Service Provider (ATC)
- ❑ The CFMU
- ❑ Support services

Elements

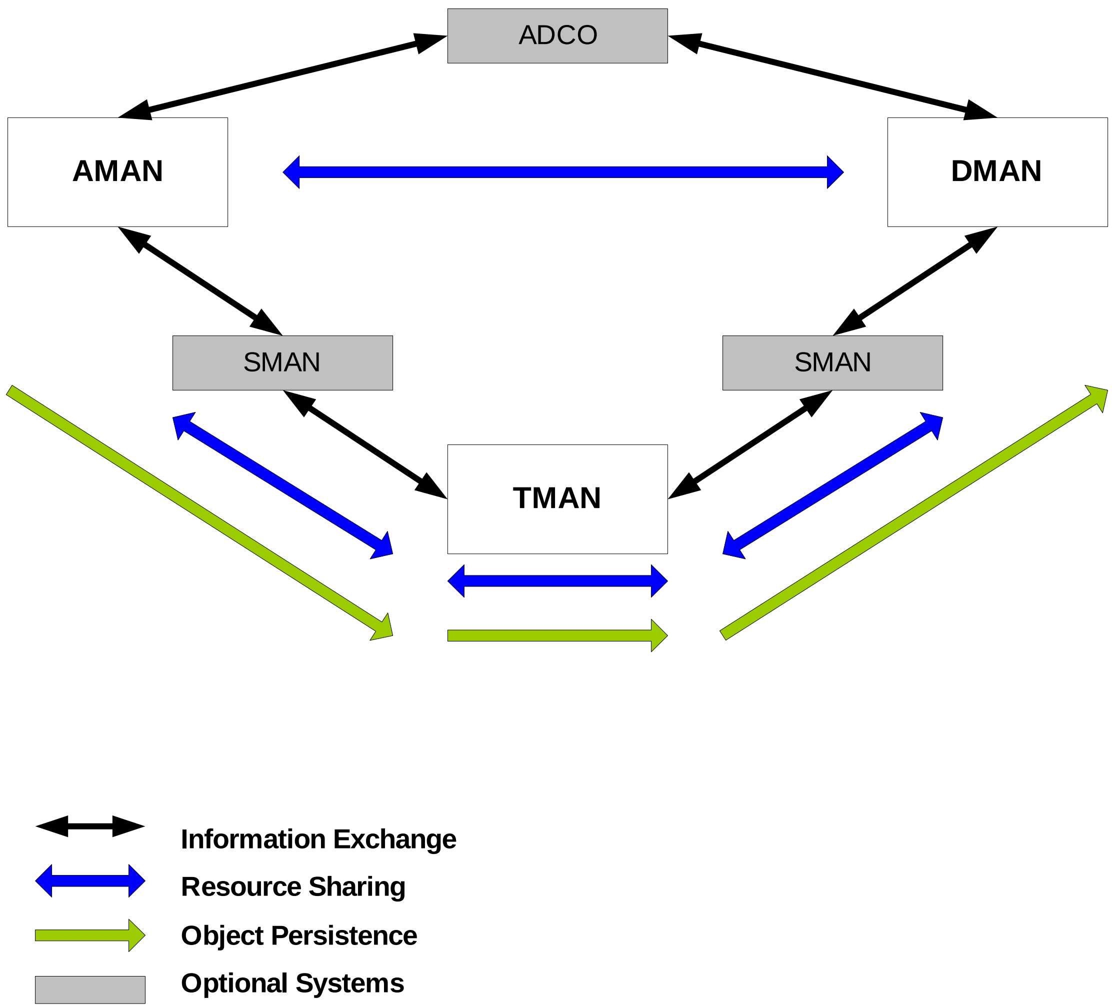
- ❑ Airport CDM Information Sharing
- ❑ Airport CDM Turn-round Process (Milestones Approach)
- ❑ Variable Taxi Time Calculation
- ❑ Collaborative Management of Flight Updates CDM-A and CFMU Message Exchange
  - FUM Flight Update Message
  - DPI Message
- ❑ Collaborative Pre-departure Sequence
- ❑ CDM in Adverse Conditions
  - Anticipate delay situation
  - Recovery strategies to facilitate a quick return to normal operations

