Commonwealth Department of Health and Aged Care

Measuring Remoteness: Accessibility/Remoteness Index of Australia (ARIA)

Revised Edition

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1 Foreword

The Accessibility/Remoteness Index of Australia (ARIA) project was sponsored by the Department of Health and Aged Care as an attempt to develop a standard classification and index of remoteness for the whole of the country. The Index and Classification supersedes the Rural, Remote & Metropolitan Areas classification (RRMA) produced in conjunction with the Department of Primary Industry and Energy (DPIE) in 1994 for Departmental use.

This Occasional Paper is an updated version of an earlier Occasional Paper (New Series No. 6) of the same title released in August 1999.

The major changes contained in this updated paper are:

- This paper contains updated information on recent and future developments relating to the ARIA index, including the increased availability of ARIA data via the Department's Internet site.
- ARIA scores for 1999 Statistical Local Areas (SLAs) are included in an appendix to assist users who have moved to using more recent versions of the Australian Bureau of Statistics (ABS) Australian Standard Geographic Classification (ASGC).
- ARIA scores for 1996 and 1999 SLAs contained in appendices of this publication now include the minimum and maximum ARIA point value within each SLA. This gives users a better understanding of the diversity of an area and may assist in deciding whether the SLA level is an appropriate level of analysis (or whether users might want to use ARIA at a different level of geography - such as localities).
- There is a new appendix containing Frequently Asked Questions and answers to them.
- There is a new appendix discussing how users of the earlier RRMA classification can apply the main RRMA categories to 1996 SLAs. RRMA category codes for 1996 SLAs are included in the separate appendix that contains ARIA scores.

The ARIA classification has been widely accepted by a variety of users since its release in 1999. The ABS will incorporate categories of remoteness based on ARIA into the 2001 edition of the ASGC. As a result, the ABS will be including ARIA related scores as part of the 2001 Census data releases. The ARIA framework has also been used as the basis of the development of alternative indexes. Within the Department of Health and Aged Care, a GPARIA index was developed for all localities to assist in determining retention payments for General Practitioners (GPs) living in non-metropolitan areas. For GPARIA a different basket of services was used to define categories of service centres. Similarly, a PHARIA index was developed for retention payments for pharmacies in rural and regional areas.

This paper contains details of ARIA Service centres (Appendix C); various colour maps of ARIA scores and categories (Appendix D); a listing of ARIA scores (including minimum and maximum ARIA point values) for 1996 SLAs (Appendix E); and listing of ARIA scores for 1999 SLAs (Appendix F).

This publication is available from the Department's Internet site (http://www.health.gov.au/ari/aria.htm). The website contains searchable databases that allow users to search for an ARIA score either by a locality name, SLA name or ABS Postal Area Code (similar to postcodes). The website also contains a range of other information that can be downloaded separately, including colour maps and files containing ARIA data by localities, SLAs and postcodes.

2 Acknowledgments

The Commonwealth Department of Health and Aged Care funded this work and Lyle Dunne co-ordinated the original project on behalf of the Department.

The National Key Centre for Social Applications of Geographical Information Systems (GISCA) developed the methodology for measuring remoteness. In particular, staff from GISCA who worked on the project included Graeme Hugo, Errol Bamford, Danielle Taylor, John Badcock, David Letch, Rachel Aylward, Marcus Blake, Matthew Donaldson, and Darren Holliday.

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- Dr Ben Ewald (Central Australian Division of General Practice).

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3 Summary

In order to systematically tailor services to meet the needs of Australians living in regional Australia, ‘remoteness’ (identified with lack of accessibility to services regarded as normal in metropolitan areas) needs to be defined.

In 1996-97, the National Key Centre for Social Applications of Geographical Information Systems (GISCA) was commissioned to assist with a number of aspects of the ABS review of the Australian Standard Geographical Classification (ASGC). This review included investigating the measuring of remoteness in a more or less objective way. They recommended applying Geographic Information System (GIS) techniques to do so.

ABS did not proceed with defining remoteness as suggested at that stage in the review of the ASGC. The Department of Health and Aged Care commissioned GISCA to work with them (under a steering committee of user Departments and the ABS) to develop a GIS methodology to produce a remoteness index and associated classification, along with a database of road, locality and service information.

The resulting Accessibility/Remoteness Index for Australia (ARIA) was designed to be **comprehensive**, sufficiently **detailed,** as **simple** as possible, **transparent, defensible**, and **stable** over time - and to make sense ‘on the ground’.

ARIA was also designed to be an unambiguously geographical approach to defining remoteness. That is socio-economic, urban/rural and population size factors are not considered for incorporation into the measure.

ARIA calculates remoteness as accessibility to some 201 service centres based on road distances. Remoteness values for 11,340 populated localities are derived from the road distance to service centres in four categories (a weighting factor is applied for islands).

Remoteness values for each populated locality are then interpolated to a 1 km grid that covers the whole of Australia and averages calculated for larger areas.

To create an associated classification, ARIA values are grouped into five categories using ‘natural breaks’ in the 0 – 12 continuous variable:

1. **Highly Accessible** (ARIA score 0 - 1.84) - relatively unrestricted accessibility to a wide range of goods and services and opportunities for social interaction.
2. **Accessible** (ARIA score >1.84 - 3.51) - some restrictions to accessibility of some goods, services and opportunities for social interaction.
3. **Moderately Accessible** (ARIA score >3.51 -5.80) - significantly restricted accessibility of goods, services and opportunities for social interaction.
4. **Remote** (ARIA score >5.80 - 9.08) - very restricted accessibility of goods, services and opportunities for social interaction.
5. **Very Remote** (ARIA score >9.08 - 12) - very little accessibility of goods, services and opportunities for social interaction.

