Working apart together : using ICTs in research collaboration
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Citation for published version (APA):

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7. ERICOM case study – Media configuration

A. Introduction to the case study

This section provides a description of the ERICOM team with a focus on a. the groups and members of the team, b. the initial task allocation and c. a brief history of the team.

The aim of ERICOM was the development of statistics, indicators and software tools for the study of the science-technology-economy system on the internet, and was funded by the IST-FP5 programme through Eurostat. Thus, while DELTA was a comparative study with a set of reports as end-product, ERICOM was a heterogeneous study, and the aim was to produce not only reports, but also statistics and indicators, software tools and databases.

The ERICOM team consisted of eight local groups, in seven different countries, and their members and background can be seen in the table in the next page (Table 9). The size of the groups differed. In the second group, there were more than ten people working part-time on ERICOM. Also group 1 had more than fifteen student researchers assigned to the project, who were only marginally involved in the team’s communication or collaboration processes. Group 7, which was an assistant contractor and had a limited budget compared to the rest of the groups, consisted of only one member.

The second difference between ERICOM and DELTA, indicated in the following table, is the institutional affiliations of their members. Whereas DELTA was almost purely academic in nature, with its groups being based in universities, in ERICOM, there was a variety of types of institutions participating, which raised different issues in the team. For instance, group 2 was a private research institute, with the accompanying mentality of the group: the group was rather protective of their own software tool and was not very keen on sharing it with the rest of the partners. ERICOM thus combined a heterogeneous intended output, and a diversity of types of actors, which is expected to result in different types of working practices in the team (chapter 2). Moreover, there was bigger diversity in the disciplines of the members. Whereas in the DELTA team almost all members were social scientists, from different specialties, in ERICOM apart from social scientists there were also mathematicians, computer scientists, physicists, and engineers.

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57 Here again, the basis of the distinction of the groups is local affiliation and continuity of task allocation and members.
### Table 9: Groups and members of ERICOM

The higher degree of interdisciplinarity in the team is expected to result in more complex patterns of collaboration: expertise would be less equally distributed than in DELTA, which would mean that a more complementary type of collaboration may result: one where each local group or member would contribute at different stages of the end-result. This was not the case in DELTA, where all members had similar backgrounds and therefore were all involved in e.g. commenting on the questionnaire and the research design.

The higher degree of interdisciplinarity is also expected to raise possible tensions between scientists and engineers (chapter 2) and between groups over translation of the object of study. In conclusion, the heterogeneity in the type of output, the sectors of the institutes involved, and the background of the members are expected to lead to increased complexity in the team, and increased need for coordination, and possibly
communication. It is also expected to lead to higher productivity, because of the wider diversity of disciplines involved.

Initial task allocation

The research design of the project was less conventional than in DELTA and also not linear in time: the phases of data collection, visualisation and analysis were synchronous and the connections between the various components (work packages) more complex. According to the contract, the research design was divided into seven substantive work packages:\footnote{This doesn’t take into account the administrative, non-technical work packages: WP1, project management, WP7 evaluation and assessment and WP10 dissemination and implementation.} WP2 referred to the physical internet data collection; WP3 referred to the web data collection; WP4 consisted of the development of two different tools for monitoring users’ behaviour online; WP5 would develop case studies; WP6 studied the role of intermediaries in the digital economy; WP8 would develop and study web indicators and the new economy; WP9 referred to the development of visualisation software tools. The interdependence between these work-packages was envisaged in a more complex way than in the case of DELTA: most interdependencies were between two or three groups (bilateral or trilateral), at different stages of the research.

The interdependence between the groups becomes evident in the following table, which shows the initial distribution of person-months among the groups, and the tasks for which each group was responsible (Table 10)\footnote{The table is based on the initial allocation of resources, and not the final one, which was substantially different.}. In the last row, the percent of person-months of the work package leader is presented. In the last column, the percent of participation of each group in the project resources is presented.

This table indicates a different task allocation than in DELTA. There, all groups participated in almost all work packages, whereas in ERICOM there were groups that focused on few work packages, with minimum or no participation in others. Group 6 only participated in WP4 and WP6, which it was leading. Group 7 only participated (as assistant contractor) in WP6, WP7 and WP10. The rest of the groups participated in more work packages. This is expected to lead to a more complementary type of collaboration (Hara et al., 2003), with lower degree of interdependence. Furthermore, as indicated above, there were tasks for which two or more groups participated, and others not, which created a lot of bilateral, inter-group interdependencies. It is expected that different patterns of collaboration will emerge in each work package, with a need for coordination and integration being higher in more collaborative work packages (WP2, WP4, WP7, WP8). Overall, this distribution of person-months entails higher degree of complexity than in DELTA: diversity between groups as well as between work packages in terms of their degree of involvement.
Table 10: Initial task allocation in ERICOM

At the same time, in ERICOM the participation of the WP leader in the technical work packages is substantially higher than in the case of DELTA, where their participation was between 22-30%, with WP6 and WP7 being a bit more than 40%. This could lead to a stronger role of the WP leader as a level of authority, which could lead to different decision-making processes in the group.