XMAN Approach

- XMAN Approach
  - Use of automated tools to assist controllers in planning and tactical decision making
  - Part of Eurocontrol’s ASA programme (Automated Support to ATS)
- Objectives
  - Increase of efficiency
  - Increase throughput (utilization of capacity)
  - Increase predictability
  - Reduce environmental impacts
- Status of system development, implementation and coordination
  - AMAN (fully developed; implemented)
  - DMAN (fully developed; implemented)
  - SMAN (partly developed)
  - TMAN (fully developed; implemented)
  - AMAN – DMAN (under development)
  - AMAN – TMAN – DMAN (first considerations)

XMAN Approach

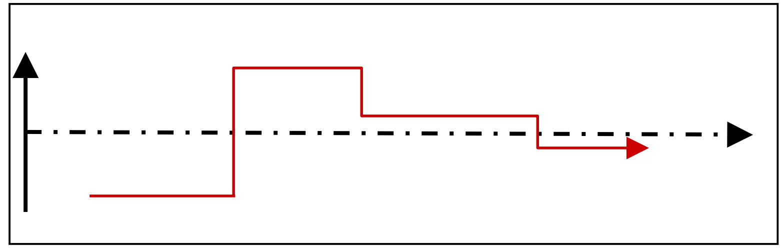
- ❑ Need for coordination is caused
  - ❑ Share of common resource(s)
    - AMAN-DMAN
      - Resource: Runway System
    - AMAN – TMAN; TMAN – DMAN
      - Resource: Stands & Gates
    - TMAN / (Hub-Control)
      - Various resources of means and personnel
  - ❑ Persistence of physical objects (aircraft)
    - Arrivals turn into departures in the turn-around process
- ❑ AMAN & SMAN: only minimal functionality required
  - ❑ aman: prediction of landing times
  - ❑ sman: prediction of taxi time
- ❑ Optional Systems:
  - ❑ SMAN
  - ❑ ADCO (Arrival Departure Coordination)

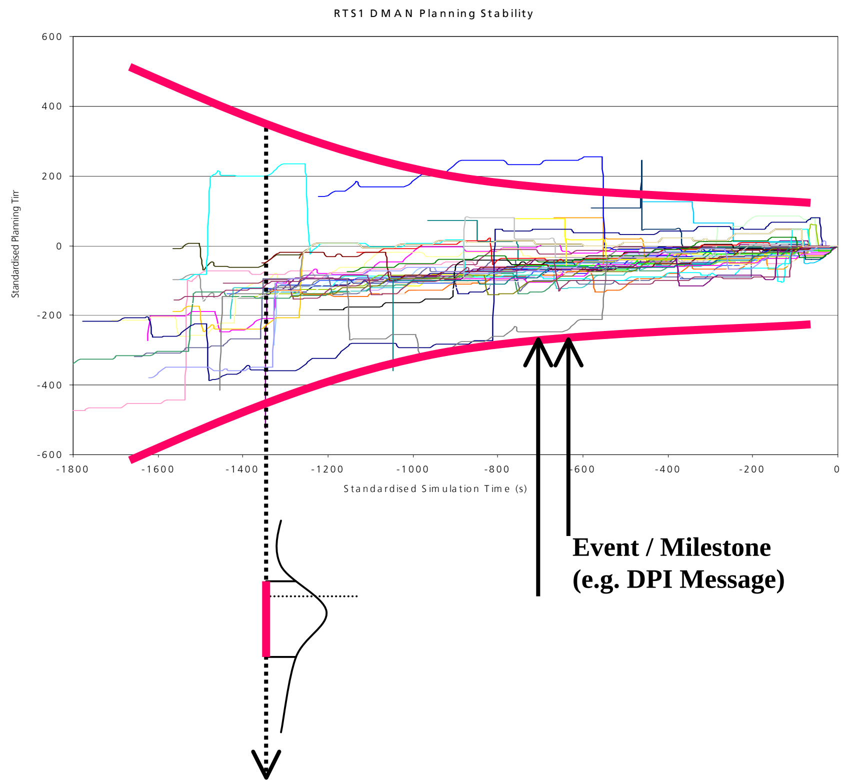


AMAN-TMAN-DMAN Coordination and its Contribution to Information Sharing and Collaborative Decision Making

