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

WASHINGTON, 13-17 MAY 2002

Meeting of the Expert Team on Migration to Table Driven Code Forms
(*SUMMARY*)

The Meeting of the Expert Team on Migration to Table Driven Code Forms (ET/MTDCF) took place, at the kind invitation of USA, in NOAA Headquarters in Washington from 13 to 17 May 2002. The Team was informed that all WMO Permanent Representatives had been asked to nominate focal point on Code Matters including the Migration to TDCF. The Secretariat had so far received 88 nominations. Focal points will receive all information concerning the migration. In order to evaluate the current situation and development, the Team reviewed the actions performed by some WMO Members and other actors associated to the migration to Table Driven Codes. The Team considered that the actions taken so far by some WMO Member Countries were very encouraging, showing clearly that the advantages of TDCF had been well understood.

The Team attempted to review the implications, due to the migration process, on WMO Members' resources for development and operation, and examined the impacts on a representative selection of Members. Advanced Countries in North America, Europe, Asia and Pacific are progressively migrating. Many are or planning soon using BUFR nationally for their Automatic Weather Station data transmission or Rawindsonde data. The Russian expert indicated that to maintain international commitment of transfer to Table Driven Code Forms, the procedure of conversion from traditional code forms to Table Driven Code Forms at WMC Moscow, RSMC Novosibirsk and RSMC Khabarovsk will be implemented. The transfer to BUFR encoding in Russian observing stations, in particular, will be performed within the course of improvement of their technological resources. A national project group of experts has been established in Russia to plan and optimize the transfer to Table Driven Code Forms. The ET on TDCF congratulated Russia for this initiative and recommended similar establishment of a Migration to TDCF Steering Group (MTSG) in every country. The big problem was still the less developing countries, in particular those from RA I. In order to be able to use BUFR coded data, NMCs in the region should be automated. An intermediate step would be the migration to CREX, which can be handled manually. This migration would require the training of staff. In view of the current status of the components of GOS and GTS in Region I, the migration process should be carried out on a step-by-step basis. Hence all RTHs indeed, and NMCs should be provided the encoding and decoding software and the relevant templates before hand for familiarisation. The idea of a pilot project, where a National Centre could be selected for implementation of BUFR and CREX decoders could very useful as an experiment to find what and where the real problems are. The Team recommended the organisation of such a workshop as soon as possible including in its agenda the definition of pilot project(s).

The team considered the impact of migration on the GTS as well as the impact of current GTS practices on migration. The Team then strongly recommended that the size limit for all binary messages be raised to 250,000 octets as soon as possible, and that new definitions of bulletin headers for BUFR/CREX be implemented as soon as possible.

The Team reassessed the relevant training needs and defined the content of an appropriate training programme, at the international level and suggested training actions at the national level. The first thing was to allow data producers who want to produce BUFR or CREX data to be able do it, and at the same time still guarantee the data users be able to access the data produced in BUFR or CREX. Therefore, the first priority is to train data users on how to include in their automated processing chain BUFR and CREX decoders, and to train forecasters on the meaning of these data. Information should also be given to manufacturers of automatic observing systems, processing systems and workstations (it could by a workshop sponsored by the manufacturers themselves).

Finally, the Team considered the preparation of the migration plan to be presented to CBS-Ext. (2002). The Team agreed that some important ideas should be expressed and passed to the WMO community to avoid misunderstanding. The specificity of BUFR relative to CREX, (which can be coded manually and read directly) should be well explained. The big misunderstanding is that some people think that the migration means that at a pre-defined agreed date everybody shall switch to BUFR, like if it was a code change for observing a new parameter and transmitting a new group in SYNOP. The freedom and flexibility should be a main principle of the plan and this should be clearly explained. The data users should have the guarantee and be given the means, if necessary, to receive, at least, the same data as before, from a producer who switches to a TDCF. The plan would have to consider the data users who are automated and those who are not (still about 40 WMO Members over 185), the data users who can receive binary data and those who cannot.

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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 NOAA Headquarters in Washington from 13 to 17 May 2002 (the participants' list can be found in the Annex to this paragraph). The Meeting was opened on Monday 13 May at 10 a.m. by Mr. Barry West, NWS, Chief Information Officer. He welcomed the participants (see list in annex to this paragraph) 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. He stressed that the table-driven codes were universal and flexible, and can be easily expanded to satisfy all observational requirements and scientific needs, which meant the representation of new parameters, new data types and increased accuracy. The work of this Team was crucial for the WMO community worldwide. He then wished a good stay for the Team members in Washington. The Representative of the WMO Secretariat thanked the excellent hospitality of the U.S. National Weather Service, who kindly offered its premises to host the 2002 meeting of the Team. He addressed a warm thank you to the local organizers from the National Weather Service, like Fred Branski, the chairman of the Team, and those unknown, for their work. He stressed that BUFR required automated processing and telecommunication lines supporting binary data, but CREX was a character code that could be coded manually and read by humans. CREX was suitable for less advanced communication lines and non-automated Centres, but it was unsuitable for large numbers of observations or reports. Thus, there was a role for CREX in the migration process, and the team had to clarify this in the migration plan. Recalling some of its terms of reference, the Team had three main tasks to perform this week:

- 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;

and the last but not least:

- to develop a detailed migration plan to table-driven representation forms to be presented to CBS-Ext.(2002).

1.1.3 Fred Branski, Chairman of the ET also welcomed the members of the Team. He said that one task of the Team was to complete the plan, including the migration matrix, for which about 80 % of the information was available. He said if the plan was to be comprehensive and effective, the Team needed to develop a vision of the complete implementation of migration, and organize the plan in a realistic manner. Input from every member was necessary to produce a useful plan.

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 (see table of contents in front).

2. REVIEW ACTIONS ALREADY TAKEN BY SECRETARIAT, TEAM MEMBERS (RELATED TO WORK/ACTION PLAN DEFINED IN FIRST MEETING)

The Team reviewed the accomplishments in relation to the actions recommended by the First Meeting of the Expert Team on Migration to Table Driven Code Forms in May 2001. All items in the action plan were scheduled to be complete in time for finalization of a migration plan to be presented to the ICT

of OPAG on ISS, which will take place in September 2002. The planned tasks are reviewed below:

2.1 Create a coordination list - Get Point of Contacts

2.1.1 A letter was sent to all WMO Permanent Representatives to nominate focal point on Code Matters including the Migration to TDCF. The Secretariat had so far received 88 nominations. Focal points will receive all information concerning the migration.

2.1.2 IOC, ICAO, ECMWF, EUMETNET and EUMETSAT are other International organizations involved in the migration to TDCF. The WMO Commission for Climatology (CCl) will be contacted for comment on templates translating CLIMAT messages in BUFR.

2.1.3 A master coordination list should be assembled from the information gathered which will be used for recurring coordination both to collect information on the status of migration and to report migration information to those affected.

2.2 Coordination with WMO Members & affected groups

Some contact has already taken place with IOC, ICAO, ECMWF, EUMETSAT and EUMETNET. The Team noted that all Regional Associations have shown interest in the migration, many understood the advantages of TDCFs and have requested more training and assistance to be prepared for their implementation (see text in Annex to this paragraph). Other groups in WMO, except JCOMM do not manifest great interest in the migration problem.

2.2.1 A lecture on WMO Migration Strategy to Table Driven Codes was given by the Secretariat's representative, Joël Martellet, at the Workshop on Meteorological Operational Systems at ECMWF in November 2001. The Team agreed more information on the Migration to TDCF needed to be disseminated to all concerned organizations and international bodies.

2.2.2 The Team agreed it was time to send, as soon as possible, a questionnaire to focal points as previously planned (see annex to this paragraph). The questionnaire should reveal the needs, capabilities, plans and status of each Centre or organization with regard to migration. It should also gather information on what systems are actually used by each Centre, their compatibility with TDCFs and plans and timing of upgrades. The questionnaire should reveal what manufacturers for automated observing platforms and operating systems are used. The questionnaire should have a prelude that provides an overview of the migration situation and plan. It should be compiled at the WMO Secretariat level and reported to CBS. Answers from each Region should be sent to the Regional Rapporteur on Data Management. A new questionnaire should be addressed every two years prior to the ICT of OPAG on ISS and CBS, to obtain the latest status of the migration process and related activities. The information from these questionnaires should be compiled and made available to all affected organizations possibly via the World Wide Web. The Chairman indicated the willingness of the U.S. to place this as well as other migration information on a migration web page within the U.S. National Weather Service Data Management web pages.

2.3 Status of current and planned exchanges of observations in BUFR/CREX

2.3.1 BUFR has been used for a long time to exchange, satellite data, wind profiler data, ACARS data and tropical cyclone information.

The USA indicated that BUFR encoded rawindsonde data will be made available on the GTS. Double dissemination will be performed and the list of stations will be available.

The Japanese Meteorological Association (JMA) is transmitting wind profiler data in BUFR (25 stations).

Within the EUMETNET pilot project, the hourly exchange of observations from both automated and manned stations in BUFR is planned to start in December 2002. Five countries are involved: Czech

Republic, Germany, France, Netherlands and Slovakia. The EUMETNET OPERA software will be refined during summer 2002.

The OPERA software had been used to encode/decode BUFR for exchanging RADAR data within Europe for several years.

Service ARGOS plans to transmit Sub-surface float data and XBT/XCTD in BUFR by end of 2003.

Ozone data are exchanged in CREX as well as soil temperature data. CREX is used operationally for exchange of hydrological data (Africa and Europe), tropical cyclone data (Pacific), Radiological data (Europe), tide-gauge data (USA).

2.3.2 The Team noted that a Country is required to notify the WMO Secretariat when planning to transmit data in BUFR or CREX and a METNO would be sent to inform all WMO Members. The problem of the identification of type of data to be transmitted in BUFR or CREX should be addressed for message switching purpose. And the identification as sub-types within the TDCF message for the application processing, should also be addressed, perhaps within the frame of a new edition for BUFR/CREX.

2.4 (Re)write Guides per information levels

2.4.1 The ET/DR&C had 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. The new Guide for BUFR/CREX was written in 2001 and can be consulted on the WMO server at:

http:/www.wmo.ch/web/www/WDM/Guide/BUFR-CREX-guide.html

As requested the BUFR/CREX guide has been 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

2.4.2 The next task will be the production of a Guide on GRIB Edition 2, which will be also layered in three parts based on the same philosophy as the BUFR/CREX Guide.

2.4.3 There is a need for a manual on reporting practices. The Manual on Codes, Volume I.1, contains more regulations related to reporting practices than formatting rules. Volume I.2, on the other hand defines formatting systems, and practically no reporting regulations. The Volume I.1 links reporting practices to the alphanumeric coding format. The migration to BUFR/CREX will push producers and users (human decoders) of BUFR/CREX codes to use Volume I.2, rather than Volume I.1. It is necessary to re-write the regulations on reporting practices, disconnecting them from the traditional alphanumeric format, and making them “universal”, to fit, for instance, various national Automatic Weather Station templates which would be used to report the so-called “surface synoptic observations” in BUFR. It will make migration to TDCFs easier for programmers of automatic platform software, for meteorologists and for observers. It will also provide for consistency in collected data that might otherwise not be there. Reporting requirements as well as observing practices are currently included along with the data representation formats for the traditional code forms. These requirements and practices should be separated from the data representation and be placed in an Annex to Volume 1.2. The task is difficult. The work will require the service of a consultant for perhaps three weeks. The activity should be performed under the responsibility of the WMO Secretariat. The new Annex on reporting practices, once written, will have to be reviewed by appropriate Teams of CBS, including the ET on Migration to TDCF.