Finally, a difference between DELTA and ERICOM that should also be noted is the number of person months. Whereas DELTA employed in total 217 person-months in total, ERICOM employed 293,8 person-months\(^6\)) Therefore it is expected that the amount of output of ERICOM would be higher than in DELTA.

**History of the team**

The idea about the ERICOM project was first discussed between Jack, George and John who had previously worked together in another, rather similar project (1999). George had met Jose in a conference before and contacted him with the idea of the project; Jose had met Nicholas in a conference as well, so he also involved him. George, Jose, Jack and Nicholas met in order to formulate the basic structure of the project. After this meeting, John informed them with an email what he wanted to do in the project, and Jose also invited Michel, who was a renowned informetrician. During the negotiations, the project officers suggested the inclusion of a partner to represent the users’ perspective. Jose then contacted Louis, who was based in a statistical office in his country, and he accepted to participate in the team as an assistant contractor. The team was formed.

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\(^6\) The budget of DELTA covered by the EU was one million euros, whereas of ERICOM was around one and a half million euros. In addition, half a million euros in ERICOM were covered by the private sector institutes that participated.
The project started formally in December 2000 and was intended to last three years. During the kick off meeting in January 2001 (week 1) the members met, presented their ideas about the work, and the setting of two emailing lists (general and managerial) was decided. The work started, with some members working on their own tasks, and others on bilateral collaborations. After the second meeting, group 4 decided to change institutional affiliation, moving its basis to a university, for which a contract amendment was required. Its members, George and Marc, were left in the mean time without any affiliation, which caused a managerial problem and a problem of resources for the group 4.

The first crisis in the project erupted in week 41, during the first review meeting of the project in Luxemburg, because no deliverable or any other document was sent to the project officers. The project was criticised, not only at the managerial level (no managerial tasks fulfilled until then) but also at the substantive level (no integration of individual work). After this review meeting and for the coming months the main focus of the team became the managerial problems and the lack of coordination of work. The focus of the project turned to the pending deliverables as well as work on WP8, which group 4 was leading. However, leadership of WP8 was problematic as group 4 was still without any resources.

In the following review meeting in week 58 the same managerial and coordination problems were identified, and the project officers focused on WP8, the work package which would integrate the rest of the work. Immediately after the meeting, a semi-collective effort on WP8 started with online discussions on its content and collective coordination, in absence of leadership from group 4. At the same time, addressing the managerial problems, the team hired a professional project manager (Pedro, week 64).

The work of group 4 on WP8 resulted in tensions between the new manager and George, as well as comments from the rest of the team, as it seemed to be heading to a different direction to that aimed by the rest of the team. These tensions also surfaced in the following meeting, where a discussion took place whether group 4 would remain in the team. After that meeting, a sequence of events described in the following chapter (section B) led to the resignation of group 4 from the project; the emailing lists, based in group 4, stopped functioning (week 76).

After this incident, the lists moved to group 6, and the team hired a new partner to carry out WP8 tasks, but work on WP8 proceeded very slowly. After the new partner came, each group resumed their own somewhat independent work, and the management of the team was entirely left to Pedro. The team was granted a four-month extension (until March 2004) to catch up with the delays and the work carried on. The formal end of the project did not come with the submission of all work: some deliverables were submitted one year after the formal end of the project (March 2005) and some even later.

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61 The Commission delayed in signing the new contract which would recognise group 8 as a partner in ERICOM.
62 The last pending documents of the project were sent to the Commission in the summer of 2006.
This brief history of the team presents the main phases of the team and its work, and can be thought as the backcloth against which the communication and collaborative practices of the team can be understood. The resignation of group 4 served as a catalyst for changes in the communication and collaboration patterns in the team. This is the reason that it will be used to indicate the transition between the first (week 1- week 76) and the second phase of the project (week 77 – end).
B. Media functions (qualitative analysis)

The main assumption of this section is that media with similar functions may substitute each other, whereas media with different functions cannot substitute each other (Vasileiadou and van den Besselaar, 2006). In the DELTA team, there was no substitution effect between media. In contrast, there was a boosting effect between the use of different media. Is this a case-specific result? This section will identify the media that were used in ERICOM and the functions they supported, and also whether these functions remained stable through time.

