WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR BASIC SYSTEMS

OPAG ON INFORMATION SYSTEMS AND SERVICES

MEETING OF THE EXPERT TEAM ON MIGRATION TO TABLE DRIVEN CODE FORMS

FINAL REPORT

GENEVA, 7-11 MAY 2001

SUMMARY

The Meeting of the Expert Team on Migration to Table Driven Code Forms (ET/MTDCF) was held in Geneva at WMO Headquarters from 7 to 11 May 2001. The Team reviewed the directives of CBS related to the migration to Table Driven Code Forms (TDCF). The necessity of coordination with other Technical Commissions of WMO, Regional Associations and external Programmes related to the WWW, like ICAO, was stressed. The opinion of WMO Members had to be taken into account in the broad sense and also on an individual basis. Members should have the freedom to switch to BUFR when they wanted and when they were ready to do so. It would have to be a long-term process with considerable flexibility. The migration plan should be multi-modal with a wide range of implementation options. The plan needed to include incentives for Member States to migrate to TDCF. The benefits of the migration have to be clearly explained to Members. The plan should be fully inclusive, non-exclusionary. The plan should allow for every WMO Member to migrate.

The role of CREX was discussed by the Team. CREX should be an interim solution since all data currently using traditional code forms should eventually be exchanged in BUFR. However, for Countries that cannot exchange BUFR data, conversion to CREX could be an option in the interim. Conversion from BUFR to a traditional alphanumeric code (TAC) could also be done, but the benefit of BUFR, which allows additional data to be represented, would be lost. Countries that cannot switch to BUFR but need to transmit more or different parameters than allowed by the TAC should use CREX.

A new guide on TDCF would have to be produced with three levels of explanations. A first level would explain the general philosophy of the TDCF, for decision-makers and general users. The Level 2 would explain more deeply the structure of the TDCF and the mechanism to update or add new data types or parameters. The Level 3 would give deep and detailed explanation with a view to guide programmers of encoder or decoders programs (e.g. manufacturers or analyst-programmers in Meteorological Services).

The Team tried to identify the technical impacts of the migration (and possible solutions) in all aspects of the World Weather Watch and associated operations. The Team noted that all Members will not migrate at the same pace. To ensure access to data for all users, the constitution of the same observation in two types of format at some stage in the World Weather Watch data flow (concept of the double transmission or double dissemination), had to be considered.

The impacts on the Global Observing Systems were considered first. The Team agreed that it would not be practical and cost-effective to encode observations in both TAC and TDCF at observation sites. In order to carry out double transmission over the GTS it might be indispensable that a GTS Centre in each NHMS or data collecting Centre for ships or other data types converts reports received from observation sites to BUFR or CREX before injecting data into the GTS. The Team recommended Members to begin planning now for the introduction of systems with software to encode observations in BUFR (or CREX). The Team urged the Secretariat to contact manufacturers of observing systems and to solicit them for the development of systems that comply with the migration strategy and to provide Members with relevant information. Since these steps require considerable investments, WMO Members should be convinced to consider reserving budget resources to implement these steps. In addition to the global organization of the migration process, the Team recommended every NMHS defines a local migration project and defines a local migration expert.

The Team considered the impacts of the migration on the GTS. The Team recognized format translation was not a role of an RTH and many RTHs would not have the processing power to be able to do this. The Team decided dual dissemination should be the primary mechanism utilized for migration. The Team also recognized however that some RTHs or Centres may have the capability to do format translation and may decide to do translation for their own needs. With significant variation of capability in different part of the GTS and among RTHs, the pace of migration will vary throughout different portions of the GTS. The Team discussed how the use of the Internet might help to solve some migration problems. For some NMHSs the Internet could allow access to data in binary formats that are not available over their GTS link. Many practices and procedures defined in the Manual on the GTS are directly linked to traditional codes. The Team felt these issues needed to be looked at in more detail and coordinated with other Teams of the OPAG on ISS dealing with the GTS.

The Team considered the impacts of migration on the Global Data Processing System, which is fed by meteorological observations. The programs receiving meteorological data are the first one to encounter the data formats, usually after having cracked the WMO Bulletins. Clearly a switch to the reception of BUFR data instead of reception of WMO TAC, should improve the data quality. CREX would somehow improve the quality, but not as much as BUFR. A universal decoder for BUFR/CREX would simplify greatly the maintenance of decoding software in pre-processing system of GDPS Centres. The big advantage of the migration to TDCF would be the facility to transmit any new data types and

additional parameters like metadata, which are requested by the meteorological applications, especially the data assimilation systems. Provision of and support for encoding and decoding software for TDCF would be necessary for a successful migration. The implementation and integration of decoder/encoder “plugged in” an operational chain of programs was not a trivial issue. It should be noted that the introduction of new software for migration might have a small to significant financial impact on many NMHSs. When NMHSs will convert BUFR messages received from the GTS into character code for their national use, there may be more sense in encoding the information in CREX instead of TAC. In any case every effort should be made to avoid converting BUFR data back into the TAC. The Team recommended that prior to the migration GDPS Centres add in their processing chain full universal BUFR and CREX decoders, to avoid missing observations.

The advantages of the migration to TDCF start to be well known by the World Weather Watch (WWW) community. A campaign of information on this subject aiming at other related Programmes will have to be undertaken before and during the migration process. One could distinguish three types of other Programmes, which are somehow connected with the WWW: the Programmes depending on the operation of WWW, which provides input data to them (e.g. World Climate Programme, GCOS, Hydrology), the Programmes which contribute to some data collection as input to the WWW, but which, anyway, are depending fully of the data processing of WWW (e.g. CAeM -aviation meteorology -ICAO, JCOMM-Marine Meteorology), finally, the Programmes, which contribute data to the WWW, but which do not need fully the WWW processing for operation (e.g. Satellites, Oceanography-IOC). All WMO Members and Programmes would be somehow affected by the migration and should be concerned by the migration plan. For some Centres, migration to TDCF would actually reduce the diversity of data formats needed to be processed reducing software and operational requirements. The Team felt It was important to fully understand the positive benefits and implications of TDCF. These positive benefits will help to create an incentive to migrate.

The Team reviewed impacts to WMO Member resources and noted there were many benefits that would not be realized until after negative impacts would occur. However, it was found for all negative impacts there were offsetting positive benefits. The Team recommended that pilot migration projects be identified, developed and implemented, as test and precursor of the migration, to show the benefits in one hand and on the other hand, put into light the difficulties, if any, encountered by the Members.

The Team refined a project for provision of and support for encoding and decoding software for the TDCF as an indispensable part of any migration plan. The Expert Team found that the encoder/decoder software should be accompanied with display tools like a "BUFR viewer". If the decoding were done in a workstation connected to INTERNET a "BUFR viewer" in a browser would be useful. Documentation on the program and how to implement it ought to be clear and comprehensive, with all interfaces with the external application well defined. CBS requested that WMO provided training should be complete no later than October 2005. The Team felt there were two levels of training that should be done and another level that should be considered if the software project was not accomplished. These levels were: level 1 - General philosophy of TDCF and migration overview, level 2 - Meteorological users, Telecommunications Managers, Data Managers, and those involved with Application Interfaces, and level 3 - for encoder and decoder programmers (only needed if the software project is not implemented). Implementation of migration at GOS, GTS and GDPS levels should be synchronised with training. To make a preliminary migration plan the Team examined the dates that were provided by CBS for a schedule and also considered the budgeting cycle of the secretariat. The TAC were grouped into six categories which were thought to share common characteristics which would allow migration to proceed in parallel. For each of these categories three target dates were set, the start of experimental exchange, the start of operational exchange and the end of operational exchange. The Team weighed various factors affecting each of these dates for each of the categories and arrived at target dates spanning over ten years.

REPORT OF MEETING OF EXPERT TEAM ON MIGRATION TO TABLE DRIVEN CODE FORMS

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REPORT OF THE MEETING OF EXPERT TEAM ON MIGRATION TO TABLE DRIVEN CODE FORMS
(Geneva, 7-11 may 2001)

1. ORGANIZATION OF THE MEETING

1.1 OPENING OF THE MEETING

1.1.1 The Meeting of the Expert Team on Migration to Table Driven Code Forms (ET/MTDCF) took place at WMO Headquarters in Geneva from 7 to 11 May 2001 (the participants' list can be found in the Annex to this paragraph). The Meeting was opened on Monday 23 April at 10.30 a.m. by Mr. Michel Jarraud, Deputy Secretary-General. He welcomed the participants and stressed that it was often forgotten that the WMO codes were fundamental to meteorology because they made possible the real-time exchange of data, which were the raw material for all meteorological applications. When the requirement for changing to a new type of codes for transmitting the main meteorological observations was recognized, great concern was expressed, because it touched on the core of World Weather Watch (WWW) operations and on numerous other implications, such as program costs, staff training, etc. The table driven codes, BUFR (Binary Universal Form for the Representation of meteorological data) and CREX (Character form for the Representation and EXchange of data), have many significant advantages over the traditional alphanumeric codes (TAC). The table-driven codes are universal and flexible, and can be easily expanded to satisfy all observational requirements including national needs for specific data exchange. Self-description, flexibility and expandability of these codes are fundamental in light of the fast evolution of science and technology, which is linked with a continuous need for representation of new data types. It was important to note that CBS did not use the term "change" to table driven code but stressed instead the term "migration", because the conversion process must be progressive and well coordinated with a smooth evolution over several years. Eventually, all observations would be exchanged in BUFR. This Expert Team was expected to analyse all implications to the WWW and other related Programmes and to build the plan for migration.

