



# **Memo 62**

## **Report on the final version of the Compliance Matrix**

S. Rawlings  
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Whitepaper design concepts for the Square Kilometre Array (SKA) were first submitted to the International SKA Steering Committee (ISSC) for review in June 2002. These designs were given detailed consideration by both the Engineering Management Team (EMT) and the International Science Advisory Committee (ISAC). The ISAC reported on their consideration to the ISSC on 1st November 2002 (SKA Memo 28). A 'Compliance Matrix' was produced as part of this report. The eighteen rows of this matrix represented the science areas determined to be 'Level 1' (highest priority) at the time of the SKA meeting in Bologna (Jan 2002); the eight columns represented the SKA straw-man design plus the seven design concepts; and the entries in the matrix were graded in five levels of compliance varying from a 'clear no' to a 'clear yes'. The ISAC had originally proposed a three-level grading system which was modified to a five-level system following feedback from the ISSC.

The version of the matrix resulting from this process can be viewed on [http://www-astro.physics.ox.ac.uk/~sr/ska/ska\\_matrix.html](http://www-astro.physics.ox.ac.uk/~sr/ska/ska_matrix.html), which was last modified on 24 March 2003.

This matrix quickly became the subject of vigorous debate inside and outside of SKA meetings. A number of shortcomings of the original analysis were clear, most notably: a lack of uniformity in the grading across the science areas; 'clear no' gradings in cases where some of the key science could be successfully undertaken by the design concept; and genuine misunderstandings by the ISAC of the capabilities of the design concepts.

Despite these shortcomings, the ISAC believes that the original version of the matrix served its main purpose, which was to stimulate modifications to each design concept with the aim of increasing the range of high priority science achievable by each design. The advocates of each design concept submitted revised whitepapers in May 2003 which, in most cases, significantly modified the capabilities of their design (revised white papers can be found on [http://www.skatelescope.org/pages/page\\_astronom.htm](http://www.skatelescope.org/pages/page_astronom.htm)). These have been checked by Peter Hall on behalf of the EMT.

At the SKA meeting in Geraldton (Aug 2003), the ISAC then revisited all of the entries in the compliance matrix. They took account of all known criticisms of the previous version of the matrix, including those written down in the revised whitepapers, those passed on by members of the ISSC, and those given verbally inside and outside of SKA meetings. They also accounted for modifications to the designs as reported in the revised whitepapers. Steve Rawlings (SR) took responsibility for a final 'tweaking' of the grades of each Working Group so as achieve a relatively uniform grading system. Here is what is meant by each grade in the final matrix:

- `clear yes' (yellow), design concept seems able to address essentially all the key scientific goals;
- `probable yes' (light blue), design concept needs minor, but conceptually straightforward, modifications (often simply just more money);
- `clear maybe' (dark blue), design concept has some technological difficulties achieving some of the scientific goals, but looks reasonable for the majority of the programme;
- `possible maybe' (pink), design concept has some technological difficulties that makes achieving most of the scientific goals very difficult, but it can still do some first-rate science in this subject area;
- `clear no' (red), design concept seems intrinsically unable to meet the main scientific goals.

Revised grades were discussed and agreed with Working Group chairs (where present) or their representatives in Geraldton. A revised matrix was then presented by SR at the Geraldton meeting. SR presented a preliminary version of the revised matrix (the version agreed by the ISAC members at Geraldton).

He gave examples of how gradings had altered as the result of criticisms of the original matrix: e.g. Working Group 2 revisiting response time requirements for transient science following verbal criticism of their original grades; and Working Group 2 revisiting the grading of Pulsar Science for the Tiles concept following written criticism of the grading in the revised Whitepaper. He gave examples of how grades had altered as the result of criticisms: e.g. the grades on transient science rising for all the concepts because of a relaxation on constraints for response time, and the pulsar science rising from a `clear no' to a `possible maybe' for the TILES concept because of the recognition that valuable SKA work could be done on pulsars with a low-frequency (only) telescope .

He also gave examples of how grades had altered as the result of modifications to the designs. The clearest examples were systematic increases in grades for the LENSES and CYLINDERS concepts because of modifications to the upper frequency limits in both cases.