Principles / facts to be taken into account

- ❑ **Planning and/or forecast information are functions of time**
  - **continuously varying (sliding / shifting)**
  - **discontinuously changing**
    - **events**
    - **sequence changes**
- ❑ **In principle, accuracy/predictability can be estimated with the help of statistical analysis based on normalized times (actual times)**
  - **accuracy/predictability itself is time-dependent**
  - **can be used in off-line analysis**
    - **e.g.: "10 minutes before landing, i.e. ELDT=NOW+10
the 90% confidence interval for ELDT is [NOW+9 NOW+12], i
.e. NOW+9<= ELDT<= NOW+12**
(95% confidence interval: [now+8 now+14])
  - **might be used in on-line quality assessments**
    - **e.g.: "When TTOT is NOW+10min, with a 90% confidence then ATOT will be in the range of
[NOW+9 NOW+12]."**

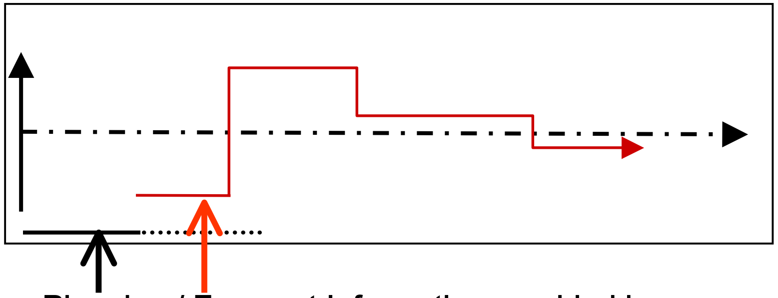




AMAN-TMAN-DMAN Coordination and its Contribution to Information Sharing and Collaborative Decision Making

Principles / facts to be taken into account

- Use of the latest information
  - requires either
    - broadcast of information (subscribing mechanism) and / or
    - persistence of information (DBMS)
- Substitution of information (more precise information replaces less precise information)
  - information is generated by a sequence of information sources
  - as a consequence thereof the accuracy of information is increasing steadily
  - e.g. TTOT
    - flight plan
    - pre-tactical departure planning
    - tactical departure planning
  - tendentious increase of accuracy
  - discontinuous changes of level of accuracy



Planning / Forecast Information provided by source A
(e.g. ETOT according filed Flight Plan, CDM)
Planning / Forecast Information provided by source B
(e.g. TTOT according DMAN)

AMAN-TMAN-DMAN Coordination and its Contribution to Information Sharing and Collaborative Decision Making

Time determination of events

- ❑ **In-Block; EIBT; AIBT**
  - **EIBT** = **SLDT** (CDM) + **EXIT** (CDM)
    = **SIBT** (CDM)
  - **EIBT** = **ELDT** (AMAN) + **EXIT** (SMAN)
  - **EIBT** = **ALDT** (CDM) + **EXIT** (SMAN)
- ❑ **Estimated / First Off-Block; (EOBT, SOBT)**
  - **EOBT** = **SIBT** (CDM) + **ETTT** (CDM)
    = **SOBT** (CDM**)**
  - **EOBT** = **EIBT** (CDM) + **ETTT** (TMAN)
  - **EOBT** >= **SOBT (by definition)**
  - **TOBT: The time that an aircraft operator / handling agent estimates that an aircraft will be ready, all doors closed, ...**
- ❑ **Target Off-Block Time (TOBT)**
  - **TOBT** = **TTOT** (DMAN) **– EXOT** (DMAN/SMAN)
  - **TTOT** >= **EOBT** (TMAN) + **EXOT** (DMAN/SMAN)
  - ⇒
    TOBT >= EOBT

Remarks

- ❑ **General principle for planning of consecutive operations**
  - **Backward propagation of target times**
  - **Forward estimation of first (earliest) times of events**
  - **Every planned Target Time shall be never smaller (earlier) than the corresponding predicted Earliest Time!**
- ❑ **Use of TOBT >= EOBT information**
  - **Will cause savings for airlines !**
    - **Avoidance of the use of additional resources**
    - **May allow the boarding of late passengers**
    - **May improve connectivity**
  - **May shorten the ETTT of other flights !**
    - **More appropriate usage of resources according to actual needs and acuteness**