1.1.2 The terms of reference for this Team are:

- to develop a detailed migration plan to table-driven representation forms to be presented to CBS-ext.(2002);
- to define a software project to specify, develop and distribute universal BUFR, CREX and GRIB 2 encoding/decoding software to all requesting countries;
- to define a training programme;
- to identify and analyse problems due to the migration of data representation at every step of the WWW data flow and develop proposals for solutions;
- to list in general terms the possible implications, due to the migration process, on WMO members' resources for development and operation, and propose solutions to mitigate the impact on members.

1.1.3 Fred Branski, Chairman of the ET also welcomed the members of the Team. Following contacts, with many colleagues, he noted that the migration concept was seen as positive, but also many people expressed concern and some fear given the enormity of the task. He stated the Team had a considerable challenge ahead of it, to devise a plan that would effectively bring data exchange into a new era. The Team's job was not only to find a methodology that would work in a complex communications environment but also one that would work for all WMO members. He said if the plan was to be comprehensive and effective, the Team needed to develop a vision of the complete implementation of migration. He stated the Team needed to define its own working plan and its completion needed to be a primary goal for this meeting.

1.1.4 Fred Branski, then, led the Team with diplomacy and efficiency.

1.2 APPROVAL OF THE AGENDA

The Team agreed to the content of the agenda as proposed, with the inclusion of the establishment of a work plan for the Expert Team itself in item 7.

2. CBS DIRECTIVES FOR MIGRATION TO TABLE DRIVEN CODE FORM

2.1 The Team reviewed the directives of CBS related to the migration to Table Driven Code Forms (TDCF). Dr Schiessl, Director of World Weather Watch-Basic Systems, stressed the necessity of coordination with other Technical Commissions of WMO, Regional Associations and external Programmes related to the WWW, like ICAO. The Team might have to set up a coordination mechanism to ensure the migration impact was positive and sustained a smooth operation of the WWW data flow. The opinion of WMO Members had to be taken into account in the broad sense and also on an individual basis. The Team had to show that it worked for the needs of the WMO community. If the proposed plan was too rigid and categorical, the rejection of the migration process might be categorical by the Members. The Chairman of the OPAG on ISS, Pr Geerd Hoffmann stressed that Members should have the freedom to switch to BUFR when they wanted and when they were ready to do so. It would have to be a long-term process with considerable flexibility. The Chairman of the Team expressed the view that the plan should be multi-modal with a wide range of implementation options. Mr. Mlaki, Chief of the Data Processing System Division, said the plan needed to include incentives for Member States to migrate to TDCF. The benefits of the migration have to be clearly explained to Members. Manufacturers of observing systems as well as processing software should be made well aware of the purpose of the migration and of its benefits. The plan should be fully inclusive, non-exclusionary. The plan should allow for every WMO Member to migrate.

2.2 A new guide on table driven code would have to be produced with three levels of explanations. The first would be for decision-makers and users of the data after decoding. The general philosophy of the TDCF would be explained. The second level would explain more deeply the philosophy of the TDCF and also the mechanism (request, validation and approval) to update or add new data types or parameters to the Code tables. Finally, the last level would explained in depth and great details the way the codes and their regulations operate, with a view to guide programmers of encoder or decoders programs (e.g. manufacturers or analyst-programmers in Meteorological Services).

2.3 The question of the human readability of the BUFR encoded data was considered by the Team as crucial, and would be a key to the success of the migration, the users having the habit of "seeing" the meteorological observations in a SYNOP, or TEMP, or SHIP, etc. Software for displaying BUFR data in some standard manner should be delivered with the BUFR decoder software. It could be a program in JAVA for a workstation or PC plugged into the INTERNET or it could be a browser interface set up to view output from a BUFR decoder. The display standard could use XML or the presentation could be a new standard. It could also be CREX based or use CREX as the display form, however CREX was better suited as an exchange format than a visualization tool.

2.4 The role of CREX was discussed by the Team. CREX should be an interim solution since all data currently using traditional code forms should eventually be exchanged in BUFR. However, for countries that cannot exchange BUFR data, conversion to CREX could be an option in the interim. Conversion to a TAC could also be done, but the benefit of BUFR that allows additional data to be represented would be lost. Countries that cannot switch to BUFR but need to transmit more or different parameters than allowed by the TAC should use CREX.

3. IDENTIFICATION OF TECHNICAL IMPACTS (AND POSSIBLE SOLUTIONS) IN WORLD WEATHER WATCH OPERATION DUE TO THE MIGRATION

The CBS considered that the migration to TDCF would have implications at every step of the World Weather Watch data flow. The Team tried to identify the technical impacts of the migration (and possible solutions) in all aspects of the World Weather Watch and associated operations. The Team noted that all Members will not migrate at the same pace. To ensure access to data for all users, the constitution of the same observation in two types of format at some stage in the World Weather Watch data flow (concept of the double transmission or double dissemination), had to be considered.

3.1 GOS

3.1.1 Most of discussions on the migration strategy had been related to the international exchange of data on the GTS so far, however, the expert from Japan, Mr Keiichi Kashiwagi stressed that more basic problems might exist in the national observing systems and national telecommunication networks. Even if the majority of the GTS Centres could deal with binary data soon, it would take a very long time for many NMHSs to introduce automated observing systems with the software to encode data in BUFR at all local sites, as well as implementing a national telecommunication network which could handle binary data.

3.1.2 Even for NMHSs using automated observing systems, it will take several years for most of them to encode observations in BUFR at observation sites because most of the current automated systems were designed to encode data in TAC. It will be even more difficult and will require an open-ended transition period for the voluntary ships to encode observations in BUFR or even in CREX. Many producers outside of NMHSs will have difficulty to migrate since they have been coding data for so long in TAC.

3.1.3 It would not be practical and cost-effective to encode observations in both TAC and TDCF at observation sites and to send them to a collecting Centre. In order to carry out double transmission over the GTS in a wholesale manner it might be indispensable that a GTS Centre in each NHMS or data collecting Centre for ships or other data types convert reports received from observation sites to BUFR or CREX before injecting data into the GTS.

3.1.4 Some NMHSs may plan to replace their automated systems and others may plan to introduce automation. Because of financial reasons, it would make very difficult for Members to replace their system during a short time. The Team recommends Members to begin planning now for the introduction of systems with software to encode observations in BUFR (or CREX). The Team urges the Secretariat to contact manufacturers of observing systems and to solicit them for the development of systems that comply with the migration strategy and to provide Members with relevant information. By experience, the time necessary for a manufacturer to develop an encoder in BUFR (for one type of observation) is estimated as six months.

3.1.5 Development and implementation of new software to generate BUFR messages (BUFR encoding software) were needed at all places where messages were currently generated in TAC. The Software Project will take care of the software development itself. However, the specific site implementation would require special attention. The task is considerable because it will affect all NMHSs. They should be encouraged to start special migration projects to implement the new encoding software in all operational observation systems, which currently produce TAC.

3.1.6 The Team considered that one of its most heavy but also challenging tasks is probably the organization of the whole migration process. For the implementation of a detailed transition plan worldwide, WMO Members need to be motivated to take the necessary steps. Since these steps require considerable investments, Members should be convinced to consider reserving budget resources to implement these steps. The expert from Netherlands, Mr Dick Blaauboer considered that it was a task for the ET to be aware of the financial impact of the various steps of the migration process on NMHSs´ budgets. In addition to the global organization of the migration process, the Team recommended every NMHS define a local migration project and define a local migration expert.

3.1.7 The Team was informed of a EUMETNET project to conduct a pilot implementation of GTS hourly exchange of AWS reports, including automatically measured present weather elements, using BUFR. The starting date for the exchange will be December 1st, 2002. The following actions would be undertaken:

- Identification of NMHSs willing to participate. A minimum of two volunteer members is necessary to provide a test-bed for the exchange. However, EUMETNET members should be encouraged to participate as much as possible.

- A detailed plan and work programme, taking into account the advise of CBS 12th session with respect to the ET/AWS proposals and ideas from the first session of the ET/MTDCF, Geneva May 7 to 11, 2001, will be proposed to be approved early in the project.

- A subset of specific quantities to be exchanged will be identified. This set will include parameters related to present weather and obtainable from current technology. The selection will be made from the table prepared by the ET/AWS and submitted to CBS approval.

- A BUFR template for hourly exchange will be developed based on the existing tables.

- Availability and suitability of existing BUFR encoding/decoding software will be investigated. One of them will be selected or, if necessary, a new one will be developed.

- Implementation wil be coordinated with the assistance of WMO, if applicable and possible.

- Coordination with the WMO will take place at each major step of the project in order to contribute fully to the process initiated by CBS to introduce the use of TDCF for all exchanges on GTS.

3.1.8 The Chairman of the Team (USA) and the representative of ECMWF indicated their willingness to receive BUFR observation data coming from any location as soon as they might be available, to fulfil experimentation. The expert from Japan indicated that Japan Meteorological Agency (JMA) used BUFR for the exchange of AWS with Korea Meteorological Administration (KMA). ECMWF indicated also its interest in these data. The Chairman reported that USA was planning to implement a BUFR encoder for the transmission of all observations in BUFR to the US Regional Offices. The expert from France, Mr Jean Clochard reported that inside France there would be soon automatic stations reporting BUFR data but that the existing French RBSN stations would not be available in BUFR on the GTS before 2003.

