SUMMARY OF THE PLAN FOR
MIGRATION TO TABLE-DRIVEN CODE FORMS (TDCF)

(Please note, the full text of the detailed Plan is now available on the WMO WWW website at:
http://www.wmo.int/web/www/documents.html
under WMO Codes and Representation Forms)

~~*http://www.wmo.ch/web/www/WDM/wdm.html#Documents*~~
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I. INTRODUCTION: ADVANTAGES OF, AND REASONS FOR, MIGRATION TO TDCF

1.1 Observational data are the lifeblood of the meteorological activities of WMO. Standardization of the formatting of the data has always been a fundamental requirement. The self-description, flexibility and expandability of TDCF, BUFR, CREX and GRIB, are the only solution to the demands of the rapidly evolving science and technology for representation of new data types, metadata, higher resolution data in time or space dimensions and higher precision of data. BUFR and CREX offer great advantages in comparison with the traditional alphanumeric codes (TAC). In addition, BUFR offers condensation (packing) of data. The alphanumeric code CREX provides human readability, but not packing. BUFR has mainly been used for satellite, aircraft and wind profiler observations, and also for tropical cyclone information and archival of all types of observational data. CREX is used for the exchange of ozone data, radiological, hydrological, tide gauge, and soil temperature data, as well as for tropical cyclone information. The TDCF will easily permit to satisfy existing as well as future needs. The reliability of binary data transmission provides for an increase in data quality and quantity received at meteorological centres. In addition, the systematic exchange of metadata in every report is easily performed with TDCF. This alleviates the difficulties currently experienced in acquiring this metadata and simplifies archival of data. Since all BUFR and CREX messages include the respective code table edition and version numbers, the correct retrieval of parameters from archives for any historical post-processing application is safer and simpler. Increased data quantity and quality will lead to the generation of better products. Less development and maintenance work and reduced associated costs will be additional operational benefits. The universal use of TDCF will reduce the diversity of data formats that need to be processed, consequently reducing software and other operational requirements. BUFR and CREX can satisfy all needs for coding observations and are recommended for all present and future WMO applications. They are the ideal codes for observations and the best adapted to the fast scientific and technological evolution of the twenty-first century.

1.2 The impact the migration may have on financial resources is a legitimate concern of WMO Members. There will be significant changes to systems, which will require many staff-hours of work. However, many Members feel this is manageable and outweighed by the advantages of migration as long as sufficient time and flexibility is allowed for in the plan.

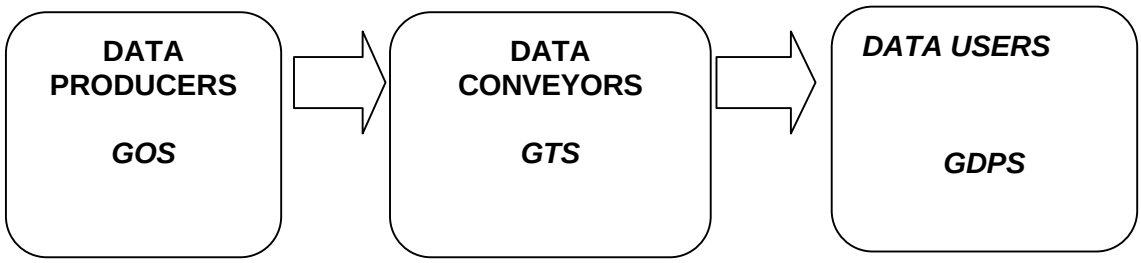
II. POTENTIAL IMPACTS OF THE MIGRATION TO TDCFs ON THE WWW

The concepts of data producers, data conveyors and data users

2.1 The migration to TDCF will have implications at every step of the WWW data flow. Technical impacts and possible solutions must be identified. The concepts of data producers, data conveyors and data users are introduced to explain the WWW data flow. The GOS and similar

systems are the data producers; the data conveyors are elements of the GTS, and the GDPS and others, who utilize the data, are the data users. Entities making up the GOS, GTS and GDPS are all located within the NMHSs.

THE WORLD WEATHER WATCH DATA FLOW



Impact on data producers of WMO observations

2.2 Most NMCs and other data producers encode traditional observations using alphanumeric codes such as SYNOP, TEMP and PILOT. A number of specialized data producers provide other observations such as satellite data (the majority already encoded in BUFR), aircraft data (AIREP, AMDAR [some already encoded in BUFR]), SHIP data, BUOY data, XBT/CTD and subsurface profiling floats data (soon to be encoded in BUFR).