Incorporation of Aircraft Priorities of the Airline/Airport

- Airline/airport preferences for departure service are often unknown to ATC
- The preferences reflect specific interests, objectives and problems of these CDM partners, e.g.
  - to assure a high extend of punctuality and passenger connectivity for their customers
  - to avoid resource conflicts (stands, personnel, ...)
- Preferences might be expressed
  a) through a preferred departure sequence (respectively sub-sequence of their own flights), i.e. technically expressed by “sequence constraints” (e.g. “aircraft A should depart before aircraft B“ ($A \prec B$)
  b) through aircraft importance factors w
  (e.g. aircraft A is twice as important as aircraft B” $w_A=2w_B$)
- Both methods require “rules”/regulations
  - expressing the conditions for “Who can induce constraints and when?”
  - in order to assure fairness between competitive airlines operating at this airport

Incorporation of Aircraft Priorities of the Airline/Airport

Pros and Cons of these methods

a) **preferences expressed by sequence constraints**

+ appropriate method for hard constraint conditions ("A must ! be pushed before B)
+ may end in a pre-departure sequence $A \prec B \prec C \Rightarrow$ A-B-C
- may become inconsistent especially when several partners/instances induce such constraints (e.g. $A \prec B$ and $B \prec C$ and $C \prec A$)
- $A \prec B$ does not express the relations to other flights ($A \prec B \Rightarrow$ A-B-C-D or $\Rightarrow$ C-D-A-B or $\Rightarrow$ A-C-D-B)
- may be unacceptable/ disadvantageous for ATC with respect to throughput, control effort etc.
- number of constraints could become greater than number of departures

b) **preferences expressed by priority importance factors w_A, $w_{B, ...}$**

+ this method never causes inconsistency
+ does express the relations to other flights (standard: w=1)
+ might not have negative impact on ATC (further investigations needed)
+ priorities can be treated easily as additional flight plan information (TMAN)
+ different priorities of airline, airport and ATC can be combined through mathematical functions (e.g.: $w_A = w_{A,Airline} * w_{A,Airport}$)
- does not guarantee that A departs before B when $w_A > w_B$
- may have unexpected impacts on other flights

Aircraft Priorities of Airlines and DMAN (ATC) Departure Scheduling

Rules of the “Game”

Basic

- Airline (participating in CDM) owns a number of “weight points” proportional to the number of owned flights
  (e.g. 10 points per flight ⇒ w=1)
- Standard is w=1
  (if no other information given)
- For every flight the number of assigned points can be changed by the airline according to its preference
- The total sum of assigned points remains constant, i.e. an increase of the importance of one flight necessarily requires a decrease of other importance weights

Additional rules to avoid instability and outwitting

- Changes of weights not later than ...
- Re-changes of weights cause a decrease of the total sum of weight points owned

Example (from RTS1 traffic scenario)

- Scandinavian Airlines induce:
  $w_{SAS589} = 2.5$; $w_{SAS172} = w_{SAS637} = w_{SAS555} = 0.5$

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Conclusions

- CDM and XMAN are not competitive but mutual supporting concepts, i.e.
  - “better” plans based on more reliable, consistent and complete information
  - more reliable information replacing the estimates (what a partner can do) by optimal targets/plans (what the partner should do)
- The XMAN planning tools can provide quantitative measures for accuracy (predictability, reliability) as on-time information based on
  - recorded data
(planning and estimates as functions of time, in dependence on events / milestones)
  - built-in statistical analysis methods
- More reliable, more actual planning information provided in combination with quantitative measures for accuracy will support both
  - Intra Airport CDM
  - Inter Airport CDM
    - CFMU (DPI messages)
    - peer-to-peer CDM-A coordination

Conclusions

- Coordinated Planning Tools, have the potential to provide techniques, with whose help airline/airport preferences can be taken into account <u>softly</u> without disadvantageous side-effects such as
  - the need of additional communication
  - the risk of inconsistent constraints
  - the risk of a substantial loss of overall efficiency
  - disturbances and complication of the management tasks of ATC

What needs to be done?

- XMAN: Extension of tactical planning horizon (pre-tactical planning) in order to
  - increase the effectuality of plan based (time based) operations
  - allow tool supported what-if-considerations by human decision makers
- TOP: Extended CDM at major airports (i.e. several CDM partners, competitive airlines) may need Total Operations Planning and an Airport Control Centre
- CDM: Extend and adapt the CDM concept with thorough consideration of the incorporation of XMAN

BECAUSE THESE TOOLS ALREADY EXIST!