3.1.9 It was pointed that satellite observations were not all coded in BUFR, and the Team recommended that a note be added in the Manual on Codes to remind producers that all new satellite observations should be coded in BUFR.

3.2 GTS

3.2.1 The Team felt it was important to consider the exchange needs of all the WMO Programmes and WMO Members. These needs should be reviewed by data type, so the Team could work in concert with its partners to develop a plan to meet them. The Team noted there might be needs not being met today that migration will help to satisfy such as additional data types and parameters.

3.2.2 As the primary carrier of data and products, the GTS can either limit or enable the exchange of data. Bandwidth and character of line (analogue or digital) determine what and how much can be delivered. Protocol, such as X.25, TCP/IP or socket streaming also affect the nature of the data exchange, whether messages or files can be sent. This also has bearing on the size of individual products. The Team felt compressibility of GRIB and BUFR were clear advantages.

3.2.3 There was much discussion on whether the most effective way to migrate would be by providing dual dissemination of data in both traditional or table driven formats or whether translation between formats should be done at RTHs or other centers. The Team recognized format translation was not a role of an RTH and many RTHs would not have the processing power to be able to do this. The additional bandwidth required by dual dissemination of code formats was relatively small and partially offset by the compressibility of BUFR encoded data. Most importantly, dual dissemination provides the greatest flexibility to WMO members from both data production and use standpoints. The Team decided dual dissemination should be the primary mechanism utilized for migration. The Team also recognized some RTHs or Centres may have the capability to do format translation and may decide to do translation for their own needs.

3.2.4 The Team recognized that there was significant variation of capability in different part of the GTS and among RTHs. There was also significant variability in the capabilities of processing Centres associated with each RTH. It may be that the limits of some processing Centres will affect how migration can be implemented on some parts of the GTS. This will result in the pace of migration varying throughout different portions of the GTS.

3.2.5 The Team also discussed how the use of the Internet may help to solve some migration problems. For some NMHSs the Internet could allow access to data in binary formats that are not available over their GTS link.

3.2.6 The Team also considered the broad effect training had on dissemination of migrated data on the GTS especially for the developing countries. The Team felt implementation of migrated data on the various parts of the GTS should be synchronized with training. Level 1 training should be widely given including high management. Level 2 training should be given to telecommunications managers, personnel involved in data exchange and data management (definitions of levels are provided in chapter 6).

3.2.7 The Team noted data designators (TTAAii) in abbreviated headings for TAC were defined in accordance with code forms, observation times, geographical areas and data flow but those of BUFR/CREX were based on broad data types. This can result in less routing flexibility for BUFR/CREX messages containing migrated data than messages in TAC. It was felt that additional capability to define migrated data types in the WMO heading should be developed. The Team discussed using a currently unassigned letter for the T_1 of WMO headings for BUFR/CREX encoded migrated data. The rest of the WMO heading (T_2AAii) could then be used to provide one to one mapping with the WMO headings of traditional data types. This is an issue that needs more work and the Team agreed this should be coordinated with other Teams of the OPAG on ISS dealing with the GTS.

3.2.8 Many practices and procedures defined in the Manual on the GTS are directly linked to traditional codes. The Team felt these issues needed to be looked at in more detail and coordinated with other Teams of the OPAG on ISS dealing with the GTS. Some examples are listed below:

- Attachment I-1: “Arrangement for the collection of ship’s weather reports and oceanographic reports (BATHY/TESAC)”,

- Attachment I-3 paragraph 2: “Principles for the establishment of the exchange programme for observational data on the MTN”

- Part II paragraph 2.3.3.2: “Text of meteorological bulletins in alphanumeric representation”

- Part II paragraph 2.8: “Procedure applicable to the transmission of reports from ships and other marine stations”

3.2.9 The Team also recognized that migration will have significant impact on the Annual Global Monitoring and Annual Antarctic Monitoring programs. Procedures for both will need significant modification. This will need to be coordinated with other Teams of the OPAG on ISS dealing with the GTS.

3.2.10 Deprecation of TAC after migration may well be very difficult to accomplish. It would be easy to simply drop them from the Manual on codes and say they should not be used on the GTS. However, even once the MTN has switched completely to TDCF there will probably continue to be some use on RMTNs and on sub-regional communications systems for some long time. Even, once communications are fully migrated, there may be a continuing need for TAC for local display. Additionally, there are considerable archives of data in TAC. The Team felt a decision on the disposition of TAC should be made in coordination with the ET/DR&C after operational exchange of each code form in BUFR or CREX is complete. This decision point has been incorporated into the final plan.

3,3 GDPS

The Global Data Processing System is fed by meteorological observations. The programs receiving meteorological data are the first one to encounter the data formats, usually after having cracked the WMO Bulletins. The decoders of WMO TAC are not simple pieces of software. Two thirds of the program, if not more, are usually dedicated to detect and correct errors in the format due to manual coding error or transmission failures. Clearly a switch to the reception of BUFR data instead of reception of WMO TAC, should improve the data quality. However, this should be dampened by the fact that errors are introduced through networks of poor quality, which might be the latest to switch to binary transmission and BUFR data. CREX would somehow improve the quality, but not as much as BUFR. A universal decoder for BUFR/CREX would simplify greatly the maintenance of decoding software in pre-processing system of GDPS Centres. The big advantage of the migration to TDCF would be the facility to transmit any new data types and additional parameters like metadata, which are requested by the meteorological applications, especially the data assimilation systems.

Main impact on GDPS

3.3.1. There were 187 National Meteorological Centres in the World. Fifty-nine of them were running a Numerical Weather Prediction Model, sixteen of them were running a Global Model and fourty-three were running only a Limited Area Model. Most of these Centres had decoders of WMO TAC. Those running global models usually had also BUFR decoders for satellite and aircraft data. Few Centres had a fully universal BUFR decoder. A great number of others might have some automated data switch systems, with a small computer processing codes for input to automatic plotting, or to data bases for real time access or archive. Some also had simple "turn-key" type work-stations which received as input GTS observation data in TAC. Finally there were still some Centres which operates "manually", with plotting performed by hand.

3.3.2 Data base storage of real time data was not so much of a problem since usually data were decoded before storage, and stored in an internal format or BUFR itself in some advance Centres. If the data were stored in the original format, then if it might become BUFR or CREX, and if a processing was operated on the data for displaying or plotting, a decoding programme for BUFR or CREX would have to be implemented.

3.3.3 Provision of and support for encoding and decoding software for TDCF would be necessary but not sufficient for a successful migration. It would take quite a long time for many NMHSs to introduce computer systems to process binary data at their local offices and a national telecommunication network to transmit binary data to their local offices even if their NMCs and GTS Centres could deal with binary data. Furthermore, a number of advanced NMCs using automated data processing systems also used application software directly linked to TAC for data plotting, data display and database simply because most of conventional observations were coded in TAC. It should be noted that the introduction of new software (and additional hardware) for migration might have a small to significant financial impact on many NMHSs.

3.3.4 When NMHSs will convert BUFR messages received from the GTS into character code for their national use, there may be more sense in encoding the information in CREX instead of TAC. In any case every effort should be made to avoid converting BUFR data back into the TAC.

Required actions prior to migration:

3.3.5. Impacts of migration to TDCF and required preparatory corrective actions at GDPS Centres to avoid missing data input can be divided in three categories:

3.3.5.1 Some Centres will have to add in their processing chain full universal BUFR and CREX decoders, to avoid missing observations.

3.3.5.2 Other Centres will have to implement a universal BUFR and CREX decoders, to be able to receive observations in BUFR or CREX. Manufacturers of "turn key" work-stations inputting GTS data would need to be approached so that they include in their software universal BUFR and CREX decoders, either in the existing systems, or for the new systems currently in development or to be developed.

3.3.5.3 Finally, some Centres, which are currently operating manually, will have to seriously consider automation with software including a universal BUFR and CREX decoder. Before automation is implemented, they could be able to receive and understand CREX messages with a relatively simple training.

3.4 INTERFACE WITH OTHER PROGRAMMES

The advantages of the migration to table driven codes start to be well known by the World Weather Watch (WWW) community. It is not sure that the advantages are also known outside the WWW circles. A campaign of information on this subject will have to be undertaken before and during the migration process.

3.4.1 One could distinguish three types of other Programmes, which are somehow connected with the WWW:

a) the Programmes depending on the operation of WWW, which provides input data to them (e.g. World Climate Programme, GCOS, Hydrology)

b) the Programmes which contribute to some data collection as input to the WWW, but which, anyway, are depending fully of the data processing of WWW (e.g. CAem -aviation meteorology -ICAO, JCOMM- Marine Meteorology)

c) the Programmes, which contribute data to the WWW, but which do not need fully the WWW processing for operation (e.g. Satellites, Oceanography-IOC)

Impacts and required actions

3.4.2 The impacts of the migration are considered for every type of Programmes. The required actions for their users, or for the World Weather Watch data processing centres themselves are listed below.

3.4.2.1 Type (a) Programmes, usually receive already processed data by extraction from data bases. The decoding of BUFR or CREX would have been performed previously by meteorological data processing centres. If TAC were usually stored and delivered, then decoders of BUFR/CREX would have to be provided to these users for the migration.