In comparison with DELTA, ERICOM team members did not use the general list to a great extent: only 697 emails, around one fourth of the emails of DELTA. Its use showed different patterns during the first and the second stage of the project: During the first phase, alongside with information exchange and general communication, it was used for decisions, and tension resolution, for socialising, and output production. Especially this latter use was something different than in the case of the DELTA team: members of ERICOM used the list for brainstorming and exchange of views on their topic, especially when the team made a concerted effort on WP8. There were almost no coordination or task allocation activities through the general list in the beginning: they only developed after the first year of the project, during the common efforts on WP8, and stopped suddenly when group 4 left the team. During the second phase of the project, the general list was used minimally (131 emails), and only for information exchange, and limited coordination. Only in the final two months of the project did the general list function again to support team processes, such as output production, exchange of work and comments, and coordination, following the persistent suggestion of a researcher.

The managerial list (379 emails) was used more after the first review meeting, which pointed to the managerial and coordination problems. During this first phase, it sustained decision-making, tensions, (limited) socialising, and (limited) coordination activities, especially during the period of concerted effort for WP8. An issue usually moved to the managerial list when it was considered sensitive, a potential source of tension among members. It also needs to be noted that researchers from groups 3, 4, and 5 also had access to the managerial list alongside the coordinators, which made it less restricted than in the DELTA team. During the second stage of the project, the managerial list was used more than the general list (197 emails), and more than the first phase. It was used mainly for information exchange, from Pedro to the team, and for all other collaborative processes. During the second phase, it was also used for the exchange of technical information and work in progress, which makes its use much more general than the general list, even though not all members had access to it.

More often than the two lists, personal and multi-addressed emails were used for all collaborative processes at a bilateral level: decisions on sensitive issues, conflict resolution, socialising, task allocation and coordination, and output production. As explained in the section about the initial task allocation, the bilateral interdependencies between groups meant that a lot of substantive and technical communication would go
through personal or multi-addressed e-mails, and also phone-calls. Here, the initial task allocation seems to influence the use of communication media towards more personal communication; something which also resulted in miscommunication problems and a lack of clear sense of what the other groups were working on. This indicates that the increased use of the general list in the DELTA team was not accidental, but rather resulted from the non-specialised, integrative type of initial task allocation in that team: all groups were involved in all stages and therefore team-wide communication was vital. I will come back to this point in the conclusions of the dissertation.

Another medium used by the team extensively was the Web. The topic of the project meant that the Web was used both for data gathering purposes, and also for the exchange of work (software tools, programs and databases). In the first phase of the project, there were two main websites: the most important was the one maintained by group 4, which was a data repository (web data), and it also had an online software tool developed for gathering web data in a password-protected area. Moreover, that website contained an open-access list of information resources on the topics of the project. Therefore, the website was used for output production and presentation of the team.

The second website in use was maintained by group 1; during the first year it only contained descriptive information about the project, functioning as a public-relations tool. Following the resignation of group 4, and as the data collection progressed, this second website was updated: part of the database was put online, together with demos of the software tools developed, presentations of the team members in various conferences and meetings, as well as some resources on the project. A password-protected area was developed where all project material was stored: administration documents, minutes of the meetings, deliverables in different versions, program codes, and data. So, in the second stage of the project there was only one website functioning, not only as a public relations tool, but also for output production, and coordination between the groups.

The most important team-wide means of communication in ERICOM were the meetings, both the general and bilateral meetings (between two or three partners). Overall, there were 24 meetings: eleven general meetings of the team, one exclusively managerial meeting, four review meetings, and eight bilateral meetings (with two or three partners, or on specific focus such as WP8)\(^3\). There is an emphasis on these bilateral, specific meetings also in the contract, because of the task allocation between the groups.

The eight bilateral or trilateral meetings were mainly on substantive technical issues; this often meant that the partners worked together on data, or analyses, visualisation techniques, or brainstormed about computer programmes or papers. Thus, the meetings functioned as actual collaboration instances, for brainstorming and output production. Moreover, they enabled all other working processes.

\(^{63}\) Additionally there are (at least) four bilateral meetings: group 3 with group 4, group 4 with group 2, group 1 with group 7 and group 2 with group 5, on which I have no chronological or other data.
The general meetings of the team had different functions at different stages. During the first three general meetings, technical and substantive discussions followed the presentations, and the meetings functioned primarily for output production activities and only secondarily for other working processes; almost no coordination or task allocation activities took place. The following two general meetings during the period of concerted effort for WP8 (in weeks 62 and 75) were used mainly for coordination of activities, even though substantive presentations of work were also given. Therefore, they sustained all working processes, with a focus on coordination and task allocation. Following this, the general meetings changed somewhat in character and non-scientific items (such as discussions on users’ requirements, or on the technology implementation plan) also became a focus, reflecting Pedro’s influence on the agenda. Substantive discussions continued, but less so than in the beginning. Also, meetings became more formalised, with recording of minutes, and an emphasis on the contract and the work promised. Therefore, in the second stage of the project, coordination of work, information exchange and decision-making processes prevailed over output production in the general meetings.

