Team systems in aviation maintenance: interaction and co-ordination across work teams.

Daniele Baranzini,
Sam Cromie
Dept. of Psychology-TCD Dublin, Ireland

ABSTRACT
The importance of teamwork in aviation maintenance has increasingly been recognised over the past two decades in recognition of the demands of managing and organising more and more complex work processes and even more difficult communication and interaction patterns within and across distributed work units, departments and functions. This paper focuses on the problem of understanding and modelling the analysis of intra- and cross-team activity and performance. In particular, within the framework and results of the EU funded Project called ADAMS 2 a new model of team systems assessment is provided. It proposes new conceptualisations of the interaction and co-ordination processes needed to sustain the demands of group’s work and a new methodology to audit cross-team co-ordination. It is suggested that the problem of teamwork in maintenance can be better understood as a problem of systems of teams in interaction. Overall, it is proposed that the understanding of team performance and proficiency requires the evaluation of cross-team interdependencies and co-ordination structures in addition to internal team processes.

Keywords
Maintenance team systems, Interdependency, Interaction and Coordination systems

INTRODUCTION
Aircraft maintenance organisations are inherently complex systems. The large amount of discrete and continuous work processes, differentiated job roles and functions as well as the presence of critical workflow and function interdependencies are some of their basic intertwined components describing such work environments. All these interdependencies and processes have to be timely organised, managed and monitored over time to balance system performance, productivity and safety (ICAO, 1995). In the last two decades, this situation led on one hand, to continuous work specialisation, compartmentalisation and functional differentiation, while, on the other hand, it amplified a strong need for intensive intra- and cross-group interaction and integration demands requiring higher levels of proficient teamwork performance and co-ordination. In general, this has been pursued throughout the analysis of competency requirements at the team level and research on team performance models and evaluation.

Maintenance teams manage a continuous exchange with the external environment, which is composed of other teams, individuals, departments or units within the overall organisation. Specifically, the management of external inputs, the team's outputs and their timely co-ordination proved to be a large determinant of team performance, and group maintenance (Taylor and Christensen, 1998; Hackman, 1990). For instance, four technicians in a hangar can be assigned to remove and replace a nose landing gear system during an afternoon shift. This task should be completed during that shift in order to move the aircraft out of the hangar just on time to make room available to enter another aircraft scheduled for the night shift. This task requires both standard and special tools, which may not be always available, or a component has to be replaced unexpectedly. In these cases, which are more frequent than expected, the team members have to interact promptly with the material shop for component or tools availability while informing their supervisor and plan a possible delay. At the same
time they may actually need more expert personnel to perform the task, which could require the appointed team supervisor to interact with the team leaders of other work teams in order to reassign and co-ordinate other technicians to perform the task, which should not be delayed.

In this view, it is understandable that co-ordination is a highly critical function where interdependency is a necessity across teams, units, and departments. Thus, within this perspective the ongoing research conducted across three large European maintenance organisations within the overall framework of the EU funded project called ADAMS2 (EU fifth framework - GROWTH Project) provided the basis to investigate such organisational determinant, the co-ordination system, sustaining work processes and workflows between and across different maintenance work teams in action.

In particular a series of in field studies and interviews with operational, planning as well as quality managers were carried out within the three maintenance companies (FLS Aerospace; KLM Engineering & Maintenance; and Sabena Techniques). The investigations uncovered that even when co-ordination between and across different teams and departments was recognised and perceived as a determinant for organisational performance, yet there is no specific measure or method to audit its functioning or its dysfunctions. Notably this is in line with most of the applied human factors research on maintenance teams that largely addressed the problem of team training systems on teamwork rather than the issue of cross-team behaviour and its evaluation (Baranzini at al. 2001; Taylor and Robertson, 1995).

Thus, a methodology to audit co-ordination systems across work groups has been proposed in order to provide maintenance organisations with a new auditing system to assess this specific organisational determinant supporting cross-team interdependencies and larger cross-departmental relations. This new co-ordination audit methodology is described here below.

THE AUDIT OF CO-ORDINATION ACROSS TEAMS

The objective to design a method to audit co-ordination has been driven by the following propositions:

- The auditing of co-ordination and its mechanisms within and between teams or larger work groups can be considered an activity to prevent or detect and recover from dysfunctions of the organisational system, which, may be endangering system performance efficiency, productivity and safety.

- Audits and diagnoses of co-ordination systems have not been fully considered nor envisaged as organisational technologies or planned interventions even though human factors research and investigations in maintenance environments often highlight co-ordination and communication deficiencies.