WMO Members' observing stations and platforms

2.2.1 Most countries still take many observations manually. Migration to BUFR will require automation, either by an automatic weather station generating BUFR messages or by an observer entering the observations into a system (possibly a Web-based interface) that encodes them into BUFR. Migration to CREX would allow manual encoding by a human observer to continue; however, the observers will need to be trained.

2.2.2 Most of the current automated observing systems encode data in TAC. It will take several years to convert or replace these systems before observations will be encoded in BUFR at these observation sites. Where human observers enter data into a computer, the encoding is de-coupled from the measurement. In these cases, encoding of BUFR or CREX could be done through modification to the encoding software. The choice of BUFR or CREX would be made based on telecommunication issues. For instance, experience with some data-collection platforms indicates CREX may be preferred because of potentially lower error rates (better error detection through the use of CREX check digits). One country estimated the work associated with the implementation of new encoding software to be about six staff-months per observing system. Implementation costs would depend on the details of each system, but in most cases would be reasonable if performed as part of normal life cycle maintenance.

National collection

2.2.3 Data collected at observational sites are usually sent to a central site for placement onto the GTS. Adjustments to the related systems and software at these sites may need to be made to add or enhance the capability to compile bulletins of BUFR or CREX encoded reports. It will be difficult for voluntary ships to encode observations in BUFR or CREX and will require a lengthy transition period. A similar situation exists for data that are encoded in TAC by producers outside of NMHSs, such as aircraft data.

Impact on data conveyors of WMO observations

2.3 For some observation types, there will likely be periods during the transition to TDCF when the same data will be exchanged in both TAC and TDCF – a period of "dual dissemination". This will facilitate migration between the code forms. Dual dissemination should not cause serious problems

with computer system hardware or bandwidth of telecommunication lines because of the rapid progress of information technology and services. While dual dissemination is occurring, there will be a temporary increased load on GTS switching systems. The volume of data that would be candidates for dual dissemination is small. Hence, the additional bandwidth required is also small and partially offset by the compressibility of BUFR encoded data. RTHs on the MTN can handle binary data, as can Managed Data Communication Networks and most satellite dissemination systems.

Impact on data users of WMO observations

2.4 The GDPS centres are dependent on meteorological observations. These centres have to extract the information contained in the observations from the formats in which they are exchanged. This usually involves separating out the individual observations from within the bulletins that contain them. Many centres use software to achieve this. For TAC, the software is complex and often much of the program is for detecting and correcting errors in the data due to manual coding errors or transmission failures. Use of TDCF will drastically reduce formatting errors resulting in more observations being available for all meteorological applications, especially data assimilation systems. Additionally, multiple programs are required today for decoding the different TAC formats. A single BUFR and/or CREX decoder would replace these.

2.4.1 Some applications may also need to be changed as a result of migrating to TDCF. Except where a data user wishes to modify an application to take advantage of new parameters that may be available, changes will be mainly in the pre-processing layer. Where a change only affects pre-processing, the work is estimated to be about one staff-month for each observation type. As a result, the impact on resources at an individual centre will vary depending on the type and number of applications concerned. Provision of, and support for, encoding and decoding software for TDCF will be necessary for successful migration. It will take significant time for many NMHSs to introduce computer systems to process binary data at their local offices and to implement a national telecommunication network which can disseminate binary data even if their NMCs and GTS Centres can handle binary data. Furthermore, even some advanced NMCs use application software directly linked to TAC for data plotting, data display and databases simply because most conventional observations are encoded in TAC. Introducing or modifying software for migration to TDCFs will have a financial impact on many NMHSs.

2.4.2 The final result of the migration on data users will be beneficial since data assimilation programs, forecasters, climate, marine and aviation databases will all have more data of higher quality with additional useful parameters.

Impact of migration to TDCF on other programmes or organizations

2.5 The advantages of migration to TDCF are becoming known to programmes and organizations outside the WWW community. BUFR and CREX decoders will be needed by those who receive meteorological observations. Some programmes are already using TDCF or are planning to do it soon. For example, satellite data producers have been using BUFR for a long time. SADC-HYCOS and MED-HYCOS use CREX for meteorological and hydrological observations. ARGOS, DBCP and SOOP are planning and developing systems for the transmission of observations in BUFR beginning in 2003. Dual dissemination could be performed during a transition period. However, some ACARS and AMDAR are already transmitted in BUFR. The WAFS centres have started disseminating some weather data in BUFR and plans are in place for further migration to occur. Aviation data users, such as pilots, will certainly need a presentation in clear character formats, but data transmission could be done in BUFR with automated decoding and display.