2.5 Encourage national training programs

The Team felt that there was yet no or little training on TDCFs within the NMHSs. Training was

mentioned in the letter addressed to PRs for focal point nomination together with the document on Introduction to TDCFs (in English or French) and a reference to the WMO web server address for Guides and documents on TDCFs.

3. REVIEW OF ACTIONS RELATED TO MIGRATION ALREADY TAKEN BY WMO MEMBERS AND OTHER WMO ASSOCIATED PROGRAMMES

In order to evaluate the current situation and already planned actions, the Team reviewed the status and actions performed and planned by some WMO Members and other organizations associated with the migration to table driven code forms. The Team considered that the actions taken so far by some WMO Member countries were very encouraging, showing clearly that the advantages of TDCF had been well understood.

3.1 EUMETNET

3.1.1 Driven by the need to improve their observing capabilities while decreasing their costs, most EUMETNET Members are conducting activities to rapidly automate their surface networks. In addition, mesoscale analysis and nowcasting activities are expressing requirements for more frequent collection and exchange of observations (at least hourly for international exchange with neighbouring countries). This context provides a strong incentive to develop a more efficient exchange of data from automatic stations based on table driven codes developed by WMO (BUFR and CREX). The representatives of Czech Republic, Germany, France, the Netherlands, and Slovakia agreed to actively participate in the pilot exchange and make necessary preparations to do so. It was planned to start in December 2002 to exchange hourly observations from both automated and manned stations in BUFR. The EUMETNET OPERA software will be refined during summer 2002.

3.1.2 EUMETNET OPERA: The objective of this programme is to harmonize and improve the operational exchange of weather radar information between national meteorological services. Currently 23 European countries are operationally exchanging radar data. Within OPERA a BUFR software package has been developed primarily for the standardized exchange of radar data. Version 2.1 will be available the second half of 2002 covering more radar products and modifications needed by the AWS project.

3.1.3 EUMETNET WINPROF: This is a programme that will start on 1 July 2002, as a continuation of the COST-76 programme. It is aiming at an operational exchange of wind profiler data at a European scale. For the exchange of data a next release of the OPERA BUFR software will be used.

3.1.4 EUMETNET OPERA SOFTWARE

3.1.4.1 The current OPERA activity provides a sufficient solution for EUMETNET Programmes with the following caveat:

- The current OPERA team can probably support only a limited increase of users;
- Although there is little doubt that the co-ordination of radar exchange will continue beyond 2003 (end of the current OPERA Programme), the future of the activity has to be ensured;
- The compatibility of the software with other data types has to be checked.

3.1.4.2 There does not appear to be any intractable technical problem to enlarge the OPERA BUFR project to make it serve the whole WMO community, but additional resources beyond the immediate EUMETNET requirements will be needed. The WMO is not in a position to provide funding to the project. Consequently, in the EUMETNET context, this situation requires a project proposal to be presented to the EUMETNET Council to seek its approval. EUMETNET OPERA and EUMETNET Coordination Office will prepare a project proposal to be submitted to the EUMETNET Council in September 2002. The proposal will be ready by June 2002 to be presented to the EUMETNET Programme Board on Observations. In the immediate future, the OPERA project manager and WMO Secretariat could further analyze the technical constraints linked to the WMO requirements and provide a better assessment of the resources necessary for a WMO software house project.

3.2 Actions related to Migration already taken by Météo France

Mr. Jean Clochard from Météo France presented its activities related to TDCF.

3.2.1 Effective use of GRIB and BUFR

Météo France started to use the GRIB code in the late 1980s, both as a basis for its forecasters' workstation project and for internal use in NWP. Use for satellite images came up shortly afterward. GRIB for NWP data, and BUFR for observations were chosen in 1993 as internal formats to build the new central processing system in Toulouse. BUFR was also chosen for radar images in co-operation with other European NMSs. Since 1996, GRIB format has been used for French NWP products exchanged over the GTS (ARPEGE model). Existing GRIB and BUFR software packages in use are mainly based on ECMWF provided packages. Radar images are BUFR encoded with EUMETNET OPERA software. Météo France has several wind profilers, though they are not operated on a fully operational basis. These are (and have been since the beginning) encoded in BUFR using a European developed template (the templates used by JMA and for some internally formatted US profilers are very similar) and exchanged on bilateral basis for quality impact studies.

3.2.2. RADOME project

A project aiming to replace all Météo France land surface observation systems was undertaken several years ago. This project, called RADOME, has recently led to the replacement of some automated stations. These stations encode data in a BUFR-like way (some data are linked to measurement systems technology and are very specific), and concentration systems extract the relevant part of the data to encode BUFR messages, which are sent on an hourly basis to the central service (and at a higher rate to regional services). Distribution of hourly observations to local and (all) regional offices is done through satellite-based broadcast (RETIM). It is planned to start implementing RADOME-style functions at a few synoptic stations, to make more data available at least at regional and local levels on an experimental basis. It is planned to double encode data in both BUFR and SYNOP at the concentration system level, so as not to interfere with other uses of associated data. France would be able to disseminate both formats of these surface data on the GTS in 2003. There is no plan yet for upper-air data.

3.2.3 Training

Some information on GRIB and BUFR codes is included at Météo France schools for all technical staff, at least during the initial course. For most of staff, the general philosophy of BUFR is taught. CREX is not mentioned, nor the migration strategy. Most staff are not provided instruction on the "physical" structure of the code(s). To some extent, this is also the case for traditional code forms, as far as it is hidden by both the observation systems (even for manned stations, the non-automated part of an observation is typed in through an interface), as well as on forecasters' systems that present data in graphical form or plotted charts.

3.3 Use of Table Driven Code Forms In the Japan Meteorological Agency

The Expert from Japan, Mr. Keiichi Kashiwagi presented the status of activities and development related to TDCF.

3.3.1 The Japanese Meteorological Agency (JMA) has been widely using table driven code forms as well as traditional alphanumeric codes (TAC) for national and international data exchange for a long time. A large number of BUFR messages are made centrally by conversion from SYNOP, SHIP, PILOT (SHIP), TEMP (SHIP), METAR, SPECI, TAF, SIGMET, ARMAD, AIREP, ARS and PIREP received from national and international telecommunication lines. Furthermore, JMA has been successively carrying out double transmission of BUFR and TAC data over their national meteorological telecommunication network since March 1997.

3.3.2 Although BUFR is widely used by the JMA, only the following BUFR data are transmitted to other WMO Members through the GTS at their requests:

- Typhoon analysis information (ISXC40): to Washington, Bracknell, Hong Kong, China and ECMWF as from May 1990.
- Cloud motion vectors derived from GMS images around typhoons (IUTC40 - 45): to Washington, Melbourne and Hong Kong, China as from January 1992.
- A part of the Automated Meteorological Data Acquisition System (AMeDAS) data (ISYA31- 56): to Seoul as from November. 1998 on an experimental basis.
- Wind Profiler data (IUPC01- 03): to Washington, Bracknell, Hong Kong, China and Soul as from April 2002.

Furthermore, forecasts of typhoon (tropical storm) tracks will be soon transmitted for the validation test of the new BUFR descriptors and template developed for the data in accordance with the programme proposed by the Expert Team on Ensemble Prediction Systems.

3.3.3 BUFR data received from foreign centers are satellite data (TOVS, AMSU-B, QuikSCAT, ERS and METEOSAT), ACARS (USA), AMDAR (Europe) and wind profiler data (USA). All these data are decoded in the Numerical Analysis and Prediction Systems (NAPS) and used only for numerical analysis and prediction. It should be noted that the types of BUFR data are very limited and most of it is satellite data. The total volume of these data is much greater than that of all the TAC data. For example the volume of BUFR and TAC data are respectively about 645MB (96%) and 27MB (4%) per day (from 2120UTC Apr. 29 to 2119UTC Apr. 30 2002). This indicates double dissemination of traditional observations (in BUFR as well as TAC) would increase the volume of GTS observational data by only a few percent.

3.3.4 CREX is used for the international exchange of ozone data and the domestic dissemination of typhoon analyses/forecasts and flood forecasts.

Future plans

3.3.5 JMA plans to replace its regional and national concentration systems, NAPS, GMS System and some observing systems including rawinsonde-sounding systems in the near future. To make more consistent and extensive use of TDCF in the new systems the following items are under consideration:

- To encode conventional surface and upper observations in BUFR at observation stations
- To encode all the satellite data produced by the GMSS in BUFR instead of SAREP, SATOB and SATEM (preferably without double transmission over the GTS)
- To encode climate data in BUFR instead of CLIMAT and CLIMAT TEMP
- To encode ARGO sub-surface float data managed by JMA in BUFR instead of TESAC
- To use WMO standard BUFR templates instead of the national templates
- To use browser type software for display of data at L-ADESS station systems
- To use XML for weather forecasts, warnings and some meteorological information currently reported by plain text

3.3.6 JMA will implement operational migration in accordance with the time schedule proposed (if acceptable to JMA) and it is possible for JMA to participate in bi-lateral migration tests on condition that the volume of exchanged data in the tests be within the current computer resources. JMA will transmit its BUFR data without changing the current national templates and practices until after the implementation of new operational systems scheduled for March 2005.

3.4 Review of actions related to migration already taken by EUMETSAT

EUMETSAT has a role mainly as data provider, but is also a user of forecast and observation data. As such EUMETSAT is in a good position to serve as an example for the migration to the use of table driven code forms from the aspect of a major center.

3.4.1 METEOSAT Transition Program, MTP

EUMETSAT currently operates three METEOSAT spacecraft (5, 6, and 7). Products from these are

archived at EUMETSAT and distributed in near real time both via the GTS and directly via the spacecraft. At the start of EUMETSAT's operations in 1995, four products were encoded in SATOB (CMW - Cloud Motion Winds, SST - Sea Surface Temperatures, UTH - Upper Tropospheric Humidities and CLA - Cloud Layer Analyses). In order to accommodate users' requests for additional data and quality control information, all subsequent data and products have been encoded in BUFR prior to dissemination or archiving. For each of these products, BUFR Table D sequences have been specifically designed and are used operationally. The BUFR encoding is performed using the ECMWF software package, which has been integrated into the product extraction facility.

The MTP system relies on forecast data, and *in situ* observation data from radiosondes as input. The forecast data come from ECMWF, and are delivered via the RMDCN in GRIB (Edition 1). The GRIB decoding is performed using the ECMWF software package, which has also been integrated into the product extraction system. The observation data arrive via the GTS and are then decoded from the "traditional" alphanumeric format in which they arrive. At present, any observation data that might arrive in BUFR or CREX would be ignored by the system, but this situation is currently under review.

3.4.2 METEOSAT Second Generation, MSG

The first MSG spacecraft, MSG-1, is scheduled for launch in August 2002. Once the system is operational, all the principal meteorological products will be generated in BUFR prior to archiving and/or dissemination via the GTS. The BUFR encoding will again be performed using the ECMWF's software package. No SATOB products will be generated. In addition to the aforementioned products, a cloud mask will be generated in GRIB Edition 2, and will be disseminated via the spacecraft, and also potentially via the GTS.

The forecast data will be ingested in GRIB Edition 1 as for MTP. In contrast to MTP, however, observation data arriving from the GTS in BUFR will also be handled automatically by the product extraction system.

3.4.3 EUMETSAT Polar System, EPS

EUMETSAT is currently preparing the European component of a joint European/US polar satellite system. The first METOP satellite, METOP-1, developed in co-operation with ESA, will be launched in the year 2005. All level 2 geophysical products generated by the system for near real time distribution via the GTS will be encoded in BUFR.