3.4.2.2 Type (b) Programmes would seriously require to be convinced of the interest of switching to BUFR (or CREX, if BUFR cannot be implemented), which will enable the transmission of more parameters and metadata, to the benefit of their users. For example, Service ARGOS, DBCP and SOOP are planning and developing systems for the transmission in BUFR during 2002/2003 of buoy, XBT, XCTD and sub-surface floats observations. Indeed the recipient of these data (WWW data processing centres also) will have to be equipped as soon as possible with BUFR decoders. Data producers who were often contractors for automatic observation platforms would have to work with the platform manufacturers to recommend BUFR or CREX as efficient codes. In some case, it was a centralised centre, which encodes in GTS format, rather than each platform coding GTS messages (e.g. Service ARGOS). In this last case, the migration would be easier since it would be easy to convert to BUFR in a centralised processing centre. Double dissemination (TAC and BUFR) could also be performed for a while. The civil aviation will probably be less encline to move. However, some ACARS data have been transmitted for a long time in BUFR, and ICAO knows well the advantages of BUFR. The WAFS centres are disseminating SIG weather data in BUFR. Their users (e.g. pilots) will certainly need for a long time a presentation in clear character formats, but the transmission could be done in BUFR, followed by an automatic decoding prior to the visualisation program.

3.4.2.3 Type (c) Programmes have less constraint imposed by a migration to BUFR or CREX, since they are probably limited users of raw observation data. The bulk of satellite data are transmitted already in BUFR. The oceanography will be a contributor of BUFR data via Service ARGOS. Scientific research Programmes will need to be informed of the benefit of TDCF. If they need to receive raw meteorological observations (perhaps satellite operators), BUFR/CREX decoders will have to be provided to these Programmes (on reciprocity for their services to the World Weather Watch!).

3.4.3 The representative of IOC, Mr Etienne Charpentier informed the Team on the issues related to the migration, of concern to the oceanographic community. Coordination at the international level of data management issues in the marine and oceanographic communities of WMO and IOC will primarily be done through the JCOMM Data Management Programme Area (data distribution and archive, data users) and through the JCOMM Observations Programme Area where panels such as the DBCP, SOOP, ASAPP, and VOS actively participate and report (data producers). Different programs or systems might be affected in various manners by the migration:

- Voluntary observing ships (VOS Programme): There were no firm plans at this point to develop capability to distribute VOS meteorological data in BUFR. This was to be discussed in the context of JCOMM and its Ship Observations Team. National initiatives to distribute ship data in BUFR would be welcome although it was recommended that character codes such as SHIP continue to be used in parallel for a long period.

- Surface buoy data: At its 16th session, the WMO-IOC Data Buoy Cooperation Panel (DBCP) took steps to insure GTS distribution of buoy data in BUFR as of early 2003. Buoy data would continue to be distributed in BUOY format in parallel for some years after BUFR distribution starts. Cooperation in recent years with the CBS ET/DR&C permitted to create needed descriptors in relevant BUFR tables. Proposed templates and examples must be defined well in advance to facilitate developments and tests before 2003.

- ARGO sub-surface profiling float data: A few float providing countries would eventually implement national solutions to GTS distribution of ARGO float data in BUFR. Other countries would rely on Argos system capabilities to produce BUFR reports that would be developed primarily for surface buoys (such capability should be compatible to some extend with requirements for GTS distribution of sub-surface floats in BUFR).

- Ship Of Opportunity data (XBTs): There were no firm plans at this point to develop capability to distribute XBT data in BUFR. This was to be discussed in the context of JCOMM, its Ship Observations Team, and SOOPIP.

3.4.3.1 The IOC representative indicated then to the Team concern on some crucial points related to the migration:

- Need for encoders/decoders: Having software available from other sites would be helpful. But, sites wishing to incorporate read/write of BUFR into operations would likely need to develop/extend general BUFR software to take into consideration characteristics of their own operations.

- Writing data into BUFR is generally easier than reading data in BUFR. However, new writers of BUFR should ask an experienced user to read the output to be sure they are doing things correctly before they generally issue their data in BUFR.

- Filtering and naming convention: At the moment, oceanographic data/products on the GTS form a small fraction of the total. The bulletin naming conventions (the TTAAii part) is used to filter out all but those headers of interest to the community. The second part is used to some extent as a filter. So, the naming of BUFR bulletins by their content would help to provide some equivalent way to focus in on the data of interest. The naming convention could change, but the functionality that the TAC bulletins provide must be kept.

- Providing specific support and services: There were not so many oceanographic places that handled GTS messages directly. Few would need to adjust to BUFR and perhaps would need to organize support to others. The meteorological Centres who routinely handled GTS data might need to provide services to users that would provide the GTS data taken from BUFR and put them into another form. This would probably be needed more so than in the past.

- Building a new "organization" for distributing ocean data: It was relatively easy to encode data into character codes and so this happened at a number of places in the oceanographic community. At least some of these places would probably view creation and maintenance of BUFR software to encode data as a burden they could do without. This would place challenges on the ocean data system to sustain and increase current levels of data dissemination. We would probably see a new "organization" of how ocean data get to the GTS in BUFR. One could expect that meteorological Centres in some Countries might be asked to help for achieving this migration.

- Monitoring the transition: Since CBS wanted a smooth transition, it would be necessary to have data in both BUFR and TAC. We already knew that data get "lost" on the GTS. There needed to be a monitoring process that ensured exactly what is in BUFR is exactly what was in the TAC. This raised an interesting problem: If someone switched to BUFR and sent data that way, but also wished to send the data in a TAC, they might be faced with the TAC supporting only part of what could go into BUFR. In fact, it could be expected that this would generally happen, since why switch to BUFR just to send the same information that you could be sent in a TAC. So, how to monitor that the same (to the extent possible) information is getting out in both forms?

3.4.3.2 The Team discussed also the use of Master Table 10 in BUFR. Master Table 10 is a table containing pure oceanographic data, which was developed few years ago by the oceanographic community. The Team recommended the Master Table 0 (meteorological) to contain only the geophysical oceanographic parameters, that were more related to meteorology (e.g. applications for ocean and coupled numerical models). The other types of oceanographic parameters (e.g. chemistry, biology) would be stored in Master Table 10.

4. IMPLICATIONS ON WMO MEMBERS RESOURCES FOR DEVELOPMENT AND OPERATION

4.1 All WMO Members would be somehow affected by the migration and should be concerned by the migration plan. For some Centres, migration to TDCF would actually reduce the diversity of data formats needed to be processed reducing software and operational requirements. The Team felt It was important to fully understand the positive benefits and implications of TDCF. These positive benefits will help to create an incentive to migrate.

4.2 The Team reviewed impacts to WMO Member resources and noted there were many benefits that would not be realized until after negative impacts would occur. However, it was found for all negative impacts there were offsetting positive benefits. The Team felt it was important to focus member's attention to these positive benefits.

4.3 The Team recommended that pilot migration projects be identified, developed and implemented, as test and precursor of the migration, to show the benefits in one hand and on the other hand, put into light the difficulties, if any, encountered by the Members.

4.4 The Team evaluated and listed both positive and negative impacts. These are included in annex to this paragraph. This list was developed with attention to three levels of concern, Global affects, Regional affects and local affects. Additional attention was given how these impacts related to all of the various operational entities of the WMO such as RTHs, NMHSs, and GDPS Centres. Also factored, were impacts by data type as well as by dissemination/ exchange system, i.e., MTN, RMTN and by commission/organization such as the DPCP. The Team will use this information in its coordination with operational organizations.

4.5 The Team also considered whether this information would be useful if compiled into a migration guidance document that could be provided to anyone interested. It was widely accepted a new guide to TDCF was needed but this document would have a different purpose in that it would specifically address migration issues whereas the guide really was dedicated to the code forms themselves and their usage. This information could also provide benefit to those organizations and communities associated with WMO such as ICAO. This document could eventually be included as an annex to the guide but should not wait for the guide to be complete before it was made available. It was agreed this was a useful enterprise and this action would be coordinated with the ET/DR&C and the Secretariat.

5. SOFTWARE PROJECT TO SPECIFY, DEVELOP AND DISTRIBUTE UNIVERSAL BUFR, CREX AND GRIB ENCODING/DECODING SOFTWARE

5.1 The Commission considered that a successful migration to TDCF would depend on several supporting projects, new measures and assistance to Member Countries. These would have to include information dissemination, training, software distribution and possible assistance in implementation. Indeed there was a need to define a software project to distribute universal BUFR, CREX (and GRIB Edition.2) encoding/decoding software to all requesting countries.

5.2 The Commission recognized that provision of and support for encoding and decoding software for the TDCF was an indispensable part of any migration plan. CBS also noted that the implementation and integration of decoder/encoder "plugged in" an operational chain of programs was not a trivial issue.

How do WMO Members presently code their observations?

5.3 The CBS Sub-Group on Data Representation and Codes (SGDR&C) distributed in 1998 a questionnaire to ask each Member of WMO which codes they use, how they use them, and the operational and planned capabilities for automatic processing of these data. The SGDR&C circulated also a survey to identify the views of users and producers of data in regard to CREX, BUFR, and traditional Codes. The questionnaire was sent to 185 Member Countries of WMO in September 1998. Fifty-seven countries answered.

5.4 Although, resulting from the survey, only two main operating systems were used by the Members (UNIX and MS/DOS) to process WMO data representation forms, it would be difficult to ensure portability of decoder/encoder software between different machines with different operating systems. The questionnaire showed also how training on BUFR, CREX and GRIB 2 would be important for many countries (see annex to this paragraph).