Impact for decision makers

2.6 There will be implications due to the migration process on WMO Members' resources for development and operation. One has to be aware of the financial impact of the various steps of the migration process on NMHSs´ budgets. There will be costs for:

(a) Training of personnel who generate or use data;
(b) Training of system and software personnel;
(c) Project management for transition;
(d) Documentation updates;
(e) Infrastructure, hardware and system changes (e.g. for automation);
(f) Software development;
(g) Operational procedure changes.

III. SOLUTIONS AND PLAN OF ACTIONS

Basic principles of the plan

3.1 The goal of the plan is the elimination of TAC for observational data exchange by the migration to BUFR.

(a) The goal of the plan is the eventual complete replacement of TAC by BUFR in the exchange of observational data;

(b) The migration process will be flexible. Within the target dates defined in the plan, WMO Members can choose their own timetable for the migration;

(c) The use of CREX is seen as an interim step in the migration to BUFR;

(d) The data producer, not the user, is the initiator of the migration process;

(e) Data producers should not be constrained in using BUFR or CREX;

(f) Data users must have access to new data produced in BUFR or CREX and be able to receive data exchanged in BUFR or CREX;

(g) Data users should have first priority for training;

(h) Data users should implement BUFR and CREX decoders as soon as possible;

(i) Dual dissemination (initially in BUFR and TAC, later in BUFR and CREX) should be provided, where data users are unable to receive or process BUFR or CREX;

(j) The successful migration in developing countries depends on capacity building. Assistance to developing countries in the form of pilot and specific projects will be necessary for implementation of new coding procedures, new software and possibly hardware for automation.

Training in parallel with actions

3.2 All WMO Members will be affected by the migration to TDCF. It is important that they understand the benefits and implications of TDCF. Training is essential for Members to realize fully the benefits. The training programme will be defined for the international level and training actions will be suggested for the national level. CBS-XII has recommended that such training be completed by October 2005.

3.2.1 Three levels of training should be addressed:

(a) Level 1 – General understanding of the philosophy of TDCF and a migration overview;
(b) Level 2 – Deeper understanding of TDCF and Introduction and use of TDCF software including debugging and the interaction with data-processing applications;
(c) Level 3 – Total understanding of the TDCF, for programming of encoders and decoders (only needed if the software project is not implemented).

3.2.2 To implement the three levels of training, two WMO training courses are proposed for two categories of trainees:

(a) P1: Trainers, data managers, general users (meteorologists) and decision makers for technical matters;

(b) P2: Technical users involved in operational software development.

3.2.3 WMO proposes to organize training seminars that would cover handling of software packages for decoding and visualization software for decoded data. The seminars would include P1 and P2 courses for technical users involved in operational software development and trainers from RMTCs. The seminars would be provided in all WMO Regions over the period 2003-2005. The total cost to WMO has been estimated at CHF 500 000.

National training

3.2.4 Currently, there is little or no training on TDCFs within the NMHSs. Level 1 and Level 2 training should be given. Level 3 should be considered if the software project is not implemented. Information on the general philosophy of BUFR and CREX codes should be included in meteorological training institutions of all countries for all technical staff. However, most staff does not need instruction on the "physical" structure of the code(s). Level 1 training is sufficient for most staff.

Information for manufacturers

3.2.5 Information should be provided to manufacturers of automatic observing systems, processing systems and workstations. It could be delivered in a seminar where documentation was also provided. The seminar would cover general principles of the codes along with examples. The WMO Secretariat may be able to arrange for such a seminar at no cost for WMO via registration fees paid by the manufacturers.

Software house project

3.3 CBS recognized that provision of, and support for, encoding and decoding software for the TDCF is an indispensable part of any migration plan. A software house project is a new paradigm for WMO but is a critical need for a successful migration to TDCFs. A centralized unit developing and supporting application program interface software is a valuable and necessary step to ensure that standard data representation forms, developed and coordinated by the WMO, are used by the widest possible user community. This will be of particular use to those users with very limited computer programming resources. The implementation of a software house project in a technologically advanced State or through an international organization will favour and help migration to TDCF. It should be noted that the first beneficiaries of such a project would be the technologically advanced States themselves, and all their meteorological applications, in particular their operational forecasting systems, with the prospect of receiving more data and better quality data, leading to better products.

Pilot project(s)

3.4 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. Pilot migration projects should be identified, developed and implemented, as a test and precursor to the migration, to show the benefits, and to show any difficulties. This will also allow for better solutions to problems to be identified.