In this view, a model to audit co-ordination has been designed and operationalised into a set of steps as defined here below:

- **Identification of the target of analysis**
- **Analysis of task and teams interdependencies**
- **Key co-ordination mechanisms**
- **Assessment of interaction/co-ordination disturbances**

Each step will now be described below as set of procedures/activities to be implemented in the maintenance organisation by a team of auditors.
Identification of the target of analysis

The assessment of co-ordination needs or co-ordination inefficiencies should be a preliminary step to run a co-ordination audit. Thus a target area should be identified or scheduled for future analyses.

The organisational motivation to run a co-ordination audit can be driven by two different strategies:

- **Preventive co-ordination audits**
- **Corrective co-ordination audits**

**Preventive** audits are planned and/or scheduled co-ordination audits which are applied over different areas (zones) of the organisation without any reference to dysfunctions or signals of co-ordination failures: the target of analysis and the time of application are defined in advance. The strategy could be considered a proactive approach.

On the other hand, **corrective** audits are interventions performed on demand. Specifically these audits are targeted at specific areas where the presence of interaction/co-ordination dysfunctions or inefficiencies has been identified. This can be considered as a reactive approach to initiate a co-ordination audit intervention.

Notably, the presence of **signals** of lack of proper co-ordination should be identifiable by the analysts. Thus, the following **signals** will be considered indicators of possible interaction/co-ordination dysfunctions between at least two or more groups/teams, working together within a shared process or workflow:

**Signals of interaction/co-ordination dysfunction**…

- Groups’ Input/Output exchange is not timed, sequenced or calibrated
- Delays are frequent
- Re-work is frequent
- Overtime is frequent
- Responsibility/Social conflicts
- Difficult/inefficient interactions (communication)
- Difficult integration in terms of activities
- Perception of lack of co-operation
- Frequent perceived competition
- Lack of knowledge of other groups/teams’ objectives, roles and procedures
- Different application of common standard work procedures

Analysis of task and teams interdependencies

Once a specific **area/zone** of intervention has been selected, the analysis will focus on the overall system under investigation, that is, the work process, workflows, work units and teams in interaction. **The analysis of the co-ordination across groups, and its potential dysfunctions, is dependent on preliminary analyses of the overall task fragmentation into subtasks within a single workflow, the established pattern of subtask dependencies and finally the organisation of work groups over these portions of tasks elements.**

In this view, a series of representations of the overall system (tasks and teams) should be obtained via operational sequence diagrams and/or workflow diagrams. Describing the overall process in terms of:

- Task fragmentation (n. of tasks within the same process)
- Task allocation (n. of groups and task allocation)
Task progression and flow (timing, speed and frequency of task operations and the flows of tasks within and across groups)

From these process descriptions it is highly critical to determine the necessary flow of task interdependencies (Herbst, 1974). These below are the basic task interdependencies, which should be assessed:

- **Sequential interdependencies**: A complete task output will be the input for another task. The transmission will be in a one-way direction.
- **Reciprocal interdependencies**: A task is reciprocally dependent on another task, where each task’s output being reciprocal inputs.
- **Convergent interdependencies**: Different tasks outputs will be inputs (converging) for a single task.
- **Divergent interdependencies**: A single task output will be input (diverging) for several tasks.

These four task interdependencies should be studied in the process in order to understand the potential transmission of failures or dysfunctions of a specific task over the other tasks in the flow.

Secondly, the organisation and relationships between and across teams over the technical process should be determined. These below are three basic types of team interdependencies that should be studied per each pair of groups in a process:

- **Interdependency by product**: A team depends on another team to start/finish its task and their internal activities remain independent.
- **Interdependency by process**: Two or more teams have reciprocally dependent processes. The groups’ internal processes and activities are tightly coupled.
- **Interdependency by resources**: Two or more teams share a pool of common resources (economical, technical, personnel, support elements).

The presence of one or more types of such team interdependencies will provide knowledge on what kind of co-ordination requirements could be more favourable to sustain effective interaction across different but related groups.

**Key co-ordination mechanisms**

Once the basic characteristics of the entire process have been defined the analysis can shift to the specific analysis and assessment of the co-ordination elements within the system.