Encoding/decoding Software for BUFR, CREX, and GRIB

5.5 The problem had not been the provision of encoding/decoding software, for a wide variety had been available for some time via the Software Exchange Program. Rather the problems had been twofold: first, such software was only available in the language and for the operating systems used by the providing Centre; second, the providing Centres were not funded for nor did they had resources to provide support for the donated software. Since the WMO community was using a wide variety of operating systems, languages, and hardware platforms, and since support for donated software was often needed, the Software Exchange Program had not been able to solve this aspect of the migration problem. The experiences was, that often this software was only written for the language and operating system used by the donating Centre, and was often embedded in an operational chain with specific interfaces, which had to be adjusted when transferred in another operational meteorological system.

5.6 The Expert Team found that the encoder/decoder software should be accompanied with display tools like a "BUFR viewer". If the decoding were done in a workstation connected to INTERNET a "BUFR viewer" in a browser would be useful. The users should have the choice of getting a "source" code or a compiled version of the encoder/decoder. The compiled version would be especially valuable for small workstations. Documentation on the program and how to implement it ought to be clear and comprehensive, with all interfaces with the external application well defined.

5.7 The Team reviewed the list of actions to implement the software project to provide encoding/decoding software and recommended the plan listed in annex to this paragraph.

5.8 USA was planning to distribute to all its regional offices data in BUFR. All software on the official NOAA Web site would be freely available to WMO Members as well, although support could not be extended to non-USA National Weather Service users. Other WMO Centres had encoding and decoding software that could, sometimes under certain conditions, be made available. For example, the ECMWF made its software available to its Member States and, through bi-lateral arrangements, to other Meteorological Services. Japan had also given its software to other meteorological services through bi-lateral agreement. There were, undoubtedly, other Centres who also made their software available as well.

5.9 The representative of ECMWF, Mr Milan Dragosavac explained a proposal of ECMWF to WMO to host a software project at its headquarters in Reading, England, for an initial period of two years. The scope of the project would encompass the development of the portable standard BUFR, CREX and GRIB software on all the major UNIX (including LINUX) platforms. Development, implementation and testing would be performed on platforms available at ECMWF. Installations on other platforms would be performed by remote access with the help of interested WMO Members. ECMWF will distribute the software freely through its Data Services to WMO Members on request.

5.10 The following additional information was given by ECMWF:

a) There is no plan at ECMWF to develop the software for the MS/DOS-WINDOWS environment. The portability of the software will ensure that it will function with suitable FORTRAN and C compilers or directly on PCs running LINUX. It would be suitable with 32 or 64 bits processor machines.

b) There will be facilities to view the information in the standard sequence of BUFR templates with BUFR/CREX element names and units.

c) Limited assistance, such as by e-mail correspondence, will be provided with the local installation of the software and other queries concerning the running of the software.

d) Enhancements in the services provided to the users of the software should be part of a second phase of the project after the initial two-year period.

e) ECMWF would host the project, provide the office space, the computer resources and the management of the project.

f) Funding will be required through the WMO for one full time consultant with the appropriate expertise to be employed by ECMWF. The project could start within six months after the necessary funds have been committed. The required fund was estimated at about 60,000 £ per year.

6. DEVELOPMENT OF A DETAILED MIGRATION PLAN

6.1 TECHNICAL PHASES

The Team reviewed what was needed for migration of all TAC and for completion of the plan. It decided to create an action plan for the work needed to be accomplished to enable completion of the migration plan. This action plan is covered under item 7 of this report.

6.2 TRAINING

6.2.1 CBS requested that WMO provided training should be complete no later than October 2005. The Team also noted some training was already being included by the Secretariat in existing programs. The Team felt there were two levels of training that should be done and another level that should be considered if the software project was not accomplished. These levels were:

Training levels:
- L1 – General philosophy of TDCF and migration overview
- L2 – Meteorological users, Telecommunications Managers, Data Managers, and those involved with Application Interfaces
- L3 – For encoder and decoder programmers (only needed if the software project is not implemented)

The schedule for this training is included in the action plan in annex to this paragraph.

6.2.2 Implementation of migration at GOS, GTS and GDPS levels should be synchronised with training.

6.3 SCHEDULE

6.3.1 The Team examined the dates that were provided by CBS and also considered the budgeting cycle of the secretariat. With these dates in mind as constraints, it then looked at what factors could be used to frame a migration schedule. The results of the codes usage survey which was done (see annex to paragraph 5.4) were used to group codes into six categories which were thought to share common characteristics which would allow migration to proceed in parallel. For each of these categories three target dates were set, the start of experimental exchange, the start of operational exchange and the end of operational exchange. The Team weighed various factors affecting each of these dates for each of the categories and arrived at target dates. This preliminary migration plan is included in annex to this paragraph. This plan will be made more complete as the activities in the action plan described below are completed.

6.3.2 The Team noted in several categories there were existing exchanges of data types. The target dates are not intended to limit when exchange may begin. In fact it is strongly encouraged that migration on a test, experimental or bi-lateral basis begin as soon as possible. These targets are the dates the Team feels it is important to have exchange of migrated data occurring no later than.

7. ACTION PLAN

7.1 The Team felt there was significant work still to be accomplished to have a comprehensive migration plan and it would be good to devise an action plan to itemize additional tasks needed to be performed or to schedule the occurrence of significant events. This action plan includes a target date as well as an assignment of primary responsibility for who will accomplish or coordinate each task. In some cases, the entire Team has been given joint responsibility for completing an action. The Chairman will provide additional coordination as needed. The action plan for the Team is included in annex to this paragraph. All items in the action plan are scheduled to be complete in time for finalization of a migration plan to be presented to the ICT of OPAG on ISS.

7.2 The Team considered what information would be needed to create a good migration plan and recognized there was a considerable amount of information that needed to be gathered and collated in a fashion that would allow good analysis of the status and progress of migration. This information gathering would be critical to formulation of an effective plan. It would also be very useful as a tool for tracking the implementation of migration. It was felt the best way to organize this information was in a matrix keyed by the individual TAC and type of Centre which would be the rows of the matrix. The columns of the matrix would include all the factors that have an impact on migration. The structure of the matrix is included in annex to this paragraph.

8. CLOSURE OF THE MEETING

The Meeting was closed by the Chairman of the ET on MTDCF at 13.30 on Friday 11May 2001.

ANNEX TO PARAGRAPH 1.1

ET/MTDCF, Geneva, 7-11 May 2001

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ANNEX to paragraph 4.4

Benefits/Impacts/Solutions

- **Benefits:**
  1. Flexibility to adapt data encoding to individual needs
     a. National and regional requirements
     b. Special purposes or practices
  2. Common format can be used for exchange, storage and archive
     a. Serves scientific and operational uses
  3. Allows encoding of data types, parameters and increased precision not accommodated by TAC
  4. Decreased diversity of code formats reduces training and software costs
  5. Maintenance of BUFR/CREX Code tables much easier than modifications to TAC when addition of data types or parameters occurred
  6. BUFR and GRIB provide compactness and compressibility
  7. Improvement of data quality after transmission (especially BUFR data) and de-facto, increase number of useful observations
  8. Improvement in products resulting from better data

- **Negative impacts:**
  1. Initial costs
     a. Training of personnel who generate or use data
     b. Training of system and software personnel
     c. Project management costs of transition
     d. Documentation updates
     e. Operational procedure changes
     f. Infrastructure, hardware and system changes
  2. Risk of data latency increase with greater volume of GTS traffic and effects of format conversion or translation.
  3. Increase of demand on GTS switching systems during migration period

- **Solutions:**
  1. Guide(s) will be available to explain codes and migration issues
  2. Training is being provided
  3. Encoder/decoder software with data viewing capability will be available
  4. Coordination with manufacturers for encoding/decoding will be done
  5. Mechanism for maintenance of templates and common sequences will be documented
  6. Templates for all common traditional code forms will be available
  7. ET/DR&C will provide continuing maintenance of TDCF
  8. Central planning and coordination by ET/MTDCF
  9. Parallel transmission of TAC along with migrated data will allow flexibility of transition
  10. CREX can be used where infrastructure cannot support BUFR
  11. Translation can be done between BUFR and CREX
  12. Progress of migration should be monitored to expedite reduction of unneeded dual transmissions

ANNEX to paragraph 5.4

RESULTS OF QUESTIONNAIRE ON WMO CODES (1998)

1. Fifty-seven countries answered:

2. From RA I, 9 countries answered.

From RA II, 14 countries answered.

From RA III, 6 countries answered.

From RA IV, 1 country answered.

From RA V, 5 countries answered.

From RA VI, 22 countries answered.

3. RESULTS Compilation of replies

The results of the questionnaire can be found in Appendices A, B and C.

4. USE OF WMO CODES (see Appendix A)

4.1 The most used WMO codes for encoding and transmitting information are SYNOP and CLIMAT (all countries-100%, then TEMP (56 countries-98%), METAR (55 countries-97%), TAF (48 countries-84%), SPECI (46 countries-81%), CLIMAT TEMP (44 countries-77%), PILOT (39 countries-68%) and SHIP (36 countries-63%).

4.2 Surprisingly, 12 (21%) countries code data in RADOB, 12 (21%) in TEMP SHIP and 10 (18%) in HYDRA.

4.3 Only one country encodes in CODAR (manually), one in ICEAN (manually), one in WAVEOB (automated), one in SFAZI and one in SFAZU.

4.4 FM 49 GRAF and FM 73 NACLI, CLINP, SPCLI, CLISA, INCLI are the only 2 codes which are not reported to be generated by any country.