Actions recommended: tasks of WMO Members for producing TDCF

3.5 Data producers will have the freedom to switch to BUFR when they need. However, they have to ensure that their users have access to the data. In some cases dual dissemination in BUFR and CREX will be necessary for users who cannot receive or process binary data. Dual dissemination in BUFR and TAC is discouraged since users will not be able to benefit from new parameters and the greater precision provided by BUFR and CREX, but users should have the capacity to understand CREX.

Manufacturers of automated platforms

3.5.1 Some NMHSs will need to plan for replacement of their automated systems and others may plan to introduce automation. Financial considerations may make it necessary for Members to do this over a long time. Members should begin planning for the introduction of systems with software to encode observations in BUFR (or CREX). Automatic platform manufacturers have to be aware of the BUFR and CREX formats for developing their new systems. Manufacturers of observing systems should be solicited for the development of systems that comply with the migration strategy.

3.5.2 Development and implementation of software to generate BUFR messages (BUFR encoding software) is needed at all places where messages are currently generated in TAC. The software project could take care of the software development itself. However, the specific site implementation would require special attention and work. NMHSs should be encouraged to start special migration projects to implement new encoding software in all operational observation systems, which currently produce TAC.

Need for double dissemination

3.5.3 As some countries begin to migrate to TDCF, double encoding, dual dissemination or translation back to TAC will need to be done to cater for countries not equipped to receive or process BUFR. Data flows and user requirements have to be analysed. So far, satellite data transmitted in BUFR have been used by a limited number of Centres running global numerical models; other users did not need these data. To decide on dual dissemination or not, producers will have to consider their users and analyse requirements for dual dissemination perhaps based on a geographical basis.

National concentration and dissemination on GTS

3.5.4 It may not be practical and cost-effective to encode observations in both TAC and TDCF at observation sites and to send them to a collecting Centre. Observation sites could transmit reports to a concentration site or to their NMC in a format, which could be national or non-standard, TAC, CREX or BUFR. The NMC or concentration site could convert the TAC or national/non-standard format to BUFR or CREX and transmit the observations onto the GTS. During a transition period, observations in TAC could be transmitted in TAC as needed. The NMC or concentration site could convert observations reported in BUFR to TAC and transmit both formats (double-dissemination) if there is a need for non-binary compatible users. Eventually, when all NMCs can understand CREX, double dissemination BUFR and CREX would be preferable. All NMCs should have BUFR decoder and CREX encoder software to perform this conversion. Testing of encoded BUFR or CREX observations with an independent decoder preferably by some other WMO Member will be a pre-requisite before starting to disseminate operationally these observations in TDCF. A WMO Member producing a new bulletin containing observations in BUFR or CREX should notify the Secretariat in

advance of its transmission, in order to pass the information to all other Members. Producers should give warning (through the WMO Secretariat) at least one or two years in advance of the date they will stop the dissemination of observations in TAC or CREX.

Non-automated stations

3.5.5 For the long term, automation should be considered. When contracting with manufacturers of automatic platforms, encoding in BUFR or CREX, not TAC, should be specified. Level 1 training for observers (if still used for entering data) will be required for explaining the new technology and TDCF. An intermediate step could be migration to CREX, which can be handled manually. This should be done if new parameters or new data types have to be transmitted despite manual encoding. This migration would require the training of staff: the observers to encode observations in CREX and the staff at NMCs to understand CREX code coming from their national stations, from the GTS or from other means.

Tasks of WMO Members for conveying TDCF

3.6 Since different centres on the GTS have varying capabilities to accomplish migration, and since message switching directories have to be changed throughout the world, it is recognized that the pace of migration will be different from centre to centre and that completion of the project will take significant time. Since format translation is not a role of an RTH and many RTHs would not have the processing power to be able to do this, dual dissemination should be the primary mechanism utilized for migration. However, some RTHs or Centres may have the capability to do format translation and may decide to convert message formats for their national needs or as regionally agreed. If centres have to convert BUFR messages received from the GTS into character code, it is recommended that they use CREX instead of TAC.

Tasks of WMO Members using TDCF

3.7 To achieve a successful migration, the data users will need decoding software and support for this software early in the process. The Software House can assist centres with this. The NMCs will also have to analyse the possible impacts on data processing resulting from the availability of new BUFR or CREX reports, new parameters and new metadata. Some immediate fixes may be required to maintain operation. Further adjustments to their database management systems and application programs may also be necessary.

3.7.1 As BUFR is the preferred format for the future, manually operated NMCs should seriously consider automation at this time. However, they may consider training manual operators to receive CREX as an interim solution. Training to receive and understand CREX is a relatively simple task. An NMC considering automation should ensure that the data-processing software developed includes universal BUFR and CREX decoders, as well as GRIB 1 and GRIB 2 decoders. Manufacturers of meteorological systems should strive to support these formats in their products.