3.4.4 Preparation for the Use of MSG data in Africa, PUMA

The PUMA stations will be delivering a selection of GTS data. These data will contain, in addition to selected meteorological products produced by EUMETSAT, forecast data in GRIB and, as the migration advances, progressively more observation data in BUFR. In this regard, the Expert Team noted that EUMETSAT was in the propitious position of being able to facilitate the utilization of GRIB, BUFR and CREX data within RA-I, if they could specify suitable decoding and processing functionality as part of the PUMA system. The Team recommended that the PUMA user community in RA-I be given the capability to decode and process GRIB, BUFR and CREX data for their meteorological applications.

3.4.5 Conclusion

By migrating product encoding to BUFR over the past years, EUMETSAT had been able to ensure that any parameters requested by users have not had to be excluded because the data format would not support them. This has been particularly true for quality control information, where the flexibility provided by BUFR has allowed the exchange of these key data. This was not possible with SATOB.

3.5 Review of activities related to migration in Germany

The German expert, Heinrich Knottenberg described the situation in Germany. Germany is involved internationally in the production of BUFR reports for RADAR, AMDAR and wind profiler data. DWD

has future plans to disseminate automatic weather station data in BUFR. However, nationally, the projects are oriented towards a centralized integrated data base approach, where objects (messages) are pushed and pull. They will make use of Java language and an Oracle data base system. The concept will be the physical format of the internal data will be independent of the observer, who will simply enter data or information in a straight forward format and the automated system will transmit in a format which interfaces with the data base. Users requesting data will be delivered the data base output fields. For international, exchange Germany foresees no problem implementing a universal BUFR or CREX encoder/decoder during the next few years, at their national Centre.

3.6 Review of activities related to migration in USA

The U.S.A. reported they produce BUFR encoded upper air reports for all U.S.A. upper air sites as well as for other sites within the geographic location of interest for their national needs. These include many stations in the Pacific basin as well as other countries in North and Central America. These BUFR messages are made centrally by conversion from traditional alphanumeric reports. These data are provided on the GTS via bilateral agreement. The U.S.A. has a program to replace their existing upper-air collection systems and these will report data in both BUFR and traditional forms such as TEMP. The BUFR data will have a much greater resolution. The TEMP coded products will be phased out when there is no longer a user for them. The U.S.A. makes all its SYNOP data from aviation reports (METAR/SPECI). USA is starting to consider what will need to be done to encode these into BUFR. The U.S.A. has begun making several new products in both BUFR and GRIB and will continue to use TDCFs for new products.

The continued production of satellite data in traditional formats is being reviewed with the goal of eliminating this production as soon as possible. The U.S.A. will address this matter with Asian and European exchange partners this year.

Work is also being done to migrate to BUFR and CREX, data from remote automated collection platforms, but this will take a significant time. It is likely that translation to BUFR will need to be done centrally. This may also be true for some other TACs but will only be done as needed.

4. REVIEW IMPLICATIONS OF MIGRATION ON WMO MEMBERS RESOURCES FOR DEVELOPMENT AND OPERATION

The Team attempted to review the implications, due to the migration process, on WMO Members' resources for development and operation, and examined the impacts on a representative selection of Members.

4.1 Possible impacts of migration to table driven code forms for Africa

The expert of Ethiopia, Mr. Seid Amedie explained the impacts and actions required to implement the migration to TDCFs in Africa.

4.1.1 In most of the NMCs in Africa data exchange at the national level is carried out through voice communication systems. Most of the reports that contribute to the WWW are Surface (SYNOP, CLIMAT), upper-air (TEMP, PILOT) and Ship observations. Data collected at observational sites are sent to a central station in traditional code formats for transmission into the GTS. The migration to BUFR cannot be envisaged nationally because local stations need to be automated to encode data in BUFR. Data encoding in BUFR could only be considered for sending the national data to regional centers. RTHs in Region I are automated and can handle binary data, but the follow up processing is not adequate for TDCF support. In order to be able to use BUFR encoded data NMCs in the region should be automated. An intermediate step would be the migration to CREX, which can be handled manually. This migration would require the training of staff, first the observers to be able to code observations in CREX and also the staff at NMCs to understand CREX code coming from their national stations or from the GTS or from other means.

4.1.2 In view of the current status of the components of GOS and GTS in Region I, the migration

process should be carried out on a step-by-step basis. NMCs in the region must be made aware of the immense advantages of using BUFR and CREX for data exchange to realize its implementation. Hence all RTHs indeed, and NMCs should be provided the encoding and decoding software and the relevant templates before hand for familiarization. There would be challenges to understand the functionality of the BUFR and CREX, especially in NMCs where automation is not implemented.

4.1.3 For most countries in Region I, the meteorological and hydrological services are run by different organizations. The hydrological services normally use other means of communications (independent of the GTS) to transmit data for global exchange. Some of them, such as SADC-HYCOS and MEDHYCOS, use CREX. Other hydrological services and aviation services of each NMC in the region should be notified of the current progress of migration for planning to switch to table driven codes.

4.1.4 In some NMCs that are using automatic observation systems, there is a need for upgrading their systems to encode data in table driven codes. Or else, new automatic systems designed to encode data in BUFR or CREX could be introduced to replace the old systems. Alternately recoding could be done at some central location. In any of these cases, additional costs would be incurred.

4.1.5 Guidance and assistance should be provided to NMCs and RTHs that are using national and regional coding practices that differ from international coding procedures. There is a need to develop BUFR and CREX descriptors to address the optional sections of existing code structures within the current alphanumeric code forms as a replacement for these structures in BUFR and CREX.

4.1.6. The successful implementation of the migration to table driven codes in developing countries largely depends on capacity building. Therefore after an analysis of needs for further development of the WWW and GTS is carried out at national and regional levels, regional strategic plans should be formulated to enhance basic facilities in the NMCs of developing countries.

4.1.7. As some countries begin to migrate to TDCF, double encoding, double dissemination or translation back to TAC will have to be performed either by those countries outside Region I or within Region I itself. This is especially so for the data of interest to Region I countries. Assistance in the form of pilot projects is urgently required for the automation of NMCs, for the introduction of information and communication technology and for the training of their technical staff.

4.2 Possible impacts of migration to table driven code forms for Russia

The expert from Russia, Dr. Vladimir Antsypovich expressed the major problems and their possible solutions related to the transfer to Table Driven Code Forms (TDCF) in the National Meteorological Service.

4.2.1 WMC Moscow will be able to encode and decode Table Driven Code Forms by 2004. RSMC Novosibirsk and RSMC Khabarovsk will be fully able to encode and decode Table Driven Code Forms by 2005.

4.2.2 At present, within Russia only a few centers possess sufficient computing and financial resources to modify their data processing facilities to migrate to Table Driven Code Forms, and for those it will be a slow phased process depending on the capabilities and needs of each center. Even the adaptation of a few centers will be difficult, because companies, who were or are the software providers, are either no longer in existence or require substantial funding to update the software. There are centers running out-of-date software and without enough funds to provide for their updating. During the transition period, these centers need to be provided with data in traditional alphanumeric code forms. However, the list of these code forms processed by such centers is limited. In some cases, the telecommunication systems of these centers receive information in a format implemented in the present Data Base of the center that is not in a standard WMO code form.

4.2.3 It will be possible for WMC Moscow, RSMC Novosibirsk and RSMC Khabarovsk to develop and implement software for data conversion from Table Driven Code Forms back into traditional code forms (for the limited list of code forms and for a limited data volume) and deliver the transformed data to the

national data processing centers which are not able to process information in Table Driven Code Forms. WMC Moscow, RSMC Novosibirsk and RSMC Khabarovsk will also provide information transfer in internal database formats for the most wide spread automated software which is "LASSO/GIS Meteo".

4.2.4 The situation regarding information transfer from observing stations is even more complicated. Given the large number of observing stations in Russia, it will not be possible to perform information transfer in Table Driven Code Forms within the period recommended by the migration plan due to technological, economic and social reasons. Presumably, this situation is typical for many National Meteorological Services maintaining a significant quantity of observing stations, for which automated data transfer is not implemented.

4.2.5 It is not planned to implement CREX in Russia. Although the use of this code would avoid some technological problems, the cost may be increased and reliability decreased due to the larger message sizes associated with CREX. Training of personnel to use CREX may be more complex and costly than simply switching to BUFR.

4.2.6 Thus, to meet the international commitment for migration to Table Driven Code Forms, the plan is to implement conversion from traditional code forms to Table Driven Code Forms at WMC Moscow, RSMC Novosibirsk and RSMC Khabarovsk. The migration to BUFR encoding for observing stations, in particular, will be performed within the normal course of upgrade or replacement of their technology. A national project group of experts is being established in Russia to plan and optimize the transfer to Table Driven Code Forms. The ET on TDCF congratulated Russia for this initiative and recommends similar establishment of a Migration to TDCF Steering Group (MTSG) in every country.

4.3 Possible impacts of migration to table driven code forms for France

Mr Jean Clochard from Météo-France presented an initial analysis of how migration was envisaged within Météo France, and how it could impact on resources.
Migration guidelines related to data production

4.3.1 Météo France has an observation network, which currently delivers data encoded with mostly traditional character forms. Only a sub-set of automated stations produce BUFR-encoded data. When enough synoptic stations are capable of using the same software, the format currently used will need to be upgraded, especially to the use the latest version of BUFR template(s). Among people working in the observation field, the general feeling is for the observing systems directly handled by Météo France staff, the encoding is de-coupled from the measurement. Thus the production of either BUFR or CREX could be done through appropriate modifications to the encoding process. At a functional level, double dissemination of current and new formats could be done. The work associated with the implementation of new encoding software is estimated to be about six man/months per observing system. The Implementation costs would depend on each observing system, but in most cases would be reasonable if combined with normal maintenance operations.

4.3.2 The observing systems mentioned above cover land surface stations, ship-based surface systems, radiosondes (both land and ASAP-based), and potentially buoys. Choice of BUFR or CREX would be done according to telecommunication issues. For instance, experience with DCP systems indicates CREX may be preferred for DCPs because of potentially lower error rates (better error detection through the use of CREX check digits) with possibly some recovery over the lines. CREX based messages (if any) would then be translated into BUFR at the concentration system level, either at a national centre, or at a DCP data collection centre. More work and analysis is needed in regard to aircraft-based measurements, because Météo France has no direct control over the encoding. Climatological messages (CLIMAT) are generated at the central service in Toulouse. Implementing their production in BUFR is estimated to require a few months work; double dissemination is not a problem.

Data ingestion and use

4.3.3 To accommodate the migration to table-driven codes, data processing and/or data visualisation

systems will have to be modified. Météo France utilizes two ways of handling observations at the database and/or pre-processing layers:

-Through a “pure database” format, retaining only needed decoded parameters (and metadata) as data base entries

-Through storage of both the complete observation in BUFR and a subset of decoded parameters

The former case is used mainly in local forecasting systems, which for GTS-compatible data types will be fed by BUFR encoded data. The necessary changes are mainly in the pre-processing layer, except if extra parameters are needed. Existing APIs (extracting software layers) are either not impacted, or they are upwardly compatible. Applications layers may not be impacted, except if handling of new parameters is required. In the simplest approach (no extra parameter to be added or used), the adaptation work is estimated at one man-month work per observation type. Implementation costs would have also to be taken into account.

The latter case (complete BUFR observation and a subset of decoded parameters) is used at the central data processing system level, and because of software sharing, also in central and regional forecasting systems. However, on central and regional forecasting systems, only the subset of decoded parameters are used for observation types concerned by the migration. APIs and applications that only use “decoded parameters” may therefore not be impacted. But, both APIs and applications, which either directly or indirectly rely on the complete BUFR observation, may be impacted. The related adjustment work is estimated to be about two man-months work per observation type (three for rawinsonde reports if individual parts are distributed in separate messages) for pre-processing and API layers. Changes would also have to be done at the application level to take advantage of these “new” observations. Otherwise, some of the additional information would be lost. Impact on resources will vary depending on each application. On production systems, it is estimated to be an average of a few days for each system. The number of applications, which will need to be adapted at the time of change, is difficult to evaluate. It is roughly estimated to be about thirty. Impacts on central and regional forecasting systems at the application level will only take place if new parameters are to be used.