4.5 Two other codes are not encoded: SFLOC and SARAD, but they are received by some centres (2 and 4 respectively).

4.6 FM 57 RADOF was omitted by mistake from this questionnaire. We know that in RA VI, this code is used for some bi-lateral exchanges.

4.7 Only 12 (21%) countries code data in BUFR, of which 7 (12%) are coding BUFR data at the observing platform or site, 10 (18%) at a processing centre and 1 at the telecommunication centre only.

4.8 Only 3 (5.3%) countries are coding in CREX of which 2 (3.5%) are reporting coding CREX data at the observing platform or site and 2 (3.5%) at a processing centre.

4.9 Fourteen (25%) countries reported they generate GRIB reports when only 8 (14%) generate GRID reports.

AUTOMATION FOR ENCODING (see Appendix B)

5.1 From RA I, 9 countries answered, 2 reported some automation in encoding of observations or products
1 reported extensive automation

From RA II, 14 countries answered, 2 reported some automation in encoding of observations or products
3 reported extensive automation

From RA III, 6 countries answered, 1 reported some automation in encoding of observations or products
1 reported extensive automation

From RA IV, 1 country answered and reported extensive automation in encoding of observations or products

From RA V, 5 countries answered, 1 reported some automation in encoding of observations or products
1 reported extensive automation

From RA VI, 22 countries answered, 8 reported some automation in encoding of observations or products
8 reported extensive automation

5.2 Fourteen countries reported some automation in encoding of observations or products and 15 countries reported extensive automation. In total 29 countries out of 57 reported automation in encoding of observations.

5.3 The countries seem to use many different computers and operating systems for encoding reports. For example, out of 20 countries reporting automatic encoding of SYNOP, 18 different combinations of systems are reported. Sometimes there are more different systems used than countries.

5.4 Overall, the main operating systems to be used are UNIX followed by MS-DOS, for languages FORTRAN 77 and C are mentioned the most. GRIB and BUFR are not processed under MS-DOS, but all under UNIX, with FORTRAN 77 and C. GRIB is indeed usually processed on bigger machines (CRAY, NEC).

ARCHIVING OF OBSERVATIONS MESSAGES

6.1 About two thirds of the countries reported they archive observations. About half reported they archive in the WMO Alphanumeric Code format, the other half in a different format, which is for one third BUFR.

6.2 Almost all the countries encoding BUFR, GRIB and CREX, archive these messages, but one fifth archive them in a different format! One country indicated it archives CREX in BUFR, which is indeed very natural!

DECODING-PROCESSING OF WMO CODES (see Appendix C)

7. Thirty-four countries reported some automation for decoding or processing alphanumeric codes. A great variety of platforms are used by the Members, however SGI is reported 10 times and PC type systems 18 times. The operating system UNIX is reported 17 times, MS-DOS 15 times. FORTRAN 77 is used 18 times, C 16 times.

BUFR

8. Thirty-eight countries reported using BUFR. Twice more countries reported for DECODING than for ENCODING. Countries indicated use of BUFR for all types of data, but mostly for satellites and RADAR data. Three countries reported they use it for automated station data. It is indeed used for archiving.

8.1 The advantages of BUFR are well known and listed again by the countries:

Overall very powerful
Compactness of data (5), Save disk memory, Save disk space
Self defined
Expandable for local or international applications (2)
Fully flexible (2)
Easy to add or change observational elements (2)
Universal Code Form (3), Manage any type of data
The only possibility for composition of RADAR data
Embedded auto-control *(?)*
Efficient for data processing and transmission
Convenient for calculation
Allows easy conversion into internal format *(?)*
Machine independent*(?)*
Portability and uniformity

8.2 The disadvantages are less known but the countries made a good list:

Not human readable (6), binary
Coordination between data source and data recipient to ensure the same interpretation
Tables updating and coordination heavy (4)
High requirement for the used computer
Requires a sophisticated ENCODER/DECODER (3), Difficulty in coding and decoding
For transmission, it requires X25 or TCP/IP
Possible confusion within tables (2)
Complexity (2)
Too strict rules *(?)*
Decrease accuracy *(?)*
Missing standard encoders/decoders for different platforms.

CREX

9. Only 3 countries indicated they use CREX, however 23 countries plan to use CREX in the future. Twenty-one said they had no plan to use it. The question which can be further asked is: do they know about CREX? Many countries indicated they planned to use CREX to replace traditional codes. It is currently used for Ozone data exchange (3 countries), typhoon forecast information (1 country), for hydrology (1 country).

9.1 Countries listed the following advantages of CREX:

Close relationship to BUFR, good solution for simple needs, human readable (in recurring cases), flexible
Experience of using CREX will be helpful for migration to BUFR
Similarity of the concept of CREX and BUFR *(flexibility, expandability)*
CREX can prevent the proliferation of new various alphanumeric codes (3)

CREX allows direct readability without various decoder
CREX does not require X25 nor TCP/IP for transmission
CREX allows data representation in commonly used units
General Code *(universality)*
Flexibility allowing to provide different data in different situation
Easy to use code
Flexibility of tables, can be used by not automated centres.

9.2 The main advantages of CREX which were expressed by the countries, were really to avoid the proliferation of new alphanumeric codes, the flexibility and the ease of use.

9.3 The countries listed the following disadvantages of CREX (comments by secretariat in italics):

Octal representation of flag tables, limitation for satellite data, less flexible than BUFR *(?),* not really readable when content varies, does not compress data *(but one can use ZIP)*, coordination of tables, coordination between data source and data recipient *(at the beginning)*
Transition of TCC to CREX would require modifications of the existing software
Cost for renewal of existing software
Could be too long a message (3), CREX is not volume efficient
Lack experienced staff *(training necessary)*

PERSPECTIVES

10. The main disadvantage expressed by the countries is the size of CREX messages. Perhaps, to counter that, a standard compressing package could be suggested. Clearly the cost to renew the existing software is a big hurdle. Only new data types without an existing WMO code should be considered to coded in CREX. A recognized WMO software house should offer standard encoder/decoder software packages, for both CREX and BUFR. Definitely, training should be provided. Heavy and intensive training would be required for programmers if encoder/decoders were not available, however if they are, a light training, more simple and just informative will be sufficient for BUFR. CREX can be easily fully understood within a few hours.

10.1 Countries listed the computers where they use or plan to use a BUFR or CREX decoder software. SGI and PC types are the most used machines (see logically the same in parag. 7.1). UNIX and MS-DOS will be the most use operating systems. FORTRAN and C are the winners for the languages.

10.2 The list of data which cannot fit in present WMO alphanumeric codes is impressive. Indeed there are the wind profilers, satellites, the ACARS and RADAR data, for which BUFR is the answer. Nevertheless, 8 countries indicated there were no data which did not fit the WMO alphanumeric codes, perhaps because they do not have new requirements. Countries listed new data types which should be considered with attention:

Monitoring reports of regional synoptic network
High resolution products
Forecast vertical profiles
Radiological sounding
Air pollution data (use internal character code)
Agrometeorological (use internal character code)
Observations and predictions of ENSO, Developing anomalies, ITCZ data, Soil hydrological bilan
Pictorial information
Advisories, Forecasts
Aeronautical data and information

Some aircraft and radiation data
Measured data from automatic station.

CANDIDATES FOR REPRESENTATION AND EXCHANGE

11. There are two groups of countries: those that said that CREX could transmit all data, and those that limit it to the new data types for which there is no existing alphanumeric WMO codes. The same answer is made for BUFR.

APPENDIX A
Questionnaire on Use of WMO Codes

Code	Encoding				Transmitted by telecomm. Centre		Received by GDPS Center		Archived by agency
	At Observing Site or Platform	At a processing Centre	At telecom-munication Centre only	If automated, indicate: computer, operating system, encoder language (e.g. CRAY J916, UNIX, FORTRAN 77)	Domes-tically	Interna-tionally	from some other domesti c source	from an interna-tional source	(specify archive format if different)
FM 12 SYNOP	56	11	2	20	45	46	19	50	17 ≠ 15 BUFR: 4
FM 13 SHIP	23	3		8	24	28	14	26	14 ≠ 7 BUFR: 3
FM 14 SYNOP MOBIL	3				3	4	3	6	3 ≠ 1
FM 15 METAR	51	4		13	41	47	18	32	21 ≠ 5 BUFR: 1
FM 16 SPECI	42	4		9	37	42	16	30	17 ≠ 4 BUFR: 1
FM 18 BUOY	4	5	2	3	8	12	4	16	8 ≠ 5 BUFR: 3
FM 20 RADOB	12			1	7	12	5	7	5 ≠ 1
FM 22 RADREP	4				2	3		2	2
FM 32 PILOT	35	4		11	26	31	16	27	14 ≠ 8 BUFR: 4
FM 33 PILOT SHIP	4	2		2	7	8	4	13	7 ≠ 5 BUFR: 4
FM 34 PILOT MOBIL	2				3	5	2	7	4 ≠ 1 BUFR: 1
FM 35 TEMP	50	6		18	40	51	19	39	21 ≠ 11 BUFR: 4
FM 36 TEMP SHIP	10	2		3	11	13	6	22	8 ≠ 7 BUFR: 4
FM 37 TEMP DROP		1		1	2	3	2	6	4 ≠ 1 BUFR: 1
FM 38 TEMP MOBIL	4				5	6	3	9	5 ≠ 2 BUFR: 2