Use of the Internet

3.7.2 The use of the Internet may help to solve some migration problems. For some NMCs, the Internet could allow earlier access to data in binary formats if they did not have a GTS link or if this data is not available over their GTS link. This assumes that these meteorological observations are made available on the Internet by some GDPS centres in their Web or FTP servers.

Actions by WMO Members — decision makers

3.8 Every WMO Member should:

(a) Define a Migration Contact Point (about 100 Members have nominated one already);
(b) Establish a National Migration to TDCF Steering Group (MTSG);
(c) Identify impacts of migration on national operation;

(d) Produce a national migration plan;
(e) Plan their requests for equipment and software (resources commitment);
(f) Start a national training programme on TDCF;
(g) As needed, modify or replace software used for observation, encoding, data concentration, dissemination systems, input data processing, message switching, decoding, visualisation and archiving;
(h) Evaluate the implications, due to the migration process, on WMO Members' resources for development and operation;
(i) Reserve the budget resources necessary to implement the migration.

Schedule

3.9 The following actions should occur in parallel:

(a) Training (2003 to 2005): organized by WMO and nationally;
(b) Installation of universal BUFR/CREX decoders as soon as possible, if necessary, provided by the Software House, starting the second half of 2003;
(c) **Every country should formulate their own national migration plan, derived from the international plan, with analysis of impacts, costs, solutions, sources of funding (if necessary), national training, technical planning and schedule.**

Code migration schedule

3.9.1 Even if the majority of the GTS Centres could support binary data early on, it would still take a long time for many NMHSs to introduce automated observing systems with the software to encode data in BUFR at the source sites, as well as implement their national telecommunication network capable of handling binary data. Based on a survey of code usage and considering constraints and factors linked to each type of TAC, the TACs have been grouped into six categories that share common characteristics that would allow migration to proceed in parallel. Considering established traditions and various factors (internal or external to the WWW) affecting each of these categories, three target dates have been set. They are: the start of experimental exchange, the start of operational exchange and the end of operational exchange (see the table below).

IV. RECOMMENDATIONS FOR COORDINATION AND REVIEW MECHANISMS

4.1 To ensure minimum impact to Members from the migration to TDCF, an effective mechanism must be put in place to provide implementation monitoring and coordination. It is critical to the process that information on the timing of changes, the availability of data and the identification of both requirements and problems be made available to Members' managers and decision makers as well as to appropriate groups within WMO and other relevant organizations.

4.2 Members should provide national focal points for migration issues, preferably the *National Focal Point for Code Matters*. The national focal point should have direct knowledge of national migration implementation plans. The national focal point would provide coordination with the regional association and other relevant WMO groups as needed regarding national plans for migration, impacts of migration on national operations and status of implementation. The national focal point would define requirements to the Expert Team on Data Representation and Codes for code changes. They would provide notification of planned implementation dates. The national focal point would also provide a channel to make Members aware of activities and critical information from other Members or organizations, such as implementation dates or changes in availability data planned by other Members.

4.3 The regional associations will need to play an active role in the coordination of the migration in their Regions, including the identification of the most effective mechanisms for management and monitoring.

4.4 Central planning and coordination of the migration will be performed by the Open Programme Area Group on Information Systems and Services and its teams. There should be a mechanism for collecting, recording and reporting implementation dates, changes in data availability and any other migration issues which have an extranational impact including information on past and future changes. Technical guidance should be developed in the form of a WMO *Code Migration Guide.*

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) Category 5 codes will need to be reviewed to determine if there is a final requirement to be migrated to BUFR/CREX. If not, they will be moved to category 6. 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.

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

(b) **Start of operational exchange:** data will be made available in BUFR (CREX if needed) whereby some (but not all) Members rely on them operationally. Some distribution of the current alphanumeric codes will still be done;

(c) **Migration complete:** at this date the BUFR (CREX if needed) exchange becomes the standard WMO practice. Distribution of the current alphanumeric codes is terminated. For archiving purposes and where BUFR or CREX exchange still causes problems, the alphanumeric codes may be used on a local or national.

Relevant conditions to be satisfied before experimental exchange may start:

(a) Corresponding BUFR/CREX-tables and templates are available;
(b) Training of exchanging parties has been completed;
(c) Required software of exchanging parties (encoding, decoding, viewing) is implemented.

Relevant conditions to be satisfied before operational exchange may start:

(a) Corresponding BUFR/CREX-tables and templates are fully validated;
(b) Training of all concerned parties has been completed;
(c) ll required software (encoding, decoding, viewing) is operational.