Data transmission

4.3.4 For this initial analysis, It is believed dual dissemination could be performed in most cases, with the possible exception of aircraft data (which will require a specific feasibility study). However, this will need further consideration before a final determination can be made.

4.4 Possible impacts of migration to table driven code forms for Japan

The Expert from Japan explained the implication of migration on the data handling and resources of the Japanese Meteorological Agency. JMA will be able to implement double transmission and operational migration to TDCF without any serious problems in accordance with the schedule of WMO if some practical items are decided soon, preferably before the end of 2002.

4.4.1 Regarding computer systems hardware and bandwidth of telecommunication lines, double transmission will not cause any serious problems because the rapid progress of information technology and services will greatly reduce the costs. Also, the additional data volume is not significant in comparison with satellite, aircraft data and NWP products. Additionally, BUFR encoding offers condensation of the total data volume over TACs.

4.4.2 Regarding decoding and encoding software used in the observing systems, telecommunication systems and data processing systems at local observatories, these are basically provided by the system providers together with hardware and other software in accordance with specifications written by JMA. To avoid additional cost for modification of software of new systems after installation JMA solicits CBS (through its ET) to develop WMO standard practices for conversion between TAC and BUFR promptly and to finalize WMO standard BUFR templates as soon as possible.

4.4.3 Regarding decoding and encoding software used in the numerical analysis and prediction systems and other data processing systems in the headquarters, these are basically developed by the JMA staff. Work to develop software is roughly estimated at a few man-months per TAC if programmers' work can be dedicated solely to migration, but it may take more than six man-months under the normal working situation in some cases. Therefore, there will be no serious impact if the migration time schedule for each TAC is decided sufficiently before the operational implementation (preferably more than one year).

4.4.4 It will be very difficult and will require an open-ended transition period for voluntary ships to encode observations in BUFR or even CREX. The same situations are expected for data that are coded in traditional codes by producers outside of NMHSs such as aircraft data. JMA will convert these data from its area of responsibility for data collection into BUFR, before placing them on the GTS.

4.5 Possible impacts of migration to table driven code forms for USA

In U.S.A., several organizations have expressed concern about the impact on financial resources that migration may have. There will be significant changes to systems that will require many man-hours of work. It is generally felt this is manageable and outweighed by the advantages of migration as long as sufficient time and flexibility is allowed for in the plan. The U.S.A. has a national inter-agency coordination office for meteorological concerns. This forum is being used to review migration issues. The U.S. NWS Data Management group is also providing information to a wide audience of data users with the hope of mitigating impacts by providing as much advance notice as possible.

5. GTS ISSUES

5.1 The team considered the impact of migration on the GTS as well as the impact of current GTS practices on migration. The Chairman arranged for several U.S. representatives to WMO GTS and telecommunications groups to join the team for a discussion of these issues (James Fenix, Daniel Starosta and Walter Mussante). Two critical concerns were the identification of many additional BUFR or CREX bulletins that will result from code migration and the problems associated with very large collectives of data that result as a compilation of many reports. This is fairly common with BUFR collectives especially for satellite data. However, at RTHs and other collection centres the number of observations or other data may grow significantly enough that collectives of data will exceed the 15,000 octets constraint of the GTS for individual messages.

5.2 Although the size constraint already creates serious problems for satellite data, it is unlikely to cause problems for TAC data encoded into BUFR until significant amounts of this data are available for operational exchange sometime in 2005. There is a segmentation procedure defined for the GTS that allows messages greater than 15,000 octets to be broken into smaller portions for transmission. However, this is not implemented at most RTHs and experience with existing data has created many problems for data users. The GTS representatives indicated that RTHs routinely handle products of 300,000 to 400,000 octets. In fact, WMO NO. 386, Manual on the Global Telecommunication System releases "digital facsimile products" from the 15,000 octets limit. WMO NO. 386 also states "sets of information, transmitted using segmentation into a series of bulletins, shall not exceed 250,000 octets". The Team then strongly recommends the size limit for all binary messages be raised to 250,000 octets as soon as possible. This should be implemented well before operational exchange. Experimental exchange is already underway.

5.3 The problem with bulletin identification is caused by the historical assignment of available characters in the WMO heading to TAC bulletins and other existing bulletin types. Of 26 possible T_1 characters, one is assigned for everything encoded in CREX, two are assigned for everything encoded in BUFR and 19 are already assigned to existing data types including text and GRIB. There are four characters that are unassigned, however these are being widely used nationally. To represent all assigned definitions for TAC bulletins taking into account the assignments of T_1T_2 already made for BUFR and CREX, there are 41 definitions that are not assigned for BUFR and CREX. There are not enough open combinations available to define the remaining bulletin type needs. The existing definition scheme needs to be revised and done so in a way that has minimal impact to existing

bulletins. This will be addressed further in a document submitted to CBS. It is recommended that the proposal for new bulletin definitions be implemented as soon as possible.

5.4 The team also noted there are some special cases where existing practices for collecting and disseminating TAC data had an operational basis that needs to be preserved when migrating to BUFR or CREX. The TDCF will permit the transmission of any number of levels of upper air data, however the timing for operational delivery of data imposes constraints. For instance, there is a need to transmit parts A and B of TEMP and PILOT data as soon as it becomes available to support operational forecasting. For TAC data this is done separately and before the parts C and D become available. The team also noted there were thirteen WMO heading definitions for TAC TEMP and PILOT data and felt there was no need to continue this practice. It decided when BUFR or CREX would replace TEMP and PILOT data for international exchange only three categories were needed: one WMO heading T_1T_2 definition for part 1 (equivalent to both combined old parts A and B data), one for part 2 (equivalent to both combined old parts C and D data) and one for a combination of the two parts 1 and 2 (equivalent to all combined old parts A, B, C and D data).

5.5 The team also thought similar timing constraints for operational delivery may exist for SYNOP and for SHIP and other oceanographic data including automatic marine stations. In these cases, it will be necessary to maintain or create as much definition in the WMO headings as needed to support operational needs.

6. STATUS OF SOFTWARE PROJECT TO SPECIFY, DEVELOP AND DISTRIBUTE UNIVERSAL BUFR, CREX AND GRIB ENCODING/DECODING SOFTWARE - CONSIDER A PILOT PROJECT

The Team assessed the status of the software project to specify, develop and distribute universal BUFR, CREX and GRIB encoding and decoding software to all requesting countries.

6.1 The WMO Secretariat representative reported that he had a discussion in November 2001 with ECMWF executives on the problem of the establishment of a software house at no cost for WMO. The ECMWF indicated the need for additional funding to run the software house project. The Team recognized a software house project in Europe would provide great benefit and help toward migration to table driven codes. It recommends this continue to be pursued in any way possible.

6.2 The WMO Secretariat representative also participated in a meeting at the EUMETNET headquarters in Paris (November 2001). The objectives of the meeting were to analyze the current actions and requirements concerning BUFR encoder and decoder software that exists within EUMETNET programmes (PWS-GTS, OPERA and WINPROF), to possibly define a common action to establish a "BUFR software resource" and to determine to what extent this resource could be put to the service of WMO. Information on EUMETNET OPERA Software can be found in chapter 3.1 of this report. So far, EUMETNET supports a limited set of users in Europe. The benefit from supporting BUFR encoder and decoder software for the world would be especially beneficial for Europe itself: reception of higher quality data as well as increased data quantity. The Director of EUMETNET stated to extend the EUMETNET project to the world was feasible.

6.3 The Team felt the ECMWF FORTRAN software, especially the BUFR and CREX decoding program library, would be well suited for centres performing substantial data processing applications on medium or large-size systems. The OPERA software might be more appropriate for smaller Windows environment systems, although the ECMWF FORTRAN library for encoding and decoding could be used on any computer with a FORTRAN compiler. OPERA software for encoding a single data type might be easier to implement on observing platforms.

6.4 The Team recommended that WMO send a letter to ECMWF, which would be submitted to their Council asking for free support to WMO members for a software house. The first priority would be for universal BUFR, CREX and GRIB decoders. Whatever ECMWF's Council decision is, WMO could still consider approaching EUMETNET. Their Council will be held in summer 2002. Since the OPERA software works on the Windows operating system and on several other operating systems, more than

the ECMWF software, the OPERA software could complement ECMWF software for non-UNIX and Windows environments.

6.5 The U.S. currently maintains a software registry where it makes available decoding, encoding, translation and other software for download. These programs are provided with existing documentation. Limited help can be provided for these programs but only as resources allow. This software is available to anyone. As new software is developed or existing software updated it will be made available.

Application Program Interface

6.6 Implementing a decoder in an automated processing chain of a program or system is not simple. Clearly, the Application Program Interface has to be well described by the software provider. The Team considered the need for the definition of a WMO standard API for BUFR decoders and encoders. The Team did not feel it was necessary at this stage to define WMO standard APIs, but that it was absolutely necessary that any encoding or decoding software delivered include clear documentation describing it's API.

Pilot Project

6.7 When any Member decides to migrate to BUFR or CREX, access to their data by all WMO Members should be guaranteed. The Team considered one of the main problems associated with migration was fully understanding both the various data delivery issues for NMSs providing data and the various uses of data received via the GTS (or INTERNET) in CREX or BUFR by all National Meteorological Centres. Therefore, the idea of a pilot project, where a National Centre(s) could be selected for implementation of BUFR and CREX decoders could be very useful as an experiment to find what and where the real problems are. This should also better reveal the needs for training to be dispensed to all staff involved in telecommunications, data management, data processing and forecasting. A country that is already automated for data processing, but not very advanced, could be selected for this test. The implications of the migration for developing countries could be studied and evaluated during a special workshop organized for that purpose. The Team recommended the organization of such a workshop as soon as possible. This workshop should also be tasked with defining requirements for a pilot project(s).

7. STATUS AND PLAN FOR EXPERIMENTAL EXCHANGES AND TESTING

7.1 Existing situation regarding exchange of data to support code migration

This is a brief summary of information provided in previous reports and as input to this meeting.

Global Situation**:** There is global exchange of observational data in table driven formats, but much of it, is data that originated in BUFR code such as wind profiler data or aircraft data. Very little of it, is data, which was formerly in a traditional code except for satellite observations which have migrated from codes such as SATOB or SATEM to BUFR. Still this provides good support to the global move towards table driven codes for it provides a base capability that can be built upon. Unfortunately, the current global exchange has grown out of bilateral arrangements without any coordinated effort to implement, manage or encourage this exchange.

Regional Situation**:** The regional situation is very similar to the global situation except that in some regions there has been better management and coordination of activities. There are also some regions where very little has been done to support experimental exchange and testing of data. This is primarily because the infrastructure to support these activities is still under development. Region VI in particular had much coordination between Members to encourage migration activities as a whole and to increase testing and exchange of data as evidenced by the EUMETNET activities.

National Situation**:** The national situation is the most diverse and is mainly a function of individual national capabilities. Internal usage of table driven formats is dependent on three main factors. Existing processing capability and automation, internal needs and financial resources. There are several programs underway to assist nations with developing their capabilities but in most of these cases the primary goal is other than code migration.

7.2 Considerations regarding the coding of data to support migration

The Expert Team for Data Representation and Codes (ET/DRC) has primary responsibility for defining codes. The work of this Team has considerable impact on code migration. The interaction between that team and the ET on MTDCFs has been highly beneficial.