It has to be noted that coordination activities in meetings, especially during the second stage, did not have the same character as in DELTA. There was no overall discussion and decision for task allocation between the groups. It rather entailed a presentation of each group on what they were working on, individually and bilaterally. So, there were no team-wide task allocation activities: this was performed bilaterally, or within each group. Finally, meetings also functioned for socialising, the creation of a team spirit, and the exchange of personal information.

Summarising, the ERICOM team used the general list for all working practices (apart from tensions and conflicts) in the first phase, whereas during the second phase only for information exchange, and limited task allocation. The managerial list was used in the first phase for decision-making processes, tensions, and (limited) task allocation activities, and in the second phase for all collaborative processes. Personal emails, and also the phone were also used for all working processes, throughout the whole project. The website (internal forum) was used in the first phase for output production, whereas in the second phase also for coordination. Finally, general meetings were used for all activities, with an emphasis in the beginning on output production, and a shift in the second stage towards coordination, assuming a formal character. Bilateral meetings were also used for all working practices, with an emphasis on output production.

Overall, there was bigger diversity in the use of communication media over time in the ERICOM team than in DELTA: the functions of media changed over time, which was not related to the different stages of the collaboration (as all the stages run parallel in time). It was rather related to the dynamics of the collaboration, and more particularly to crises situations (negative review, resignation of group 4, new project manager). The functions that media supported in ERICOM did not stabilise in time. The following table (Table 11) distinguishes the communication media according to the functions they performed in ERICOM.
<table>
<thead>
<tr>
<th>MEDIA</th>
<th>INTERNAL/ EXTERNAL</th>
<th>PERSONAL/ TEAM-LEVEL</th>
<th>WORKING PROCESSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>General list</td>
<td>internal</td>
<td>team</td>
<td>Beginning: all except conflicts/ second phase: (limited) task allocation</td>
</tr>
<tr>
<td>Management list</td>
<td>internal</td>
<td>team</td>
<td>Beginning: decisions and tensions/ second phase: all processes</td>
</tr>
<tr>
<td>Website</td>
<td>both</td>
<td>team</td>
<td>Output production / Task allocation</td>
</tr>
<tr>
<td>Meetings</td>
<td>internal</td>
<td>both</td>
<td>all</td>
</tr>
<tr>
<td>Personal emails</td>
<td>both</td>
<td>personal</td>
<td>all</td>
</tr>
<tr>
<td>Phone</td>
<td>both</td>
<td>personal</td>
<td>all</td>
</tr>
</tbody>
</table>

Table 11: Functions of the media used by ERICOM
C. Dynamics in time

In DELTA, decisions, socialising, output production, coming deadlines and coming meetings increased the frequency of media use. Moreover, there was a boosting effect between different communication media. There, the functions that each medium supported remained the same through time, the frequency of media use was evenly distributed in time, and the models describing the media use were based on a short-term influence of random shocks with return to equilibrium; in this sense DELTA managed to produce a rather stable media configuration over time. I will now explore the dynamics of media use of ERICOM. The first negative review, the hiring of Pedro, the resignation of group 4 resulted in a change in the functions that the two lists and the meetings supported, as indicated in the qualitative analysis. Which working processes increased the frequency of media use? I start with a visual inspection of the variables.

![Figure 11: Distribution of the general list emails over time](image)

In Figure 11, we can see a clear distinction of the general list activity in four periods, roughly referring to: week 1- week 45 (continuous but limited activity); week 46 – week 76 (continuous increased activity); week 80 – week 162 (sparse discontinuous activity), week 163-week 172 (continuous increased activity). The second period corresponds to the collective attempt for coordination and collaboration on WP8, and abruptly stops when group 4 resigns. After that there is sparse activity, and the last period corresponds to the discussions before and after the final meeting, with the exchange of documents to be reviewed, after the request of a researcher. It has to be noted that, unlike in the DELTA general list, the four periods identified here have completely different intensity
of communication. The activity in the general list, thus, reflects the collective team-wide effort, with limited activity in the beginning, then a collective effort for integrated work (on WP8), then a return to local and bilateral activities, and a brief team-wide effort in the end. It is also clear that the negative review meeting and the resignation of group 4 also changed the frequency of the list: the former increased the frequency of emails and the latter decreased it. It is also important to note that the frequency of the general list is not evenly distributed in time, as was the general list of DELTA.

![Attachments in the general list](image)

**Figure 12: Distribution of the attachments in the general list over time**

In Figure 12 the distinction of the general list activity in four periods is less clear than in the previous figure, even though still discernible: a limited activity until week 46; then a more continuous and increased activity until week 76, when it stops abruptly; then a scarce activity until week 160; and then increased activity around the last meeting. Here again, the intensity of communication is very different at different stages of the project.

