

## Fractional vs integer frame rates in UHD TV standards

### March 2014

#### Introduction

There is general agreement that UHD TV will benefit from a higher frame rate than 60 Hz, due to the enhanced motion rendition which is so critical to picture quality at higher resolutions. Therefore 120 Hz has already been included in the UHD TV1 systems definition, as published in SMPTE ST 2036-1 and recommended by ITU in Rec. BT 2020.

Some broadcasters would like to add 119.88 Hz (120/1.001) to UHD TV standards for easier integration with today's fractional standards. There may be a supposition that conversion back to fractional standards could be achieved via frame drop/insertion, leading to lower complexity (and therefore lower cost) conversion products.

Others would prefer not to include new fractional frame rates in the standard, i.e. only allowing 120 Hz. This allows for easier handling of audio and metadata, and avoids the need for drop-frame timecode and the daily jam.

In this White Paper, we discuss the issues relating to integer and fractional frame rates, not only considering the quality of conversion from 4K UHD TV material at 120 Hz down to today's fractional HD standard (1080 59p), but also looking at issues of timecode, audio and metadata handling.

#### Why support fractional frame rates?

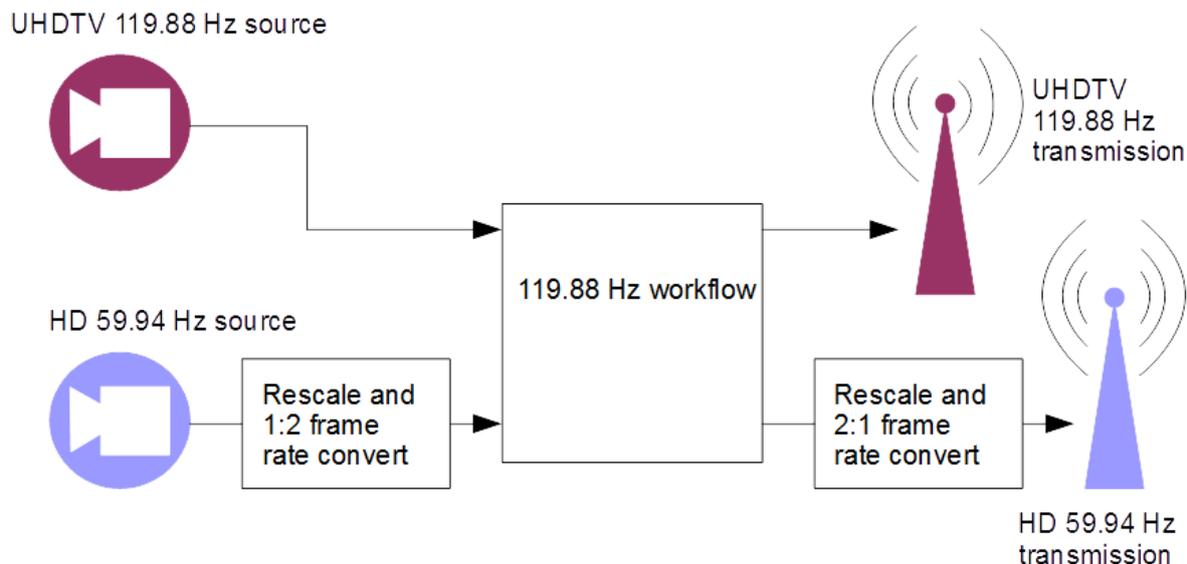
Within the initial report of the SMPTE UHD TV Ecosystem Study Group (<https://www.smpte.org/uhdtv-report>), concern is raised relating to conversion from 120 Hz to fractional 1/1.001 lower frame rates which are allowed for UHD TV1. The report authors argue that sophisticated frame rate conversion methods would be required to minimize motion artifacts. Sophisticated standards conversion products are generally expensive and, due to the complex nature of the conversion process, even the very best converters may occasionally fail to achieve a perfect conversion on very challenging content.

As with all new formats, standards conversion of UHD TV material sourced at 120 Hz will be required to and from current 50 or 59.94 Hz HD systems. High quality conversion is essential since temporal artifacts in frame rate conversion are highly undesirable, and can particularly affect viewer enjoyment of premium content such as live sports and blockbuster movies.

The SMPTE UHD TV study group recognizes that motion compensated frame rate conversion is continuously improving but raises concerns that "current implementations may be significantly challenged by the processing bandwidths required for UHD TV1 images at 120 Hz". Therefore some proponents suggest it may be desirable for the UHD TV1 specification to support 120/1.001 fps. The main argument for this is the assumption that it will enable broadcasters to convert to and from today's HDTV frame rates without temporal artifacts, with minimal latency and at low cost.

Figure 1 shows a possible future workflow, where a broadcaster is managing a mixed HD and UHD TV environment. One scenario is a live UHD TV 119.88 Hz program transmission, where in-field HD 59.94 Hz sources may be arriving from

existing outside broadcast vehicles. Such HD material needs to be upconverted in resolution and frame rate for integration with the 119.88 Hz workflow, where effects, graphics and other processing are carried out. At the point of transmission, downconversion back to HD 59.94 Hz is needed to support today's fractional services. Use of simple up and down conversion processing will clearly benefit this scenario.