Encoding Considerations**:** It is not absolutely essential to have templates to encode traditional coded data in a table driven format but they greatly facilitate this function and they also provide a standard method of representation. It is essential to have descriptors for all parameters that can be encoded in a traditional code form including regional and national practices. To this end the ET/DRC has already created many of the templates needed and most of the descriptors also exist.

Decoding Considerations**:** There are two primary purposes for decoding data. One is for input into a processing or archival system and the other for display. Decoding data for processing has up to now been the primary use for table driven codes and most all of the existing exchange has been developed to support this function. Although this has helped major Centers move forward with migration, it has done little to support global scale migration. Decoding for display however is growing. Some systems used in national hydrometeorological offices now have some capability to decode and display table driven code forms. Some commercial systems providers now manufacture systems with a decode-and-display capability. For migration to continue forward on a global scale, decode-and-display capability must be widely available and affordable. Decode-and-display is especially critical to ICAO's migration plans.

7.3 Testing of Data in Table Driven Code Forms to support migration

Up to now most activity in this area has been to validate the work of the ET/DRC in developing descriptors and templates for migrating code forms. This work needs to continue. It has been the seed for the small amount of code-migrated data already on the GTS outside of the satellite arena.

Regional and National Testing**:** There has been considerable testing done regionally and nationally in support of programs to collect and disseminate data in table driven formats. In many cases this has centered on automated observation systems. There is also work being done to provide code translation either to or from a table driven code form depending on need. This regional and national testing has the potential to considerably ease migration especially, if a way to spread the knowledge and capability to all Members can be found. Ideally, this will reduce the need for some Members to duplicate these activities.

7.4 Review of the Status of TDCF Templates

7.4.1 At the first session of ET on Migration to Table Driven Code Forms, Geneva, 7-11 May 2001, a preliminary migration plan was elaborated. Traditional code forms were grouped into six categories that were thought to share common characteristic that 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. SYNOP, SYNOP MOBIL, SHIP, PILOT, PILOT SHIP, PILOT MOBIL, TEMP, TEMP DROP, TEMP SHIP, TEMP MOBIL, CLIMAT, CLIMAT SHIP, CLIMAT TEMP and CLIMAT TEMP SHIP were put into the first category (the common code forms) with the start of experimental exchange in November 2002

7.4.2 The first session of the Expert Team on Data Representation and Codes (ET/DR&C), Toulouse, 23-27 April 2001, reviewed BUFR/CREX templates for SYNOP, SHIP, BATHY/TESAC, BUOY, AMDAR, AIREP, TEMP and PILOT and METAR and SPECI data types. Templates for SYNOP, SHIP

and PILOT were further modified based on the outcome of the second session of ET/DR&C, Prague, 22-26 April 2002. Following the 2002 ET/DR&C additional BUFR templates for CLIMAT, CLIMAT SHIP, CLIMAT TEMP and CLIMAT TEMP SHIP have been proposed. These templates have been recommended for validation via experimental exchange.

7.4.3 The second session of ET/DR&C also recommended new descriptors for approval by the CBS to support BUFR templates needed specifically for migration from TACs.

7.4.4 The team also considered the need for templates of differing complexity or comprehensiveness for TACs. It was agreed there was a need for both simple and complex templates.

7.4.5 Meteorological messages containing observations of various types are exchanged between NMHS's using the GTS. For surface observations one message often contains observational information of a set of different stations at the same observation time. A compilation process in which the observation data from multiple stations is collected in the message usually creates this set. Mostly, there are a number of messages for different dissemination strategies (i.e. national, regional or worldwide dissemination). The place of this compilation process in the ICT-architecture of an NHMS can be different from case to case, but (when available) often this will be the meteorological message switching system. Now, the encoding of the observational information of the stations will take place on a per station basis in principle independent of the compilation process. When the encoding will take place in BUFR-code, compilation of the information of various stations will only be feasible when the template (data description section, section 3) of the various stations to be compiled is identical, otherwise the different templates will have to be merged automatically and this would be a very complex and perhaps unpredictable process.

7.4.5.1 The team reviewed a proposal to use delayed replication to allow turning off portions of a complex template and increment descriptors to allow combining multiple reports with an incrementing value in a way which automates the incrementations as part of replication. The team felt the proposals had merit, particularly the ability to modularize complex templates. It felt this would be more useful for individual or small sets of data where the delayed replication wouldn't affect compression. This could possibly be applied to AWSs. The team felt these proposals should be kept in mind by ET/DR&C for use as they review requirements for templates.

7.4.5.2 Not all observational stations in a country will contain all the parameters that are proposed in the BUFR template for surface observations. Using the proposed template for the BUFR code, all the fields of the non-observed parameters should be filled with a "missing value" code. This could generate a lot of "missing value" information, for instance a station that only registers a few parameters, or parameters from sea stations which will never be registered on land-surface stations (which are a majority).

7.4.5.3 Combining the constraint of paragraph 7.4.5 (only compilation of station-observations in one meteorological message when the BUFR-data description section is the same) with the reality of paragraph 7.4.5.2 (not all stations will register all parameters), points to the need of a generic solution (e.g. several different common sequences) to cope with stations registering different numbers of parameters when compiling station observations in one message.

7.5 Draft Plan for Further Exchange and Testing of Traditional Data in Table Driven Code Forms and Coordination of Migration Activities

- Catalogue data already available in a table driven format other than direct model output and actively coordinate its global exchange:

    - Most of this data will be in either BUFR or CREX and much of it will have been developed for regional or national purposes.
    - Some of this data will not have been previously available in a traditional code form. It should still be part of this process because it will help to spread the capability to handle table driven code forms.

- There is already a mechanism in WMO for cataloguing this information. It is Pub. 9, Vol. C. However, it is very generic, under-utilized and provides no focus to migration. Migration is important enough to warrant a special focus.
- The purpose of the cataloguing is to help increase data exchange by making Members aware of what is available, to assist in tracking migration and as a tool to help coordinate migration and data exchange.
- This activity would be done by the national focal points that WMO has already requested from each member. It would be coordinated regionally through each region's Rapporteur or Data Management who would be given migration responsibilities. It is also would be coordinated with each respective RTH focal point.
- The cataloguing would include a complete review of existing bulletin definition to ensure the current catalogue is correct. It is important that obsolete bulletins are removed and that the de-cataloguing of bulletins is continued through the migration process.
- Central coordination of data exchange would then be possible with this information.

- Establish a periodic regular review of code descriptor and template requirements for representation of all data possibilities in traditional code forms, coordinate needs with ET/DR&C and provide central coordination of testing:

    - This is critical to enabling successful migration of all traditional codes.
    - Coordination of this activity will be done with the ET/DR&C but to insure better integration with overall migration the requirements review process will be integrated with the overall migration coordination process involving national and regional focal points along with the ET/MTDCF.
    - This should be done at an organized meeting at least year and as needed in between meetings via correspondence.

- Information coordination and reporting of Migration Activities. Mechanisms must be put in place to ensure all activities are integrated, impacts are minimized, problems are identified and progress monitored.

    - Information coordination will be done via a tree structure with national and organizational focal points at the bottom. The next level would be regional focal points (e.g. rapporteur on Data Management (on Codes and Migration to TDCF) and possibly focal points in some other teams or groups. The high level will be the ET/MTDCF.
    - Each level would have responsibility for collecting information on migration activities and progress, consolidating it and making it available to levels above and below them.
    - Regional and other appropriate focal points should have migration responsibilities outlined in their terms of reference.
    - These persons would provide central coordination of activities including experimental exchange and testing.
    - ET/MTDCF would provide reports to OPAG/ISS, CBS or other bodies as needed.
    - It is recommended that the chairman of ET/MTDCF would sit as a member on ET/DRC and other groups as needed.

8. MIGRATION MATRIX

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. 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 columns of the matrix. The cells of the matrix would include all the factors that are impacted by the migration. The matrix will be part of the annex to the migration plan and will be regularly updated thereafter.

9. TRAINING PROGRAMME

The Team reassessed the relevant training needs and defined the content of an appropriate training programme at the international level and suggested training actions at the national level. The CBS recommended that such training should be completed by October 2005.

9.1 As proposed in the Plan (see chapter 10), data producers who want to produce BUFR or CREX data should not be constrained from doing so. At the same time, data users must be guaranteed access to the new data produced in BUFR or CREX. Therefore, the first priority is to train data users on how to include in their automated processing chain BUFR and CREX decoders, and to train forecasters on the meaning or usage of these data. It is important to consider the problem of countries that have some automation capability, but are not very advanced. These may have difficulty implementing a decoder 0r encoder in their existing processing software. Some training might be needed specifically for that purpose. This illustrates the need for good API documentation and possibly for a standard API. The tasks of data producers wishing to switch to TDCF in automatic observing platforms should be facilitated. Depending on their capacities (telecommunication lines, level of automation) they will encode in CREX or BUFR. For encoding in BUFR, automation at the encoding stage is essential; therefore some training for programmers of automatic station software, and other encoding programs will have to be provided. AWS programmers are often concerned for only one or a small set of data types.

9.2 The Team re-defined three levels of training on the basis of concepts developed at its first Meeting in 2001.

These levels were:

L1 – Understanding of general philosophy of TDCF and migration overview
L2 – Deeper understanding of the TDCF (reference to Part 2 of the Guide) - Introduction and use of TDCF software including debugging and interfacing with data processing applications
L3 – Total understanding of the TDCF, for programming of encoder and decoder (only needed if the software project is not implemented)

9.2.1 To implement the three levels of training the Team envisaged two different training courses for two types of trainees:

- P1: Trainers, data managers and also people interfacing with general users (meteorologists) and decision-makers for technical matters.

- P2: Technical users involved in operational software development.

9.2.1.1 The course P1 should cover the general philosophy of TDCF, migration overview and targets (Level 1). It should also include examples of manually encoding and decoding CREX data. The encoding and decoding of a very simple report should be done, but examples of a parameter addition should be included to demonstrate the flexibility of a TDCF. Interfacing with an NMC preprocessing system should also be covered (part of Level 2). This training should be organized at least once per WMO Region, from 2003 to 2005. The duration of the training should be at least two-three days and could be combined with GRIB 2 training to cover a week. Trainers (RMTCs, National Code experts and focal points) should be trained first. If funds are significantly limited, well advanced Countries should be omitted from the training. Countries already automated or in the process of becoming automated should be given higher consideration.

9.2.1.2 The course level P2 should start with the same general philosophy and overview as P1 (Level 1). It should then move on to a different focus (Level 2 and if necessary part or all Level 3). A PC-based environment will be needed as well as an encoding and decoding package, and simple application(s). Participants should be trained to use the software, and to debug it and the application(s). Implementation in a processing chain should be covered, and people should be trained how to write the technical part of an invitation to tender (ITT) related to systems in automatic observing platforms. This training should be done shortly before or along with members' planning activities for

migration, typically one year before any migration implementation. The end of a pilot project in a Region might be the start of technical training in the concerned Region, building on the experience, difficulties and benefits reported. The training course should last five days.

9.2.2 In addition to P1 and P2, the general philosophy of TDCF (Level 1) is now presented in all WMO GDPS training seminars (Niamey 2000, Seychelles 2000, Bahrain 2002, Peru 2002) and will continue. The targets here are the forecasters. Emphasis is and should continue to be put on the additional data they can receive and the value of the TDCFs for providing new parameters as well as their impacts on resolving the long term problems of metadata and Volume A.

9.2.3 The Team also recalled the training seminar foreseen in the context of the PUMA initiative could provide an opportunity to bring P1 and P2 type training to the RA I community. It recommends this leveraging of training opportunities continue to be exploited.