In Figure 13, the activity in the managerial list is presented, with two periods with different type of activity: week 1 – week 52, with scarce activity; week 53 – end with almost continuous but decreasing activity. The first period reflects the lack of coordination and management activities, whereas the second period reflects the coordination and management activities by the whole team and then by Pedro. The figure

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64 The high value in week 62 was replaced by the next biggest value for the ARIMA analysis, following the suggestion of Warner (1998).
also suggests high turbulence of the variable in higher values, which suggests the need for log transformation in the modelling process.

Figure 13: Distribution of managerial list emails over time

If we compare Figure 13 with the managerial list of DELTA (Figure 4) one can see a similar pattern: scarce activity in the beginning, then high activity and then decrease over time. The difference is that the time span in ERICOM is longer. It could be, therefore, the result of a slower learning process of administration and management in the team. However, it could be the case that a substitution effect took place later in the project. Moreover, the three events (the review meeting, the new manager, and the resignation of group 4) do not seem to alter the frequency of emails sent to the list, as they altered the functions that the management list supported.

What we also see is that in the second phase of the project, the use of the managerial list is higher than the general list, except from the last ten weeks. It seems that the focus of the team-wide communication shifted towards the managerial list in the second phase of the project. In the second phase of the project, as Pedro started taking over the team’s communication, team-wide communication revolved around managerial issues and the use of the general list declined, according to the qualitative analysis. Even some technical work was sent through the managerial and not the general list, because the work now was a managerial issue: a deliverable to be sent to the Commission according to the contract. This change in the mentality and attitude is reflected by the comparison of the two lists. A possible substitution effect between the two lists in the second phase will also be tested empirically later on with the use of cross-correlation between the two lists.

Figure 14 shows the downloading activity (internal forum), where almost all activity seems to be concentrated in the period week 76 – week 105. This was at the second stage
of the project, and could be related to the evaluation activities of two external specialists, who were hired by the ERICOM team to review the team’s deliverables, and were given access to the internal forum to download them. This activity took place at some point in the period week 78 – week 87. Another possible explanation is the arrival of the group 8 in the team (week 94) and their downloading of the work. After this period, the downloading activity decreased substantially. Here again we see that the distribution of the downloading activity is not even in time, and the higher the values of the variable, the higher its variance. This suggests the need for log transformation in the ARIMA modelling.

![Figure 14: Downloading from the internal forum over time](image)

In short, we see that events that changed the functions of media (see previous section), also seem to change the distribution of the frequency of media use: the resignation of group 4 led to a decrease of the level of activity in the general list; the negative review led to the increase of the level of activity of the general list and the managerial list; the arrival of group 8 and the external evaluation seem to have led to the increase of activity in the internal forum. In addition, the frequency of the media used is not distributed evenly through time, with periods of increased frequency, and sudden changes to periods of scarce and limited communication. Media in ERICOM seem much more sensitive to external events, than in DELTA. This will be discussed below.

Next, I checked for stationarity with the ADF test (Appendix p. 5), which shows that the general list, the managerial list and the internal forum are not mean-stationary and need to be differenced.
Following this, the Autocorrelations and Partial Correlations of the variables were computed (Appendix pp. 12-14). The ACF/PACF revealed memory in all variables, except from the meetings. Here, as in the case of the DELTA team, the number of people participating in meetings revealed no memory. The lack of memory means that the number of people participating in meetings did not depend on how many people participated in previous meetings. The meetings in ERICOM maintained a level of formality. This level of formality was also exhibited by the communications without memory in the DELTA team (uploading activity, meetings) which indicates a link between the level of formality of the communication activity and the lack of memory. This is the same with the participants in the meetings: since meetings took place, participants from the relevant groups had to be there.

Again here, as in DELTA OLS regressions and cross-correlations were conducted as preliminary analyses, to identify which independent variables would need to be put in the ARIMA models. The linear regressions (Appendix pp. 15-16) identified which collaborative processes were expected to have a statistically significant influence. The analyses show that socialising and conflicts were expected to have a contemporaneous positive influence on the general list, controlling for the other variables; conflicts and output production were expected to have a contemporaneous positive influence on the general list attachments, controlling for the other variables; decisions and conflicts were expected to have a contemporaneous positive influence on the managerial list, controlling for the other variables; and decisions were expected to have a contemporaneous positive influence on the management list attachments, controlling for the other variables.

Further, cross-correlations were conducted with meetings, deadlines and collaborative processes (Appendix p. 17) to identify whether there was any lagged relationship which should be included in the multivariate ARIMA model. The variables with the highest coefficient were included. Indeed, the analyses there suggest that meetings in a following week were expected to have a positive impact on the internal forum, the management list and the general list attachments; a coming deadline in two weeks was expected to increase the management list attachments; and a coming deadline in 4 weeks was expected to influence the increase in general list attachments. Again in ERICOM, as in DELTA, no lead-lag relationship was found between collaboration variables (decisions, output production etc) and media frequencies, indicating a short-term impact of these independent variables on media frequencies.