Code	Encoding				Transmitted by telecomm. Centre		Received by GDPS Center		Archived by agency
	At Observing Site or Platform	At a processing Centre	At telecom-munication Centre only	If automated, indicate: computer, operating system, encoder language (e.g. CRAY J916, UNIX, FORTRAN 77)	Domes-tically	Interna-tionally	from some other domestic source	from an interna-tional source	(specify archive format if different)
FM 39 ROCOB	3			1	2	3	2	4	3
FM 40 ROCOB SHIP	2				1	2	1	2	1
FM 41 CODAR	1				2	2	1	3	3
FM 42 AMDAR	4	4		2	5	7	5	13	5 ≠ 4 BUFR: 2
FM 44 ICEAN	1				1	2		1	2
FM 45 IAC	3				3	3	2	2	1
FM 46 IAC FLEET	1	1			2	1		2	1
FM 47 GRID	1	7		6	8	11	2	26	7 ≠ 2
FM 49 GRAF									
FM 50 WINTEM	1	4		1	5	6	1	9	4 ≠ 1
FM 51 TAF	32	16	2	7	38	46	13	29	13 ≠ 5 BUFR: 1
FM 53 ARFOR	3	3		1	9	7	3	7	2
FN 54 ROFOR	7	5		2	13	13	4	8	5
FM 61 MAFOR	2	1		1	4	3	1		2
FM 62 TRACKOB	2	4		3	2	5	1	4	4
FM 63 BATHY	5	4		4	5	9	4	8	4 ≠ 4 BUFR: 2
FM 64 TESAC	2	3		3	3	7	2	7	3 ≠ 4 BUFR: 2

Code	Encoding				Transmitted by telecomm. Centre		Received by GDPS Center		Archived by agency
	At Observing Site or Platform	At a processing Centre	At telecom-munication Centre only	If automated, indicate: computer, operating system, encoder language (e.g. CRAY J916, UNIX, FORTRAN 77)	Domes-tically	Interna-tionally	from some other domestic source	from an interna-tional source	(specify archive format if different)
FM 65 WAVEOB	1			1	1		2		≠ 1 BUFR: 1
FM 67 HYDRA	9	1		1	5	6		5	4 ≠ 2
FM 68 HYFOR	4	1		1	2	4		3	2 ≠ 1
FM 71 CLIMAT	41	19		9	29	51	15	31	16 ≠ 6
FM 72 CLIMAT SHIP	3	1			2	5	3	5	4
FM 73 NACLI,...					1	1			
FM 75 CLIMAT TEMP	32	12		10	22	38	11	23	12 ≠ 3
FM 76 CLIMAT TEMP SHIP	2	2			2	4	2	6	3 ≠ 1
FM 81 SFAZI		1							
FM 82 SFLOC					2			2	
FM 83 SFAZU		1							
FM 85 SAREP		3		1	2	3	2	4	5
FM 86 SATEM	1	4		2	5	7	2	15	6 ≠ 4 BUFR: 3
FM 87 SARAD					2	5		4	2
FM 88 SATOB	1	3		2	6	8	3	16	5 ≠ 2 BUFR: 1
FM 92 GRIB	2	14		14	15	12	4	25	11 ≠ 1

Code	Encoding				Transmitted by telecomm. Centre		Received by GDPS Center		Archived by agency
	At Observing Site or Platform	At a processing Centre	At telecom-munication Centre only	If automated, indicate: computer, operating system, encoder language (e.g. CRAY J916, UNIX, FORTRAN 77)	Domes-tically	Interna-tionally	from some other domestic source	from an interna-tional source	(specify archive format if different)
FM 94 BUFR	7	10	1	12	12	10	5	11	8 ≠ 2
FM 95 CREX (experimental up to April 2000 - operational in May 2000)	2	2		3	3	3		3	2 ≠ 1

ANNEX to paragraph 5.6

SOFTWARE PROJECT REQUIREMENTS

i) To specify the user interfaces for encoding and decoding.

ii) To build software to decode BUFR, CREX, and GRIB according to specifications mentioned above. At a minimum, software should compile and run on the most common dialects of UNIX (including LINUX) and WINDOWS. It should be compatible with 32-bit and 64-bit architectures. The software delivered should be callable from applications, written in most common programming languages, such as FORTRAN and C.

iii) To apply the same process for encoding data.

iv) Printing and display routines should be available to view the whole contents of decoded data, and should be completed by user-friendly interface(s) as appropriate.

v) The user should have access to Code tables, both for human reading and editing (typically for local tables).

vi) The software should be well documented, and able to decode previous editions of BUFR (starting from edition 0).

vii) User-friendly human interface(s) to encode most current data types that may be collected manually would be appreciated.

viii) The software will be developed under the responsibility and supervision of a major NWP Centre.

ix) The software will be distributed to WMO Members and WMO associated Programs. It will be maintained and upgraded when required. Queries will be answered.

x) Software should also be made available to manufacturers of systems providing or using meteorological data, and more generally extension to public domain should be considered. Such types of delivery should be made on an “as is” basis, in the appropriate form (binary form when possible, source code otherwise).

xi) Some funding, if requested by the selected provider, will be made available under some WMO auspices, in order to provide the salary support for the staff needed to perform the task.

ANNEX to paragraph 6.3.1

PRELIMINARY MIGRATION PLAN

Last CBS decisions (made every two years):

- CBS(EXT)-2002 to review the migration plan;
- Training to be completed not later than October 2005; this is in agreement with the proposed training schedule:
    - L1: 2001
    - L2: 2002 onward
    - L3: 2004-2005 (as needed)
- Guide completed by the end of 2001;
- Templates completed by summer 2001 (current migration schedule foresees completion by March 2002).

Table:

The table below summarizes preliminary target dates for the migration process. Dates may need to be adjusted when new information from Members or other Organizations becomes available.

	Cat.1: common	**Cat.2: satellite obs.**	**Cat.3: aviation***	**Cat. 4: maritime**	**Cat. 5: miscellaneous**	**Cat. 6: almost obsolete**
Traditional code forms	SYNOP SYNOP MOBIL PILOT PILOT MOBIL PILOT SHIP TEMP TEMP MOBIL TEMP SHIP TEMP DROP CLIMAT CLIMAT TEMP CLIMAT TEMP SHIP	SAREP SATEM SARAD SATOB	METAR SPECI TAF CODAR AMDAR WINTEM ARFOR ROFOR	BUOY TRACKOB BATHY TESAC WAVEOB SHIP CLIMAT SHIP	RADOB RADREP IAC IAC FLEET GRID*(->GRIB)* MAFOR HYDRA HYFOR RADOF	ICEAN GRAF NACLI etc. SFAZI SFLOC SFAZU ROCOB ROCOB SHIP
Start experimental. exchange	**Nov. 2002** Current at some Centres for upper air data	Current at some Centres	**2006** Current at some Centres for AMDAR	**2005** **2003** for Argos data (BUOY)	**2004**	Not applicable (see below)
Start operational exchange	**Nov. 2005** Current at some Centres for upper air data	Current at some Centres	**2008** Current at some Centres for AMDAR	**2007** **2003** for Argos data (BUOY)	**2006**	Not applicable (see below)
Migration complete	**Nov. 2010**	**Nov. 2006**	**2015** **2005** for AMDAR	**2012** **2008** for Argos data (BUOY)	**2008**	Not applicable (see below)

Notes:

(1)* Aviation Codes require ICAO coordination and approval.

(2) For all categories consider that codes need to be reviewed in order to decide whether or not they should be migrated to BUFR/CREX. Codes in category 6 are not to be migrated.

(3) All dates above are meant as "not later than". However, members and organizations are encouraged to start experimental exchange, and, if all relevant conditions (see below) are satisfied, to start operational exchange as soon as possible.

- Start of experimental exchange: data will be made available in BUFR (CREX) but not operationally, i.e. in addition to the current alphanumeric codes, which are still operational.

- Start of operational exchange: data will be made available in BUFR (CREX) whereby some (but not all) Members rely on them operationally. Still the current alphanumeric codes will be distributed (parallel distribution).

- Migration complete: at this date the BUFR (CREX) exchange becomes the standard WMO practice. Parallel distribution is terminated. For archiving purposes and at places where BUFR (CREX) exchange still causes problems the alphanumeric codes may be used on a local basis only.

Relevant condition to be satisfied before operational exchange may start:

- Training has been completed;
- All required software (encoding, decoding, viewing) is available;
- BUFR/CREX-tables and templates (if required) are available;
- …

ANNEX to paragraph 7.1

Work/Action Plan for the Team on MTDCF

1. **Create Migration Matrix** TD: Jun 15 - Resp.: Chair

The Migration Matrix will be organized with the primary key being TAC types. Additional fields will represent all factors involved with migration from the TAC to TDCF.

2. **Completion of Migration Matrix** TD: Feb. - Resp.: Chair/All

Input of data into Migration Matrix will begin as soon as data are available. It will be regularly updated as additional information becomes available or information changes. The target date is designed as a goal to have as much information as possible to enable a draft migration plan to be completed. Information gathering will continue indefinitely and the Migration Matrix and Plan will be updated as needed.

3. **Create a coordination list. Get Point of Contacts** TD: Jun 15 - Resp.: Chair/Sec.