Most of the literature discussing the problem of co-ordination as a process refers to a number of co-ordination mechanisms, by which the interactions across groups will be timed, sequenced and calibrated (Mintzberg, 1993; Galbraith, 1977). In the ADAMS 2 project, six basic co-ordination mechanisms have been considered and reported here below:

- **Mutual Adjustment**
- **Supervisory Co-ordination**
- **Standardisation of output**
- **Standardisation of process**
- **Standardisation of resources**
- **Standardisation of skills**

The mechanisms of Mutual adjustment and Supervisory co-ordination are all human activities to monitor/assess and control/regulate behaviours of interacting work groups. In Mutual adjustment the control of the co-ordination is left to each group during their own reciprocal
exchanges (e.g., face-to-face informal meetings, phone calls, briefings). In the Supervisory co-ordination, on the contrary, the monitoring and regulating functions are delegated to an “external agent”, generally a supervisor or team leader. This mechanism is often applied whenever the resources to monitor and regulate a number of teams/groups in reciprocal interaction (information and behaviours) exceed each individual team/group’s capacity and resources.

The Standardisation of output, process, resources, and/or skills are four other types of co-ordination mechanisms which refer to built-in solutions to keep the intra- and cross-group relationships timed, sequenced and well organised by the application of norms, procedures and operational standards. These co-ordination mechanisms are “embedded” in the task/workflow, controlling what and how things should be done in advance.

Overall, the assessment of which forms of co-ordination are involved in the process and where these could most likely affect the relations across different specific groups has been envisaged as a matching process to identify what specific co-ordination mechanism is used over specific portions of the workflow where the interaction across teams has been detected as dysfunctional.

This step of the methodology has been envisaged as a task assigned to each group involved in the audit. In particular, each team/group involved in the audit will assess the following criteria:

- the presence of signals of specific disturbances when interacting with another team
- the section in the workflow where the signals appear
- the possible cause for those dysfunctions
- the group involved in the dysfunctional interaction
- the co-ordination mechanism/s operating over that process

For instance, a work team x within a maintenance process under investigation has reported the presence (signals) of a disturbed interaction (e.g., different application of common standard work procedures) with the group y (group) in a specific portion of the process (section in the workflow). This is probably caused by the lack of resources of the group y (possible cause). Finally, their co-ordination at that level of the workflow is ruled by a number of procedures of communication and an agreed time and deadline to exchange their products (co-ordination mechanisms).

Overall, the repetition of these analyses per each target group will give the overall frequencies of the key co-ordination mechanisms associated with each specific dysfunctional group-group relation.

Assessment of interaction/co-ordination disturbances

The identified key co-ordination mechanisms will now be tested to understand if such mechanisms can explain or be related to the cross-group inefficiencies.

In particular, the identified key co-ordination mechanisms together with the signals of co-ordination dysfunction will now be mapped onto the workflow diagram of the audited process. This re-description will provide an overview of all the information obtained in the previous steps of the methodology and will be used as a common framework of reference during the final step of the audit process.

In particular, each signal of co-ordination dysfunction for each pair of teams should be reviewed to evaluate if:
The co-ordination mechanism/s operating over that section of the process is/are determining the inefficiency

The co-ordination mechanism/s in use could be inadequate or insufficient to manage the task and team interdependencies present in the workflow

The disturbance is determined by previous dysfunctions in the workflow

Overall, the repetition of this exercise for all the teams interacting in the process could provide the analysts with a reliable estimate of 1) which co-ordination mechanisms are actually determining the disturbance, and 2) which variables are actually affecting the cross-group interactions in terms previous dysfunctions transmitted throughout the workflow.

CONCLUSIONS

This paper presented a promising research and methodological tool to cover the analysis of co-ordination operating between and across work teams, units and large departments interacting within critical processes and workflows. Independently by the type and level of work teams being analysed a new co-ordination audit methodology has been designed to cover both a human factors research gap in maintenance team performance assessments and a lack of operational methods and techniques to assess cross-team functioning and departmental relationships in aviation maintenance domain.

Although the general validity and generalisability of the proposed co-ordination audit methodology is yet to be fully tested beyond the three large maintenance companies participating within the ADAMS 2 project the overall methodology provides maintenance organisations with a practical approach to understand and audit the status of their functions and work processes in terms of those organisational structures, the co-ordination systems, which influence individual and multiple work teams in action.

In particular the concept of co-ordination can be assessed to understand why and where different work teams fail in performance and productivity beyond the level of individual team members’ inefficiencies. Factors such as the design and operation of entire workflows can be reviewed to test those built in procedures and actual co-ordination practices across teams, units or larger departments supporting team leaders, managers and individual team members to operate proficiently within and across teams.

REFERENCES