Finally, the independent variables which resulted from the OLS regressions and the cross-correlations, were included in the multivariate ARIMA models for the media variables with memory. The following tables show the most fitting model for each of the media variables, together with the independent variables. I remind that the models were found following three criteria: statistical significance of terms; lowest AIC/SBC indicators; residuals without autocorrelation (white noise). Further, some of the independent variables became statistically insignificant, once inserted in the ARIMA models.
Table 12 shows that the multivariate model for the internal forum is ARIMA \((0,1,1)\) with \(\theta=0.600\) and log transformation, as suggested by the visual inspection of the variable. Neither the coming meetings, nor any other lagged or contemporaneous collaborative activity, have any statistically significant influence on the variable.

<table>
<thead>
<tr>
<th></th>
<th>Estimates</th>
<th>Std Error</th>
<th>t</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA1</td>
<td>0.600</td>
<td>0.08</td>
<td>7.496</td>
<td>0.000</td>
</tr>
<tr>
<td>Meetings ((t+1))</td>
<td>-0.005</td>
<td>0.126</td>
<td>-0.042</td>
<td>0.967</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.043</td>
<td>0.163</td>
<td>-0.266</td>
<td>0.790</td>
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Table 12: ARIMA model for logged internal forum (after differencing)

<table>
<thead>
<tr>
<th></th>
<th>Estimates</th>
<th>Std Error</th>
<th>t</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA1</td>
<td>0.727</td>
<td>0.055</td>
<td>13.194</td>
<td>0.000</td>
</tr>
<tr>
<td>Socialising</td>
<td>1.175</td>
<td>0.628</td>
<td>1.870</td>
<td>0.063</td>
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<tr>
<td>Conflicts</td>
<td>3.030</td>
<td>0.966</td>
<td>3.136</td>
<td>0.002</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.005</td>
<td>0.082</td>
<td>-0.059</td>
<td>0.953</td>
</tr>
</tbody>
</table>

Table 13: ARIMA model for general list (after differencing)

Table 13 shows that the multivariate model for the general list is ARIMA \((0,1,1)\) with \(\theta=0.727\). Further, conflicts result in an increase in the change of the variable of 3.

<table>
<thead>
<tr>
<th></th>
<th>Estimates</th>
<th>Std Error</th>
<th>t</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR1</td>
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<td>0.240</td>
<td>0.479</td>
<td>0.633</td>
</tr>
<tr>
<td>MA1</td>
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<td>0.349</td>
</tr>
<tr>
<td>Conflict</td>
<td>1.096</td>
<td>0.548</td>
<td>1.999</td>
<td>0.047</td>
</tr>
<tr>
<td>Output production</td>
<td>1.323</td>
<td>0.346</td>
<td>3.822</td>
<td>0.000</td>
</tr>
<tr>
<td>Meetings ((t+1))</td>
<td>0.132</td>
<td>0.052</td>
<td>2.532</td>
<td>0.012</td>
</tr>
<tr>
<td>Deadline ((t+4))</td>
<td>0.121</td>
<td>0.176</td>
<td>0.688</td>
<td>0.493</td>
</tr>
<tr>
<td>Constant</td>
<td>0.413</td>
<td>0.281</td>
<td>1.471</td>
<td>0.143</td>
</tr>
</tbody>
</table>

Table 14: ARIMA model for general list attachments

Table 14 shows that, even though the univariate model is ARIMA \((1,0,1)\), when controlled for other independent variables, the MA1 and AR1 parameters become
statistically insignificant. Both output production and conflicts increase the exchange of work through the general list, as well as a meeting in the following week. All other parameters do not have any statistically significant influence.

Table 15 shows that the multivariate model for the management list attachments is ARIMA (1,0,1) with θ=0.835 and φ=0.923. Further, decisions increase management list attachments, whereas the influence of the coming deadline is not statistically significant.

Finally, Table 16 shows that, even though the univariate specification for the managerial list is ARIMA (0,1,1) with log transformation (Appendix p. 8), when independent variables are included, the MA coefficient is not statistically significant. Both decisions and conflicts increase the management list.