**Figure 1 : Hybrid HD 59.94 Hz and UHD TV 119.88 Hz scenario**

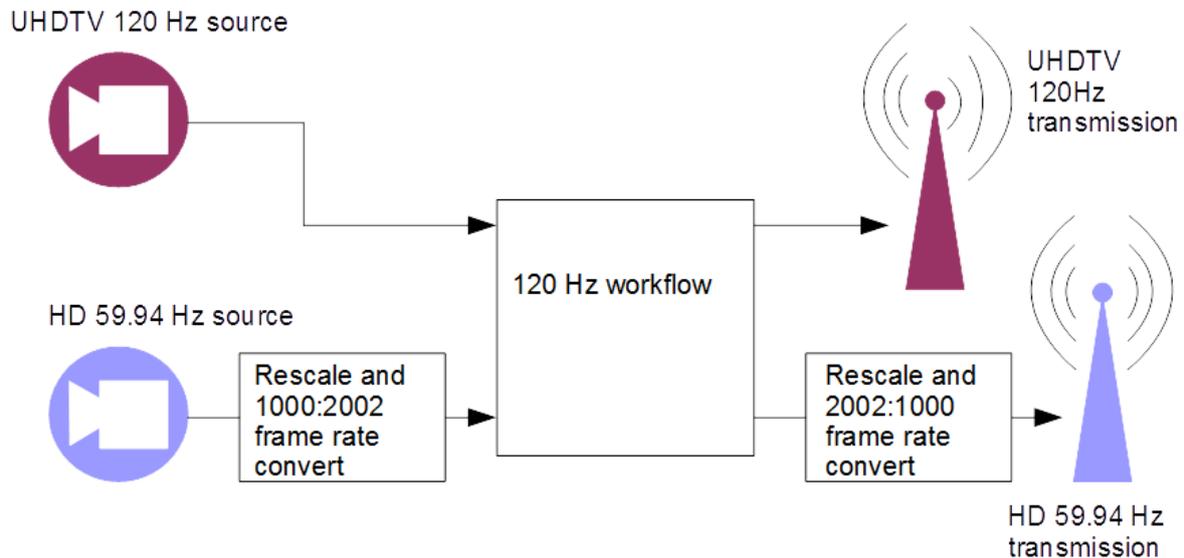
### Why only allow integer frame rates?

Certain industry experts point out that fractional frame rates originated due to issues around the precise frequency of subcarrier in the 1950s. The root cause no longer exists, but a whole industry has been built up around fractional frame-rate workflows. Users persist with a compromise position, where timecode is not consistent for 59.94 and 23.98 Hz content (and many users do not understand drop-frame timecode), and fractional audio resampling is required. There is a certain amount of industry support for the perspective that development of a new standard provides the opportunity to break away from restrictive, legacy concepts which hinder progress into the new world.

For example, leading UHD TV specialist Matthew Goldman, Senior Vice President TV Compression Technology, Ericsson said " I can think of no better time than now - before we create another generation of "new legacy" formats - to define how to convert integer higher frame rates to existing fractional frame rates (i.e. up to 60/1.001) and vice-versa." Although he notes that "...it will not be easy to define the conversions and all the supporting recommended practices." and that although "...there is always some level of pain when technology moves forward...we need to wean ourselves off legacy methods that have little basis for moving forward".

Furthermore, some opinions go one step further, suggesting that support for fractional frame rates themselves have particular costs. After many years developing workarounds and establishing specific workflow practices, users may not directly see the extra costs of products which need additional design work to support fractional

frame rates. Also, since some people refer to 59.94 Hz programming as "60 Hz" (and occasionally, but less often, say 24 Hz when they mean 23.976 Hz), there can be major misunderstandings, especially relating to timecode, which adds to the cost and time for staff training e.g. on drop-frame timecode and the need to reset timecode clocks at midnight since real (wall clock) time and timecode time will drift by around 86 seconds per day if non-drop-frame timecode is used.



**Figure 2 : Hybrid HD 59.94 Hz and UHDTV 120 Hz workflow**

Certain opinions within SMPTE have argued that allowing 120/1.001 into the standard will make conversion to and from today's fractional frame rates easier, but actually this may not be the case, since the difference between a 2:1 and a 2002/1000 conversion is not significant. The possible hybrid HD 59.94 Hz and UHDTV 120 Hz workflow is shown in Figure 2.

A good 2:1 frame rate (up or down) conversion will not just drop or insert frames, so the complexity in going from 120 Hz to 59.94 Hz will be very similar to that of 119.9 Hz to 59.94 Hz, i.e. the difference in cost, latency and complexity between the converters shown in Figures 1 and 2 may not be very great. In fact manufacturers, such as InSync Technology, are developing highly efficient standards conversion methods which could lead to future low cost implementations, allowing broadcasters to realize the benefits of 120 Hz production without sacrificing quality when converting to and from 59.94 Hz.