Compile list of organizations to contact to provide information about the migration and request information from.

o Provide the following information:
- General information about code migration
- Terms of reference of ET/MTDCF
- General information about initial migration plans

o Request the following information:
- Existing capability to process binary data
- Existing capability to transmit and receive binary data
- Existing exchanges of GRIB, BUFR and CREX
- Plans for future exchanges of GRIB, BUFR and CREX
- Availability of BUFR or CREX encoded data not received from some other country, Centre or Organization external to your national, local or organizational operations
- Plans for future encoding of data in BUFR or CREX
- Willingness to provide available BUFR or CREX data for pilot exchange programs
- Willingness to receive, forward on, or decode BUFR or CREX as part of pilot exchange programs
- Possible impacts from code migration
- Possible benefits of code migration
- Specific operational concerns about migration

4. **Coordination with members & affected groups** TD: Jul 15 - Resp.: Chair/Sec.

Initial coordination by E-mail with other groups' chairmen, RTH focal points, GDPS centers, RSMCs, other Commissions, and other impacted organizations. Draft letter providing information and status/impact enquiry to WMO members and other appropriate organizations. Input feedback received into matrix.

5. **Reanalyze codes survey, update results** TD: Aug -Resp.: Chair

6. **Recommend WMO training program** TD: Mar - Resp.: Sec.

Work to include training to information level L1* without delay (2001). WMO to look into providing training to information level L2* from 2002 to 2003.

7. **Determine impacts (negative & positive)** TD: Jan - Resp.: Chair/All

8. **Propose solutions** TD: Feb - Resp.: Chair/All

9. **Establish/coordinate migration target dates** TD: Mar - Resp.: Chair/All

10. **Determine current exchanges** TD: Feb - Resp.: All

11. **Recommend additional exchanges and testing** TD: Mar - Resp.: All

12. **Establish coordination of exchange and testing results** TD: Mar - Resp.: Chair/Sec

Feedback to plan and community.

13**. Build BUFR/CREX templates for most used codes**

The ET/DR&C should finalize the work to build templates for most used codes (SYNOP, SHIP, BATHY/TESAC, BUOY, AMDAR, AIREP, TEMP+PILOT ,METAR+SPECI), with target date for March 2002 and identify the needs to build templates for other observation codes, for review at its next meeting, and then at ET/MTDCF meeting.

14**. (Re)write guides per information levels (see paragraph 6.2.1)**

At its last meeting in Toulouse, the ET/DR&C pointed out the need for a new guide to BUFR/CREX, a manual for reporting practices, a guide for modifications to TDCFs, and a guide to GRIB edition 2.

As far as migration is concerned, special attention should be given to the BUFR/CREX guide. It should be layered in three parts:

- L1: for general philosophy
- L2: for meteorological and application interfacing users, including data managers and telecommunications managers
- L3: for encoder/decoder programmers

The work should be managed by the WMO Secretariat, with a target date of December, 2001. The service of a consultant was strongly recommended by the ET/MTDCF Team.

15**. Encourage national training program**

The Team felt that there is yet no or little training to TDCF within the NMHSs. The WMO Secretariat should send a letter to appropriate Members recommending countries with national experts on TDCF to develop their own national training program. Target date for letter is December, 2001.

16. **Recommend WMO training program**

The WMO Secretariat is already including in its 2001 training program level L1. The Team recommended to WMO to provide training to information level L2 from 2002 onwards.

17**. Identify needs for level L3 training**

Documentation at level L3 will be given through software and/or BUFR/CREX guide. The Expert Team felt that training at level 3 was not relevant if a software project for encoder/decoder was implemented.

18**. Request and evaluate proposals for software project, establish project**

To be done by the Secretariat, with a target date of July, 2001 (at least for the request).

19. **Draft of final plan** TD: Apr - Resp.: Chair

Annex to paragraph 7.2

Migration Matrix Structure

- **Rows:** Traditional code forms – Each FM type subdivided by centre type (RTH, GDPS, RSMC, etc.)
    - FM12 – RTH Tokyo
    - FM12 – RTH Washington
    - FM12 – RTH Nairobi
    - FM12 – ECMWF
    - FM12 – LFPW
    - Etc

- **Columns:**
    - BUFR/CREX templates available
    - T_1T_2 of WMO heading for corresponding BUFR and CREX bulletins
    - Number of WMO members and other agencies who insert this data type onto the GTS
    - Number of WMO members and other agencies who require this data type
    - Approximate number of reports per day
    - Number of locations inserting this data onto the GTS
    - Is encoding done at report generation site or a centralized location
    - Level of consistency of parameters reported
    - Current status of BUFR exchange of this data type
        - RA-I through RA-VI and Antarctica
    - Current status of CREX exchange of this data type
        - RA-I through RA-VI and Antarctica
    - Target dates for migration
        - Start of experimental exchange
        - Start of operational exchange
        - Completion of operational migration
    - Negative impacts
        - Global level
        - Regional level (and RTHs)
        - National level
    - Positive impacts (benefits)
        - Global level
        - Regional level (and RTHs)
        - National level
    - Other problems affecting exchange of the data type
    - Solution for negative impacts or to problems
        - Global level
        - Regional level (and RTHs)
        - National level

ANNEX

LIST OF ACRONYMS

ACARS	AirCraft Addressing and Reporting System
AFWA	Air Force Weather Agency
ANSI	American National Standards Institute
API	Application Program Interface
ARGO	Array for Geostrophic Oceanography
ASAPP	Automated Shipboard Aerological Programme Panel
AWS	Automatic Weather Station
ATSR	Along Tack Scanning Radiometer
BUFR	Binary Universal Form for data Representation
CBS	Commission for Basic Systems
CBS-Ext.(98)	Extraordinary session of CBS held in 1998
CIMO	Commission for Instruments and Methods of Observations
COST	European Co-Operation in the field of Scientific and Technical research
CREX	Character Representation form for data EXchange
DBCP	Data Buoy Cooperation Panel
DBMS	Data Base Management System
DCP	Data Collection Platform
DIF	Directory Interchange Format
DPFS	Data Processing and Forecasting Systems
DRT	Data Representation Template
DT	Data Template
DWD	Deutscher Wetter Dienst
EC	Executive Council of the WMO
ECMWF	European Centre for Medium-range Weather Forecast
EPS	Ensemble Prediction System
ESA	European Space Agency
ET	Expert Team
ET/EDF	Expert Team on Evolution of Data Formats
ET/DR&C	Expert Team on Data Representation and Codes
EUMETNET	European Meteorological Networks
EUMETSAT	EUropean organisation for the exploitation of METeorological SATellites
FNMOC	Fleet Numerical Meteorology and Oceanography Centre
FORTRAN	FORmula TRANslation
FTP	File Transfer Protocol
GCOS	Global Climate Observing System
GDPS	Global Data Processing System
GDT	Grid Definition Template
GIF	Graphic Interchange Format
GIS	Geographic Information System
GOS	Global Observing System
GRIB 1	Processed data in the form of GRId-point values expressed in Binary form - GRIB Edition 1
GRIB 2	General Regularly distributed Information in Binary form - GRIB Edition 2
GTS	Global Telecommunications System
HTML	Hyper Text Markup Language
ICAO	International Civil Aviation Organisation
ICT	Implementation/Coordination Team (of CBS)
ICT/DRC	Implementation/Coordination Team on Data Representation and Codes
ID	Identifier
IEC	International Electrotechnical Commission
IEEE	Institution of Electrical and Electronics Engineers

IOC	Intergovernmental Oceanographic Commission
ISO	International Standards Organization
ISS	Information Systems and Services
JCOMM	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology
JMA	Japan Meteorological Agency
JPEG	Joint Photographic Experts Group format
LINUX	*Not an acronym – name of an operating system*
MS/DOS	/Disk Operating System
MSS	Message Switching System
MTDCF	Migration to Table Driven Code Forms
MTN	Main Telecommunications Network (of the GTS)
NASA	National Aeronautics and Space Administration
NCEP	National Centre for Environment Prediction
NESDIS	National Environmental Satellite Data and Information Service
NMC	National Meteorological Centre
NMHS	National Meteorological or Hydrological Service
NMS	National Meteorological Service
NWP	Numerical Weather Prediction
NWS	National Weather Service
OMF	weather Observation Markup Format
OPAG	Open Programme Area Group (of CBS)
OPAG-ISS	Open Programme Area Group on Information Systems and Services
PDT	Product Definition Template
PNG	Portable Network Graphic
RA	Regional Association (WMO)
RASS	Radio Acoustic Sounding System
RDBC	Regional Data Bank Centre
RMTN	Regional Meteorological Telecommunication Network
RSMC	Regional Specialised Meteorological Centre
RTH	Regional Telecommunication Hub
SGDR&C	Sub-Group on Data Representation and Codes (CBS)
SGML	Standard Generalized Markup Language
SI	System International
SOOP	Ship Of Opportunity Programme
SOOPIP	Ship Of Opportunity Programme Implementation Programme
SST	Sea Surface Temperature
TAC	Traditional Alphanumeric Codes
TCP	Tropical Cyclone Programme
TCP/IP	Transport Control Protocol/Internet Protocol
TDCF	Table Driven Code Forms
TDL	Techniques Development Laboratory
TIFF	Tagged Image File Format
UKMO	United Kingdom Meteorological Office
UNIX	*Not an acronym – name of an operating system*
UTC	Universal Time Coordinate
VOS	Voluntary Observing Ship
WAFS	World Area Forecasting System
WGDM	Working Group on Data Management (CBS)
WGS	Working Group on Standards
WMO	World Meteorological Organization
WWW	World Weather Watch
W3C	World Wide Web Consortium
XBT	eXpendable Bathy Thermograph

XCTD	eXpendable Conductivity Temperature Depth sensor
XML	eXtensible Markup Language