<table>
<thead>
<tr>
<th></th>
<th>Estimates</th>
<th>Std Error</th>
<th>t</th>
<th>p value</th>
</tr>
</thead>
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<tr>
<td>MA1</td>
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<td>1.079</td>
<td>0.927</td>
<td>0.355</td>
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<tr>
<td>Decisions</td>
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<td>0.604</td>
<td>4.528</td>
<td>0.000</td>
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<td>Conflicts</td>
<td>2.550</td>
<td>0.879</td>
<td>2.901</td>
<td>0.004</td>
</tr>
<tr>
<td>Meetings (t+1)</td>
<td>-0.006</td>
<td>0.091</td>
<td>-0.062</td>
<td>0.951</td>
</tr>
<tr>
<td>Constant</td>
<td>0.021</td>
<td>0.005</td>
<td>4.026</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Table 16: ARIMA model for logged management list (after differencing)

The univariate specification of the models for the two lists and the internal forum is ARIMA (0,1,1) whereas the univariate specification for the attachments of the two lists is ARIMA (1,0,1) with φ value very close to 10.65. The models for the management list, the general list attachments and the internal forum also required log transformation. The coefficients in the integrated MA-models are all positive, indicating that the influence of the disturbance of the previous time lag on the current change of the variable (or its log) is positive. Consequently, a larger than expected change of the variable in week t results in a greater than expected change in the following week (t+1). This is the opposite with DELTA where the coefficients were negative, and after each shock the variable returned to equilibrium. This reflects the positive feedback loops which are the characteristic of systems with high complexity. In such systems, we lose predictability, as “small differences can build upon themselves and create large differences, making precise prediction difficult” (Miller and Page, 2007; 75). The existence of positive feedback loops was hypothesised in chapter 2 (section D) and it was linked to systems with high degree of complexity.

In ERICOM, the more permanent effect of each shock on the change of the variable is also indicated by the integrated model, which reflects the cumulative effect of the shocks in all previous time periods. This, as discussed in chapter 4, suggests that initial random shocks were highly influential of the latter behaviour of the variable, which reflects high degree of path dependence in ERICOM. The variables that did not need differencing, (management list attachments and general list attachments) had an autoregressive

\[These\ can\ be\ seen\ in\ the\ Appendix:\ p.8.\ I\ remind\ that\ the\ Integrated\ process\ can\ be\ understood\ as\ an\ AR\ (1,0,0)\ with\ \varphi=1.\]
component with $\phi$ value very close to 1. This again indicates the long-term memory of the variable of its previous values. Further, the log transformations needed for some communication variables shows that the higher the value of the variable, the more turbulent it was (variance fluctuating more at higher levels than at lower).\textsuperscript{66} Therefore, the dynamics of the media variables do not indicate one equilibrium point to which the values of the variable return. Instead, this suggests that after each shock, the variables tended to different equilibria, as also indicated in the visual inspection.

Finally, the qualitative analysis and the visual inspection suggested that two events influenced the use of, at least, some communication media: the resignation of the team 4; and the arrival of the professional manager. In order to test systematically this influence I performed two types of analyses. First, I split the frequencies of the communication media in two periods: one before the resignation and one after the resignation (as this event seemed to have the most pronounced effect). I wanted to investigate to what extent the resignation of the group 4 resulted in different time dynamics of the media frequencies. The results (Appendix p. 19, Table 12) suggest that media frequencies had similar dynamics in the two periods: non stationary models with drift of the mean, and short-term influence of random shocks, with positive feedbacks of the random shocks on subsequent changes. The only difference is that of the general list attachments, which in the second period acquires a memory of its previous change values, instead of a short term memory of the random shock [instead of an ARIMA (0,1,1), the variable is now described with (1,1,0)]. Therefore, even though the resignation of the group 4 changed the frequency of the media, and the level of their use, it did not change its underlying dynamics in time.

Second, I investigated whether by including the two events (the resignation of group 4 and the arrival of the professional manager) the multivariate ARIMA model was improved. In other words, I wanted to investigate to what extent these two events could explain the frequencies of media use better. I inserted the two events as dummy variables in the multivariate ARIMA models described above. Because I wanted to see whether they had a permanent effect on the dependent variables, I coded them with 0s in the period before, and 1s starting from the week they happened, onwards. The results (Appendix p. 19, Table 13) suggest that the two events had minor, if any, explanatory power. The resignation of group 4 reduced the use of the general list (by approximately 10 emails) and increased the attachments of the managerial list (by approximately 2 attachments), and the arrival of the professional manager further reduced the use of the general list (by approximately 4 emails). Both were already indicated in the qualitative analysis, and the visual inspection of the variables. However, both events had little explanatory power.

In general, even though the arrival of the professional manager and the resignation of the group 4 changed the dynamics of the team, and the frequency of some media, this did not reflect in a big change in the time dynamics of the frequency of the media, or in helping

\textsuperscript{66} This distinction between turbulent periods and more tranquil periods of the variable was already indicated during the visual inspection of the variables.
us explain better the decrease or increase of their use. Only for the case of the general list do both of the events reflect comparatively big changes in its use (decrease).

These results, if combined with the result of the qualitative analysis which showed that the functions of media did not stabilise in time, point to the overall lack of stabilisation of the communication patterns of ERICOM.