9.3 Training at the national level (e.g. for students) should be done by trainers having followed a P1 type course and/or by experts in the field of TDCFs. In developed Countries, this training may have already started. For developing Countries, it should start reasonably soon after the P1 training for trainers. Focal points should be reminded of these recommendations and should have access to documentation (WMO server, CD-ROM). A CD-ROM containing all guides, Manuals, documentation and the migration plan itself should be produced by the Secretariat.

9.4 Information should also be provided to manufacturers of automatic observing systems, processing systems and workstations. It could be delivered in a seminar where some documentation could also be given along with general principles and some examples. The WMO Secretariat may be able to arrange for seminar sponsorship by the manufacturers themselves.

10. FINALIZATION OF THE DETAILED MIGRATION PLAN FOR CBS

10.1 The first and primary term of reference of the Team is to develop a detailed migration plan to table-driven representation forms to be presented to CBS-Ext.2002 (December 2002). The Team had to finalize, taking into account views of other Commissions' representatives (e.g. JCOMM, CAeM, etc.), a detailed migration plan to table-driven representation forms. The Team has accumulated a substantial volume of material and information on this subject, which has provided the basis to produce a plan. The aim is to present the plan to CBS-Ext. (2002) including options for disposition of character codes following migration. The plan will define technical phases in accordance with the words of the CBS, which considered a phased approach that would comprise progressive steps for a shift (or migration strategy) to the use of Table Driven Codes for transmission of surface and upper-air observations, whereby synoptic data producers and originating and processing centres of ships, buoys, satellites, aircraft observations and other types of observing sensors and platforms would be invited to transmit data in BUFR or CREX.

Some basic principles

10.2 The Team agreed it is critical the important ideas and philosophy of migration should be clearly expressed and passed to the WMO community to avoid misunderstanding. The plan needed to be clear, fully inclusive, flexible and capable of dynamically adjusting as migration proceeds.

10.2.1 The advantages and the reasons for the migration should be briefly recalled at the beginning of the plan. The plan should be helpful for managers and decision makers.

10.2.2 The specificity of BUFR relative to CREX, and their respective use has to be well explained. People often think that CREX is as complicated as BUFR and that one needs a computer to encode it. If the programming of a CREX encoder/decoder is almost as complicated as for BUFR (although without compression and data quality features), people should realize that it can also be coded manually and read directly by humans.

10.2.3 The concept of data producers, data conveyors and data users should be explained and used to

make clearer the way migration can be implemented in the context of our traditional systems of GOS, GTS and GDPS.

10.2.4 The idea that the decision when to migration will be determined by each data producer, based on when it is ready to do so must be clearly explained. Observational data producers (WMO Members) should have the freedom to switch to BUFR (or CREX) when they want and when they are ready to do so. For that purpose data users should have first priority for training and be equipped with BUFR and CREX decoders as soon as possible. Double dissemination should be considered to cater for non-automated users or "non-binary-connected" users. Conversion from BUFR back to traditional code forms should be avoided, if a conversion has to take place back to an alphanumeric code, it is better to be from BUFR to CREX, to keep the advantages of the TDCF. However, for internal national systems, Members have the ability to define their own needs.

10.2.5 A big misunderstanding of some is that migration means on a pre-defined agreed date everybody will switch to BUFR, like if it was a code change for observing a new parameter or transmitting a new group in SYNOP. The freedom and flexibility of migration will be a main principle of the plan and clearly explained. The data users should be given the means, if necessary, to receive at least the same data as before, from a producer who switches to a TDCF.

10.2.6 The plan will consider data users who are automated and those who are not (about 40 out of 185 WMO Members) and the data users who can receive binary data and those who cannot. Similarly, the plan will consider the data producers who can easily switch to binary transmission and those who cannot. Then the plan will provide guidelines for what each category of data users and data producers should do, and what are priorities.

10.3. The plan should contain also in particular:

10.3.1 The migration process will be long in time, but with targets (several years ahead) foreseeing elimination of traditional alphanumeric codes, which should be indicated for motivating the Members. The plan should describe a long-term migration process with considerable flexibility.

10.3.2 The plan should consider in sequence and in parallel, with appropriate schedule: software house project(s), pilot project(s), training programmes, software development, experimental co-ordinated exchange tests, where necessary, and operational implementation by Member(s).

10.3.3 The respective roles of data producers, data conveyors, data users, NMCs and RTHs, as well as those expected from manufacturers of observing stations or platforms, and of the private software producers for telecommunication and processing packages, as well as work-stations has to be clearly explained.

Structure of the plan

10.4. The plan may be organised in 5 parts and one Annex. The structure of the plan is listed in Annex to this paragraph.

11. ACTION PLAN

- Focal points to receive all information concerning the migration (2.1.1 Secretariat - ASAP)
- The WMO Commission for Climatology (CCl) to be contacted for comment on Templates translating CLIMAT messages in BUFR (2.1.2 Secretariat - ASAP)
- More information on the Migration to TDCF to be disseminated also to all concerned organisations or international bodies (2.1.3 All - Systematic)
- Send a questionnaire to Focal points (2.2.2 Secretariat - ASAP and every two years)
- Questionnaire answers from a Region to be sent to the Regional Rapporteur on Data Management (2.2.2 Secretariat)
- To make BUFR encoded rawindsonde data available on the GTS and give list of stations (2.3.1 USA - ASAP)

- To notify the WMO Secretariat when planning to transmit data in BUFR or CREX (2.3.2 WMO Members) and METNO to be sent to inform all WMO Members (2.3.2 Secretariat).
- Identification as sub-types within the TDCF message for the application processing to be addressed, perhaps within the frame of a new edition for BUFR/CREX (2.3.2 ET/DR&C).
- Produce Guide on GRIB 2 (2.4.2 Secretariat - ASAP)
- Produce Manual on Reporting Practices (2.4.3 Secretariat - ASAP)
- Start National training on TDCF (2.5 WMO Members - ASAP)
- To develop BUFR/CREX descriptors to address the Optional Section of the code structures that would replace the current alphanumeric code forms (4.1.5 ET/DR&C).
- Size limit for all binary messages be raised to 250,000 octets (5.2 Secretariat and ET on GTS - ASAP)
- Bulletin headers definition scheme to be revised and document submitted to CBS (5.3 Chairman, Secretariat and ET on GTS - ASAP, **URGENT**)
- Letter to ECMWF, which would be submitted at their Council asking for free support to WMO Members for a software house (6.4 Secretariat - ASAP)
- Approach EUMETNET (6.4 Secretariat - ASAP)
- Organise workshop on implications of the migration to TDCF for developing Countries and defining pilot project(s) (6.7 Secretariat - ASAP).
- BUFR templates for CLIMAT, CLIMAT SHIP, CLIMAT TEMP and CLIMAT TEMP SHIP validated via experimental exchange (7.4.2 members of ET/DR&C - ASAP)
- To define more common sequences (7.4.5.3 members of ET/DR&C - ASAP)
- Catalogue data already available in a table driven format other than direct model output and actively coordinate its global exchange (7.5 National focal points, RTH focal points, DM Regional Rapporteur, Secretariat - ASAP)
- Establish a periodic regular review of code descriptor and template requirements for representation of all data possibilities in traditional code forms, coordinate needs with ET/DR&C and provide central coordination of testing (7.5 ET/DR&C and ET/MTDCF - as needed, at least every year)
- Information coordination and reporting of Migration Activities (7.5 National focal points, RTH focal points, DM Regional Rapporteur, ET/MTDCF, Secretariat - ASAP)
- Updating Migration Matrix (8. ET/MTDCF, Secretariat - ASAP)
- Organize WMO training programme on MTDCF for trainers and software users (9.2.1, 9.2.2 Secretariat - ASAP)
- Organize Seminar with manufacturers (9.4 Secretariat - ASAP)
- Provide Level 1 training in WMO seminar (9.5 Secretariat - ASAP)
- Detailed migration plan for CBS (10.1 Chairman, Secretariat - before End of June 2002)

12. CLOSURE OF THE MEETING

The Meeting was closed by the Chairman of the ET on MTDCF at 15.30 on Friday 17 May 2002.

ANNEX TO PARAGRAPH 1.1

ET/MTDCF, Washington, 13-17 May 2002

List of Participants

Dr Fred BRANSKI, Chairman
NOAA/NWS, SSMC II, 5347
1325 East West Highway
SILVER SPRING, MD 20910
USA
Tel: (1301) 713 0864 Ext. 146
Fax: (1301) 713 1409
Email: fred.branski@noaa.gov

Mr Seid AMEDIE
National Meteorological Services Agency
P.O. Box 1090
ADDIS ABABA
ETHIOPIA
Tel: (251 1) 51 22 99
Fax: (251 1) 51 70 66
Email: nmsa@telecom.net.et

Mr Jean CLOCHARD
Météo-France
42 Avenue Coriolis
31057 TOULOUSE CEDEX
FRANCE
Tel: +33 5 6107 8104
Fax: +33 5 6107 8109
Email: jean.clochard@meteo.fr

Mr Heinrich KNOTTENBERG
Postfach 100465
D 63004 OFFENBACH
GERMANY
Tel: (49 69) 80622567
Fax: (49 69) 80623566
Email: Heinrich.Knottenberg@dwd.de

Mr Keiichi KASHIWAGI
Japan Meteorological Agency
1-3-4 Ote-machi, Chiyoda-ku
TOKYO 100-8122
JAPAN
Tel: 81 3 32 11 8402
Fax: 81 3 3212 4666
Email: kashiwagi@met.kishou.go.jp

Mr Jaap van der PLANK
Royal Netherlands Meteorological Institute
Wilhelminalaan 10, Postbus 201
3730 AE DE BILT
NETHERLANDS
Tel: (3130) 2206455
Fax: (3130) 2210843
Email: Jaap.van.der.Plank@knmi.nl

Dr Vladimir ANTSYPOVICH
Main Computer Centre of Roshydromet
B. Predtechensky 9-13
123242 MOSCOW
RUSSIAN FEDERATION
Tel: 007 (095) 252 37 46
Fax: 007 (095) 255 21 89
Email: antsyp@hydromet.ru

Mr Jeffrey ATOR
NWS National Centers for Environmental Prediction
5200 Auth Road
Camp Springs, Maryland 20746
USA
Tel: (301) 7638000 ext. 7104
Fax: (301) 7638381
Email: jeff.ator@noaa.gov

Mr Milan DRAGOSAVAC
ECMWF
Shinfield Park
READING, BERKSHIRE RG2 9AX
UNITED KINGDOM
Tel: +44 118 9499 4403
Fax: +44 118 986 9450
Email: milan.dragosavac@ecmwf.int

Dr Simon ELLIOTT
EUMETSAT
Am Kavalleriesand 31
D-64295 DARMSTADT
GERMANY
Tel: +49 6151 807 385
Fax: +49 6151 807 304
Email: elliott@eumetsat.de

WMO SECRETARIAT
Mr Joël MARTELLET
World Meteorological Organization
7 bis, avenue de la Paix
Case postale No. 2300
CH-1211 GENEVA 2
Switzerland
Tel: +41 22 730 8313
Fax: +41 22 730 8021
E-mail: joel@www.wmo.ch

ANNEX TO PARAGRAPH 2.2

RA I: In several reports RA I stressed the need for training in Table Driven Codes and assistance in automation. Telecommunication lines and software might not be adequate for binary transmission.