SR highlighted the fact that the science case for the SKA is under major review, and that the capabilities now demanded of the `ideal SKA' were changing due to very recent scientific developments. Two examples given were: (i) our changing view of the epoch of reionization (EOR) due to recent results from the WMAP experiment, showing the EOR to be extended in time (redshift) and complex; and (ii) the realization that large-volume galaxy redshift surveys, such as are possible using HI with the SKA, can generate very strong constraints on the properties of the dark energy that is now known to dominate the Universe. The first example gives a stronger requirement for SKA HI sensitivity over a larger range of redshifts, and hence frequencies, than previously thought. The second example gives a much firmer requirement for large instantaneous field-of-view than previously thought. He noted that some science areas, notably the EOR, remained very difficult for all the proposed SKA concepts

He noted, however, that the gross trends in the revised matrix looked similar to those reported, and commented on, previously by the ISAC. Specifically, the dichotomy

between concepts capable of very-high-frequency (>20 GHz) science, and those capable of very wide fields of view and/or multi-fielding remains. He noted that the generally high grades for the revised CYLINDERS concept reflected the fact that, to some extent, this is starting to look a little like a hybrid solution to this problem.

He concluded by reminding the audience that the ISAC were now in the process of revising the science case, and focussing in particular on identifying the 'level 0' (truly most fundamental and unique) science. Whatever replaces the matrix analysis will certainly give high weight to this smaller number of key science topics. He also emphasised that the next round of comparisons between science aims and design concepts would require more sophisticated measures of design capabilities (e.g. A/Tsys as a function of frequency). Ideally scientific simulations would be fed through technical simulations (e.g. at Swinburne University of Technology) to give well defined figures of merit for each design concept as a function of science goal.

Since Geraldton, the preliminary version of the revised matrix has received scrutiny by the full ISAC, a few minor changes have been made (from the version shown by SR at Geraldton), and the final version is available at [http://www-astro.physics.ox.ac.uk/~sr/ska/ska\\_fmatrix.html](http://www-astro.physics.ox.ac.uk/~sr/ska/ska_fmatrix.html).

Another change in the revised version of this matrix is that links to very detailed sub-Web-pages, giving more details of the reasons for the grades, have been removed (although the old versions of these are still linked from the original version of the matrix). These have been replaced by commentaries, given below, on the reasons for the grades for each concept. This should be an easier way of seeing the reasoning behind the ISAC's grades.

One final point concerns the disparate costs of the concepts (e.g. it is not clear that the CYLINDERS concept can go to a higher frequency than the LENSES concept at fixed cost). This has only a small impact on the grades as, in gross terms, it potentially influences only the two upper grades on the scale.

### ***Commentaries on the ISAC grades of each design concept***

Note first that all concepts are graded 'Possible Maybe' for 'EOR' and 'CMES' because of the difficulties associated with observing at very low frequencies (and, for 'EOR', of putting sufficient collecting area in a compact core).

#### **KARST Concept:**

Fails on 'Inner AGN' because very long baselines are essential. Fails on 'PPS', 'IGM T' and 'Geodesy' because all require very high frequencies. 'Possible Maybe' in most other areas: principally because of high-frequency limit (Galactic NT+B, CO, SS bodies, Spacecraft Tracking), lack of long baselines (Transients, Pulsars, Continuum surveys), slow response times (SETI), problems with UV coverage (IGM NT, Galactic HI; 'Clear maybe' for HI surveys (mapping speed low) and high-z AGN (lack of long baselines and UV coverage issues).

## **TILES Concept:**

Fails on `Galactic NT+B, `CO' `PPS', `IGM T', `Geodesy' and `Spacecraft Tracking' because all require high frequencies. `Possible Maybe' in many other areas: principally because of high-frequency limit (Transients, Pulsars, SETI, Inner AGN, SS bodies, IGM NT). `Clear Maybe' for continuum surveys (high-frequency limit).

## **Preloaded Concept:**

`Possible Maybe' for `CO', `PPS', `SS bodies' because of high-frequency limit.  
`Clear Maybe' for `Transients', `Pulsars', `SETI' (response time and frequency limit),  
`Inner AGN', `IGM T', `Spacecraft Tracking' and `Geodesy' (frequency limit).

## **Lenses Concept:**

`Possible Maybe' for `CO', `PPS', `SS bodies', `Spacecraft Tracking' because of high-frequency limit. `Clear Maybe' for `Transients', `Pulsars', `SETI' (response time and frequency limit), `Inner AGN', `IGM T' and `Geodesy' (frequency limit).

## **Cylinders Concept:**

`Clear Maybe' for `PPS', `SS bodies', `Spacecraft Tracking' (frequency limit).

## **LNSD Concept:**

Nothing further to report.

## **LAR Concept:**

`Clear Maybe' for `Inner AGN' (need for many sub-arrays) and `Spacecraft Tracking' (high-frequency limit).

## ***Final Word***

The ISAC wishes to emphasise that the dynamic nature of astrophysics means that the science areas of highest priority change with time. The ISAC is currently undertaking a major review of scientific priorities which will not be complete until October 2004. At this point it will probably be sensible to make another study of compliance, although it is not yet clear what form that analysis should take.