But why was media use in ERICOM more sensitive to random shocks, than DELTA? Why were external events (such as the hiring of the new manager) influencing the functions that media supported? It could be the result of uncertainty about the course of the project, at the level of the review, but also at the substantive level, because of the innovative character of the project. The constant insecurity thus resulted in an inability of ERICOM to function as a stable team (with a consistent sense of collective responsibility and collective identity), to coordinate itself and to create a stable media configuration. This result is also related to the higher level of complexity of the team than in DELTA: more disciplinary perspectives, different task allocation in different work-packages, more heterogeneous institutions (see section A). Therefore, the environment of the team became more dominant in influencing media use, as well as other collaborative practices, as we shall see in the next chapter. So how does the use of media change through time? Media in ERICOM changed their functions throughout time, often reflecting environmental, external processes (such as the negative evaluation, the hiring of the new manager, the resignation of group 4).

The recursive-ness of the communication patterns of both teams (that is, the memory of their communications, and the way the communications became the building blocks of further communications in time) suggests that both teams functioned as complex systems. The patterns of short-term memory of previous shocks (MA-models), and perfect memory of initial conditions (Integrated- models) that the communications of the two teams exhibit, suggest that they are complex systems: groups which can be understood as interconnections between local actors and elements, with emerging properties that are more than the sum of their parts. ERICOM exhibited higher complexity than DELTA, which possibly resulted in higher path dependency of its communications on initial conditions (Integrated models), higher sensitivity to random shocks, and multiple equilibria of its communications.

Turning to the influence of the working processes on the media frequencies, the multivariate specification of the ARIMA models show that: conflicts and decisions increase the change of the logged management list; decisions increase the change of the management list attachments; output production and the expectations of coming meetings increase the change in the logged general list attachments; and conflicts increase the change in the general list from one week to the next.

It is noted that unlike DELTA, where conflicts had no systematic impact on media frequencies, in ERICOM conflicts have an impact on the use of both the general list and the management list. Also, lacking from ERICOM is the systematic impact of socialising on media frequency. Predictably, output production has a positive impact on the
exchange of work through the general list, as in DELTA. The expectation of meetings had a much smaller impact in ERICOM, and only on the exchange of work through the list, whereas in DELTA the expectation of meetings resulted in an increase in both the exchange of work and the exchange of emails through the list. Finally, deadlines have no systematic effect on media frequencies in ERICOM. This relates to the observation (following chapter) that in ERICOM deadlines were actually not kept.

Did media in ERICOM reinforce each other, as in DELTA? The visual inspection indicated there may be a substitution effect between the two lists, especially in the second period of the project. To identify any possible short-term substitution effect I performed cross-correlations for the frequency of media use. There was a statistically significant positive correlation between the managerial and the general list at lag 0 (r=0.215), which suggests a boosting effect between the two lists, and does not lend empirical support to a substitution effect between the two lists.

This analysis suggests that the gradual decrease of the managerial list over time did not result from a substitution effect, but from a learning process of administration and management tasks, as was the case also in DELTA.

Moreover, there was a statistically significant positive cross-correlation between the attachments of the managerial list and the downloading activity at lag 0 (r=0.221). Since the internal forum started operating shortly before the resignation of group 4 (which marks the two phases of the project) we can understand that this result refers more to the second phase of the project. So, information exchange in the team happened simultaneously: the sending of documents through one medium correlated with receiving of documents in another medium. In conclusion, there was no clear indication of substitution effect between media in ERICOM team either, but strong indication of boosting effect between some media.

What do these analyses tell us about the media use in the ERICOM team? The team used a variety of different media for internal and external, team-wide and personal communication to support different functions/working processes. The functions that the media supported varied throughout time and there was a clear differentiation in periods according to working processes that media sustained. Moreover, the frequency of media use was not evenly distributed in time, as was the case in DELTA, but exhibited sudden changes in different periods. If we combine this with the results of the ARIMA analysis, it is clear that the team did not manage to create and sustain a stable media configuration. The ARIMA models suggest higher sensitivity to “random shocks”, no return to equilibrium point after random shocks, longer memory of random shocks (path dependence), and higher complexity than DELTA. Which working processes influence the use of media? The qualitative analysis showed that the negative review, the hiring of the new manager and the resignation of group 4 changed the functions that media sustained. Moreover, the negative review and the resignation of group 4 influenced the

67 The cross-correlations were performed on the variables after the removal of memory.
frequency of media use (increase of the general list in the former; and increase of the management list attachments in the latter). In addition, the arrival of the new group and the external review of the team also seem to have influenced the frequency of media use (increase of internal forum). Further, decisions, output production and conflicts increased somewhat the use of the two lists, but not as much as in DELTA.

So, how does the frequency of media use change through time? In chapter 3 it was argued that different media would show different dynamics in time. Here, the frequency of all media followed a \((0,1,1)\) model, with high sensitivity to random shocks. This higher sensitivity is related to higher complexity and uncertainty in the team, which resulted in the environment of the team becoming more dominant in influencing media use, as well as other collaborative practices, as we shall see in the next chapter.