RA II (Seoul, 19-27 September 2000)

"The Association noted that a survey undertaken by the rapporteur had indicated that there was no plan, in general, to introduce the comprehensive use of BUFR/CREX in the Region. More than 75 per cent of respondents pointed out the necessity of guidance material on CREX messages and information on the availability of decoding/encoding software. Furthermore no respondents opposed the migration from character codes to BUFR/CREX. On the other hand, most expressed difficulty with accepting a quick migration because their telecommunication circuits do not accommodate binary data or the unavailability of decoding/encoding software.
4.6.3 The Association taking the above survey results into consideration, requested that guidance material on table-driven codes and the characteristics of GRIB, BUFR/CREX be prepared. It strongly encouraged CBS to establish a "software support office" as proposed by CBS, which would assist Members in acquiring, using and maintaining encoding/decoding software for binary codes. The Association realized that a comprehensive migration to table-driven codes would be connected with substantive cost for the Members. The Association therefore urged CBS to collaborate closely with the Regional Associations with a view to pursuing a well coordinated approach to this issue, which must result in a smooth and manageable transition."

RA III (Quito, 19-26 September 2001):

"The Association followed EC-LIII and CBS-XII in recognizing that the self-description, flexibility and expandability of Table Driven Codes like BUFR and CREX would be the solution to the frequent demands of the rapidly evolving science and technology for representation of new data types and metadata. Table driven codes would also substantially contribute to improving data quantity and quality. The Association noted that CBS had considered a well coordinated phased approach that would comprise a progressive transition to the use of Table Driven Codes. The Association noted with appreciation that the Council felt such a transition, to be successful, would need to include support projects for training and decoding/encoding software distribution. The Association noted that the Council requested CBS to develop further this plan and to submit a report to its next session. The Association took note with appreciation of the proposal of several Members and of ECMWF to make available to all WMO Members encoder/decoder software for the WMO binary codes. The Association stressed the need for training to prepare the NMHSs in time for the use of BUFR and CREX, as well as GRIB Edition 2, and welcomed, in this connection, the offer of the USA to help in providing and supporting training courses for this purpose."

RA IV (Maracay, 28 March-6 April 2001)

"4.3.13 The Association recognized that CREX was a table-driven alphanumeric data representation form and its fundamental objective was to serve as a tool to avoid the proliferation of new alphanumeric code forms by permitting the exchange of observations for which no traditional character code existed and which, for various reasons, could not be transmitted in BUFR. CBS-Ext.(98) had adopted the following recommendations to promote the use of table-driven data representation forms CREX, BUFR and GRIB:

(a) Urge WMO Members to use CREX when requirements were identified for new data types that were required by Members who did not have the capability to handle binary data formats (BUFR);

(b) Strongly encourage the use of CREX when new requirements for expansion of traditional codes were identified;

(c) Support user requirements and facilitate the use of table-driven data formats whenever possible;

(d) Request that new satellite data exchanged on the GTS would be encoded in BUFR or GRIB;

(e) Encourage the development of standard software that was easy to install and use for handling data in CREX, BUFR or GRIB.

4.3.14 The Association recalled that CREX, a number of additions to code tables, and several modifications to character codes, including SYNOP, PILOT and TEMP were implemented for operational use as of 3 May 2000. All NMHSs of Region IV were urged to take any required steps to accommodate them, if not already done.

4.3.15 The Association noted with interest that CBS-XII had given consideration to a strategy for the comprehensive migration from conventional character-based codes to the table-driven data representation forms BUFR and GRIB within a ten-year period. The Commission was studying the various implications such a strategy would have, and would, based on the results, develop and recommend to the Executive Council an appropriate implementation plan. In this connection, the Association emphasised the need for training to prepare the NMHSs in time for the use of BUFR and GRIB as well as CREX. It welcomed with gratitude the offer of the USA to provide some training courses for this purpose."

RA V (Manila, 21-28 May 2002)

"The Association also noted that migration to table driven codes to replace the traditional character codes, and a timetable for implementation has been proposed. It recognized that the migration to table driven codes will be a complex task and will take many years. However given that codes are essential to the operations of NMSs, it emphasised that the introduction of table driven codes must be approached with deliberation and caution. The session noted that the potential impact and implications for the Region must be determined once the implementation schedule becomes better defined.

4.6.1 The Association noted that CREX format was starting to be used within the Region, with RSMC Nadi issuing cyclone trajectory forecasts and the US NWS issuing automated rainfall reports in CREX. The Association noted that the use of CREX by some Members represented an opportunity to gain experience in the use and flexibility of the CREX table driven format."

RA VI (Geneva, 2-10 May 2002)

"The Association agreed that the wider use of the table driven code forms depended upon development of widely available, easy to use software. The availability of "load and go" or commercial quality software will be the single most important component of a strategy to migrate to binary and table-driven formats. The best mechanism to ensure development and ongoing maintenance of quality software for dealing with WMO formats will be the establishment of a centralized office to support software for the WMO formats (BUFR, GRIB and CREX). Members also need to receive full information on the migration through promotion, training and information on the Web sites.

4.3.5 The Association noted the benefits of the migration as flexibility, expandability and self-description of the codes allowing transmission of any new data types or parameters, especially all required metadata. It will improve data quality and it offers data compression (BUFR). It will also mean the suppression of the costly software modifications required when the traditional alphanumeric codes needed to be changed. It agreed on the necessity of coordination between CBS and the regional association on this difficult issue. It recognized that Members have the freedom to switch to BUFR or CREX when they want and when they are ready to do so. The migration plan should enable every WMO Member to migrate. The plan needed to include encouragement for Member States to migrate.

4.3.6 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. Translation from BUFR to CREX code might also be done in some RTHs before distribution to NMCs not supporting binary codes. Concern was expressed by some Members on the burden it might add on Telecommunications Centres, and therefore the Association agreed that the impacts on the GTS should not be under-estimated and the migration should be very carefully planned.

4.3.7 The Association was informed of consultations between WMO and the ECMWF to act as "software house" for all WMO Members to deliver free encoder/decoder software for BUFR, CREX and GRIB2 (on UNIX or LINUX operating systems, in FORTRAN or C). The Association appreciated this initiative and expressed the hope that ECMWF would find some ways and means to take up this activity on a sustainable basis as a contribution to the wider meteorological community. The Association also took note with appreciation , of the initiative taken by EUMETNET, aspart of the migration startegy, to make the OPEAR BUFR software available to Members.

4.3.8 To prepare for the migration, the Association agreed that Members should update their national training (in NMHS and other institutions) on meteorological codes to put in first priority BUFR and CREX for their full understanding, instead of traditional alphanumeric codes. GRIB Edition 2 should be also explained. It agreed that Members contact and inform manufacturers of automatic observing systems and data-processing systems (e.g. workstations) of the requirement to migrate and the benefits of TDCF and in particular:

- Plan resources (staff and finance) for migration to TDCF;

- Nominate a national migration focal point;

- Develop a national migration project and schedule, based on the CBS decisions (which have been approved by EC)."

Executive Council 53, June 2001

"3.1.20 Regarding data representation, the Council noted that CBS had recognized that the self-description, flexibility and expandability of Table Driven Codes like BUFR and CREX would be the solution to the frequent demands of the rapidly evolving science and technology for representation of new data types and metadata. Table driven codes would also substantially contribute to improving data quantity and quality. The Council noted that CBS had considered a well co-ordinated phased approach that would comprise a progressive transition to the use of Table Driven Codes. The Council felt that such a transition to be successful would need to include support projects for training and decoding/encoding software distribution. The Council requested CBS to develop further this plan and to submit a report to its next session. The Council took note with appreciation of the proposal of several Members and of ECMWF to make available to all WMO Members encoder/decoder software for the WMO binary codes. The Council emphasized the need for training to prepare the NMHSs in time for the use of BUFR and CREX, as well as GRIB Edition 2. The Council welcomed the offer of the USA to help in providing and supporting training courses for this purpose."

ANNEX TO PARAGRAPH 2.2.2

Questionnaire to Focal points which could possibly contain the following information:

- Existing capability to transmit and receive binary data at NMC level (or RTH level) (link, line speed, protocols, hardware, software)
- Existing capability to process binary data at NMC level (hardware, software, competent manpower: to perform and support the technical work)
- Existing capability to generate BUFR reports at observing site or platform (for which data type)
- Existing capability to generate CREX reports at observing site or platform (for which data type)
- Existing capability to generate BUFR reports at National Data Collection Centre (telecommunication or data processing Centre) (for which data type)
- Existing capability to generate CREX reports at National Data Collection Centre (telecommunication or data processing Centre) (for which data type)
- Existing reception of BUFR messages (for which data type)
- Existing reception of GRIB messages (GRIB 1 and/or GRIB 2)
- Existing reception of CREX messages (for which data type)
- Plans for future encoding of data in BUFR (capabilities at Observing sites or platforms, centralised levels) (for which data type)
    - When validation exchange tests are planned (for which data type)?
    - When operational migration is expected and for which data type?
- Plans for future encoding of data in CREX (capabilities at Observing sites or platforms, centralised levels) (for which data type)
    - When validation exchange tests are planned (for which data type)?
    - When operational migration is expected and for which data type?
- Plans for future exchanges of GRIB 2 messages
    - When operational exchange is expected and for which data type?
- Plans for future exchanges of BUFR messages (for which data type)
    - When operational exchange is expected and for which data type?
- Plans for future exchanges of CREX messages (for which data type)
    - When operational exchange is expected and for which data type?
- Willingness to provide available BUFR data for pilot exchange programs (for which data type)
- Willingness to provide available CREX data for pilot exchange programs (for which data type)
- Willingness to receive, forward on, or decode BUFR as part of pilot exchange programs (for which data type)
- Willingness to receive, forward on, or decode CREX as part of pilot exchange programs (for which data type)
- Possible impacts from code migration
- Possible benefits of code migration
- Specific operational concerns about migration

ANNEX TO PARAGRAPH 10.4

STRUCTURE OF THE PLAN

4. The plan may be organised in 5 parts and one Annex:

I. Introduction

- Recall CBS and EC statements
- List principles and goals

II. Advantages and reasons of the migration to TDCF:

1) Better data representation:
   - Self-description
   - Flexibility
   - Expandability

2) Science requirements
   - New parameters
   - New data types
   - More data
   - Better quality data

3) Operational aspects
   - Less development
   - Less maintenance
   - Easier archiving
   - Easier archives processing

III. Description and analysis of the current data flow in the World Weather Watch

1) Introduce concepts of data producers, data conveyors and data users

2) WMO observation data producers
   - WMO Members
     - Observing stations and platforms
       - Observers
       - Automation
     - Observation data collection Centre
   - Other Organisations or Agencies (e.g. EUMETSAT, ARGOS)
     - Observation data generation Centre
   - Role of Manufacturers of observing stations or platforms

3) WMO observation data conveyors
   - RTHs

4) WMO observation data users
   - RSMCs
   - NMCs
   - Private software producers for telecommunication and processing packages, as well as work-stations
   - End users:
     - NWP
     - Forecast Office

- Climate
- Marine
- Aviation
- Other Programmes or Agencies

IV. Impacts of the Migration on every group:

1) Producers
   - WMO Members
   - Other Organisations or Agencies (e.g. EUMETSAT, ARGOS)
   - Manufacturers of observing stations or platforms

2) Conveyors
   - NMCs
   - RTHs
   - Specialised agencies (e.g. Service ARGOS, ARINC)

3) Users
   - RSMCs
   - NMCs
   - Private software producers for telecommunication and processing packages, as well as work-stations
   - End users:
     - NWP
     - Forecast Office
     - Climate
     - Marine
     - Aviation
     - Other Programmes or Agencies

V. Solutions and plan of actions

1) Recall principles for the plan

2) Training in parallel with actions
   - Organized by Secretariat (cost and budget request)
     - Seminar for Members: what staff (Trainers, forecasters, etc..), Levels
     - Workshops (Manufacturers)
     - Fellowships

   - Organized nationally

3) Actions recommended to:

   - WMO as a whole (and Secretariat)
     - Software project
     - Information

   - WMO Members for producing TDCF
     - Automated
     - Non-automated

   - WMO Members for conveying TDCF

   - WMO Members for using TDCF
     - Automated

- Non-automated

- Other Organisations or Agencies (e.g. EUMETSAT, ARGOS)

4) Software house project
   - Good documentation (API)
   - Good assistance
   - Printing and display routines should be available

5) Pilot Project(s)
   - Definition (proposed Country)
   - Schedule
   - Assessment
   - Consequences on the Plan itself

6) Schedule

   - Ultimate achievement
   - Schedule table

7) Recommendations for co-ordination and review mechanisms

   - At CBS level
     - ET on MTDCF's role (coordination with other OPAGs ETs)
     - Migration Matrix

   - At WMO level
     - Inter-Commissions
     - With other Organisations, Agencies

   - At Regional and National Levels
     - Regional rapporteurs' role
     - National Focal-points' role
     - Establishment of a National Migration to TDCF Steering Group (NMTSG)

Annexes:

Give Status in 2002:

- List actions already taken
- Code Migration Schedule
- Centre/Facility Migration Matrix
- New Bulletins Headers

Code Migration Schedule

Category →	**Cat.1: common**	**Cat.2: satellite observations**	**Cat.3: aviation[(1)]**	**Cat. 4: maritime**	**Cat. 5[(2)]: miscellaneous**	**Cat. 6[(2)]: almost obsolete**
Lists of → Traditional code forms	SYNOP SYNOP MOBIL PILOT PILOT MOBIL TEMP TEMP MOBIL TEMP DROP CLIMAT CLIMAT TEMP	SAREP SATEM SARAD SATOB	METAR SPECI TAF CODAR AMDAR WINTEM ARFOR ROFOR	BUOY TRACKOB BATHY TESAC WAVEOB SHIP CLIMAT SHIP PILOT SHIP TEMP SHIP CLIMAT TEMP SHIP	RADOB RADREP IAC IAC FLEET GRID*(to GRIB)* MAFOR HYDRA HYFOR RADOF	ICEAN GRAF NACLI etc. SFAZI SFLOC SFAZU ROCOB ROCOB SHIP
Schedule ↓						
Start experimental Exchange[(3)]	**Nov. 2002** for some data (AWS SYNOP, TEMP USA)	Current at some Centres	**2006** **2002** at some Centres for AMDAR	**2005** **2003** for Argos data (BUOY, sub-surface floats, XBT/XCTD)	**2004**	Not applicable
Start operational exchange[(3)]	**Nov. 2005**	Current at some Centres	**2008** **2003** for AMDAR	**2007** **2003** for Argos data (BUOY, sub-surface floats, XBT/XCTD)	**2006**	Not applicable
Migration complete	**Nov. 2010**	**Nov. 2006**	**2015** **2005** for AMDAR	**2012** **2008** for Argos data (BUOY, sub-surface floats, XBT/XCTD)	**2008**	Not applicable

Notes:

(1) Aviation Codes require ICAO coordination and approval.

(2) For category 5 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 conditions to be satisfied before experimental exchange may start:
- Corresponding BUFR/CREX-tables and templates are available;
- Training of concerned testing parties has been completed;
- Required software of testing parties (encoding, decoding, viewing) is implemented;

Relevant conditions to be satisfied before operational exchange may start:
- Corresponding BUFR/CREX-tables and templates are fully validated;
- Training of all concerned parties has been completed;
- All required software (encoding, decoding, viewing) is operational.

Centre/Facility Migration Matrix
(see notes at bottom)

TAC Category ↓	**Type of Centre** and Role→ **TAC ↓**	**Observing Site** Data Producer			**National Observation Data Collection Centre** Data Producer	**Observation Data Generation Centre** Data Producer	**RTH** Data Conveyor	**Data Processing Centre (NMC)** Data User and Data Producer (products)?	**Local Forecast Office** Data User and Data Producer (products)?	**National Met. Service Administration** Data Producer, Conveyor?, User
		Observer	**Micro-chip Embedded System**	**Software Programmer**						
CAT1 common: (Exp Exch Nov. 2002, Oper Exch Nov 2005, Migr Cmplt Nov 2010)	SYNOP SYNOP MOBIL PILOT PILOT MOBIL TEMP TEMP MOBIL TEMP DROP CLIMAT CLIMAT TEMP	Encoding (CREX)?, Typing in parameters (BUFR) Training: L2P1(BUFR) or L3(CREX?)	Encoding, Reprogramming EPROM, Double encoding?	Encoding, Double encoding? Volume + Training: L3	Conversion? Encoding? Double encoding? Double Transmission? Volume + Training: L2P2 or L3	*Not Applicable*	Double Transmission? Volume + Bulletins +	Decoding Display? Volume + Bulletins + Conversion? Training: L2P2	Decoding? Display? Parameters: + Volume + Training: L1 or L2P1or L2P2	Plan and formulate request for equipment and software (resources commitment). Need to receive Training: L1
Cat.2 Satellite: obs: (Exp Exch Current, Oper Exch Current, Migr Cmplt Nov 2006)	SAREP SATEM SARAD SATOB	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*	Encoding? Double encoding? Double Transmission? Volume + Training: L2P2 or L3	Volume + Double Transmission? Bulletins +	Decoding Display? Volume + Bulletins + Training: L2P2	Decoding? Display? Parameters: + Volume + Training: L1 or L2P1or L2P2	Training: L1
CAT3 aviation: (Exp Exch Current, Oper Exch Nov 2008, Migr Cmplt Nov 2015)	Obs.:METAR SPECI CODAR AMDAR	Encoding (CREX)? Typing in parameters (BUFR) Training: L2P1(BUFR) or L3(CREX?)	Encoding, Reprogramming EPROM, Double encoding?	Encoding, Double encoding? Volume + Training: L3	Conversion? Encoding? Double encoding? Double Transmission? Volume + Training: L2P2 or L3	Conversion? Encoding? Double encoding? Double Transmission? Volume + Training: L2P2 or L3	Double Transmission? Volume + Bulletins +	Decoding Display? Volume + Bulletins + Conversion? Training: L2P2	Decoding? Display? Parameters: + Volume + Training: L1 or L2P1or L2P2	Plan and formulate request for equipment and software (resources commitment). Need to receive Training: L1

TAC Category ↓	**Type of Centre** and Role→ **TAC ↓**	**Observing Site** Data Producer			**National Observation Data Collection Centre** Data Producer	**Observation Data Generation Centre** Data Producer	**RTH** Data Conveyor	**Data Processing Centre (NMC)** Data User and Data Producer (products)?	**Local Forecast Office** Data User and Data Producer (products)?	**National Met. Service Administration** Data Producer, Conveyor?, User
		Observer	**Micro-chip Embedded System**	**Software Programmer**						
CAT3 aviation: (Exp Exch Current, Oper Exch Nov 2008, Migr Cmplt Nov 2015)	Products: TAF WINTEM ARFOR ROFOR	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*	Double Transmission? Volume + Bulletins +	Decoding Display? Volume + Bulletins + Encoding? Double encoding? Double Transmission? Training: L2P2 or L3	Parameters: + Volume + Decoding? Display? Encoding? Double encoding? Training: L1 or L2P1or L2P2	Plan and formulate request for equipment and software (resources commitment). Need to receive Training: L1
CAT4 maritime: (Exp Exch Nov. 2003, Oper Exch Nov 2007 Migr Cmplt Nov 2012)	BUOY TRACKOB BATHY TESAC WAVEOB SHIP CLIMAT SHIP PILOT SHIP TEMP SHIP CLIMAT-TEMP SHIP	Encoding (CREX)?, Typing in parameters (BUFR) Training: L2P1 (BUFR) or L3(CREX?)	Encoding, Reprogramming EPROM, Double encoding?	Encoding, Double encoding? Volume + Training: L3	Conversion?, Encoding? Double encoding? Volume + Training: L2P2 or L3	Conversion, Encoding? Double encoding? Volume + Training: L2P2 or L3	Double Transmission? Volume + Bulletins +	Decoding Display? Volume + Bulletins + Conversion? Training: L2P2	Parameters: + Volume + Decoding? Display? Training: L1 or L2P1or L2P2	Plan and formulate request for equipment and software (resources commitment). International coordination Need to receive Training: L1
CAT5 m\sc: (Exp Exch Nov. 2004, Oper Exch Nov 2006 Migr Cmplt Nov 2008)	Obs: HYDRA RADREP RADOB	Encoding (CREX)?, Typing in parameters (BUFR) Training: L2P1 (BUFR) or L3(CREX?)	Encoding, Reprogramming EPROM, Double encoding?	Encoding, Double encoding? Volume + Training: L3	Conversion?, Encoding? Double encoding? Volume + Training: L2P2 or L3	Conversion, Encoding? Double encoding? Volume + Training: L2P2 or L3	Double Transmission? Volume + Bulletins +	Decoding Display? Volume + Bulletins + Conversion? Training: L2P2	Parameters: + Volume + Decoding? Display? Training: L1 or L2P1or L2P2	Plan and formulate request for equipment and software (resources commitment). International coordination Need to receive Training: L1

TAC Category ↓	**Type of Centre** and Role→ **TAC ↓**	**Observing Site** Data Producer			**National Observation Data Collection Centre** Data Producer	**Observation Data Generation Centre** Data Producer	**RTH** Data Conveyor	**Data Processing Centre (NMC)** Data User and Data Producer (products)?	**Local Forecast Office** Data User and Data Producer (products)?	**National Met. Service Administration** Data Producer, Conveyor?, User
		Observer	**Micro-chip Embedded System**	**Software Programmer**						
CAT5 m\sc: (Exp Exch Nov. 2004, Oper Exch Nov 2006 Migr Cmplt Nov 2008)	Products: IAC IAC FLEET GRID*(->GRIB)* MAFOR HYFOR RADOF	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*	Double Transmission? Volume + Bulletins +	Decoding Display? Volume + Bulletins + Conversion? Encoding? Double encoding? Double Transmission? Training: L2P2 or L3	Parameters: + Volume + Decoding Display? Encoding? Double encoding? Training: L2P2 or L3	Plan and formulate request for equipment and software (resources commitment). International coordination Need to receive Training: L1
CAT6 almost obsolete: (Exp Exch NA, Oper Exch NA Migr Cmplt Nov 2012)	ICEAN GRAF NACLI etc. SFAZI SFLOC SFAZU ROCOB ROCOB SHIP	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*

NOTES:

- NMCs and Local Forecast Offices can generate products.
- National Observation Data Collection Centres collect observations and produce observation reports and generate GTS bulletins. It can be also part of the functions of a National Telecommunication Centre interfacing with the GTS.
- Observation Data Generation Centres produces observations or observations products (e.g., Service ARGOS, EUMETSAT). It may produce GTS bulletins.
- The Data Processing Centre (NMC) may produce bulletins of products. . It can be also part of the functions of a National Telecommunication Centre interfacing with the GTS.
- Levels of Training:
    - L1 – General philosophy of TDCF and migration overview
    - L2 – Meteorological users, Telecommunications Managers, Data Managers, and those involved with Application Interfaces
        - P1) Trainers, data managers and also people interfacing with general users (meteorologists) and decision-makers for technical matters.
        - P2) Technical users involved in operational software development.
    - L3 – For encoder and decoder programmers (only needed if the software project is not fully implemented)

ANNEX

LIST OF ACRONYMS

ACARS	AirCraft Addressing and Reporting System
AFWA	Air Force Weather Agency
AMSU	Advanced Microwave Sounding Unit
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 the Representation of (meteorological) data
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
ERS	European Research Satellite
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
ICT	Information and Communication Technology
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
TOVS	TIROS Operational Vertical Sounder
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