4 Project Outputs

The project outputs were:

- A GIS database containing road, locality and service information that can be used to calculate a remoteness index for anywhere in Australia;
- A GIS methodology to measure remoteness (as a continuous variable);
- An index of remoteness and an associated classification of remoteness based on the ARIA values;
- Remoteness values at Census Collection District (CCD), SLA and postcode levels; and
- Remoteness maps of Australia at the CCD, postcode and SLA levels.

5 Background

There has been an increasing concern over a number of years about the difficulties faced by Australians living in rural and remote areas in accessing services that most Australians take for granted. Government in particular has sought to appreciate circumstances and needs of people living in regional Australia and to target programs accordingly.

However, the concept of remoteness itself has lacked precision. It is clear that central to most people's understanding of the concept is distance, for example:

> *Remote: …Far away, far off, distant from some place, thing or person; removed, set apart…*[1]

For the purposes of the project the concept of 'remoteness' had to be refined to the extent that it could be quantified, as a necessary step to identifying and responding to the needs of people living outside metropolitan areas. With access to an objective measure of 'remoteness', services can more easily be designed and targeted to address priority areas of need.

Effort has focussed on disadvantage in terms of accessible services, especially those routinely available to people in metropolitan areas. Remoteness has largely come to be identified with lack of accessibility[2] to services.

The Overview of the 1994 *Rural, Remote & Metropolitan Areas classification* (RRMA)[3] publication commenced with the words:

> *This classification has been developed in response to the growing need for knowledge and information about issues of concern to rural and remote Australia.* [p1]

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[1] Shorter Oxford Dictionary.

[2] The term "accessibility" is generally used rather than "access", as the approach has been to consider the extent to which services are *able* to be accessed, rather than the extent to which people are *actually* accessing them.

[3] DPIE/HSH, Nov 1994; described in detail below.

The RRMA has itself been used as the basis for a number of government programs targeted at ‘Rural and Remote’ Australians, in several Commonwealth Agencies. The Classification has also formed the basis for building up the information base in this area, notably in the recent Australian Institute of Health and Welfare (AIHW) publication *Health in Rural and Remote Australia*. In the process, however, it has become apparent that there is a need for a formal national standard, which would take advantage of the significant increases in the availability of data and computing power and could be used in the production of official statistics.

The RRMA and other classifications treated the terms ‘remote’, ‘rural’, ‘urban’, and ‘metropolitan’ as values of a single categorical (or ordinal) variable. The ARIA approach, by contrast, has been to isolate the concept of ‘pure’ remoteness as a continuous variable measured in terms of accessibility, based on road distances.

ARIA is a culmination of effort over a number of years directed toward quantifying remoteness, to serve as both an analytical and a policy tool.

5.1 Previous Approaches to Measuring Remoteness in Australia

Earlier classifications of non-metropolitan areas in Australia were carried out largely on the basis of the related variables of population density, intensity of land use and habitability. However, in the 1980s there emerged an emphasis on attempting to subdivide the non-metropolitan parts of Australia on the basis of their degree of *‘remoteness’*. This reflected recognition of the locational disadvantage suffered by Australians residing in areas of low accessibility to services, and the need to embrace different types and standards of government service provision in response to these barriers. Accordingly a number of attempts were made, mostly by Commonwealth agencies, to recognise and delimit zones of remoteness in Australia. These are described below.

5.1.1 Faulkner and French

One of the major early attempts to develop an Index of Remoteness for non-metropolitan Australia was that of Faulkner and French (1983). Their methodology involved the following components:

- Six levels of the urban hierarchy in Australia were identified according to population size.
- A grid was laid over the map of Australia, producing 702 squares. The distance from the centre of each square was then measured to the nearest urban centre at each of the six levels of the hierarchy. These distances were combined into a single figure and standardised using *z* scores[4] to obtain a relative measure of accessibility.
- Contours of remoteness were plotted from the indices for the 702 grid squares.

[4] *z* scores are calculated by subtracting the mean from the raw score and dividing by the standard deviation. This produces distributions with a common mean (0) and standard deviation (1), which when summed will contribute equally to the variance of the total.

5.1.2 Rural, Remote & Metropolitan Areas classification (RRMA)

The next major attempt to generate an index of remoteness was the RRMA, undertaken by the then Department of Primary Industries and Energy and Department of Human Services and Health (1994). This involved the following elements:

- SLAs formed the basic building blocks of the index.
- An index of remoteness was calculated for each SLA. The index was calculated in a similar way to the Faulkner and French approach, but used only four levels of the urban hierarchy, and a 'personal distance' factor to reflect population density.
- Distance was measured from the centroid of the SLA to the nearest centre in each of the four levels of the urban hierarchy.
- The most distinctive feature of this classification was the recognition of a separation of 'rural' and 'remote' zones, each of which was subdivided into other sub-categories.

The RRMA has been criticised on the following grounds:

- The use of the SLA as the basic building block is flawed because of the large and varying size and great heterogeneity of those units.
- The urban hierarchy categories group highly dissimilar centres.
- There are anomalies in the classification obtained using the technique, largely arising from combination of population size with access measures.
- The personal distance measure is problematical.
- The simple straight-line distance measure does not capture all of the dimensions of accessibility.

5.1.3 Griffith Service Access Frame (GSAF)

Griffith has proposed one of the most detailed methodologies to develop an index of accessibility, which he designates the Griffith Service Access Frame (GSAF). This approach uses CCDs as its basic unit - a definite improvement over other methods based on SLAs. Griffith's index comprises:

- The distance measured in time and cost terms from a CCD to a service centre, in turn hierarchically ranked for particular services (e.g. for access to tertiary education, this may be a centre of at least 20,000 people); and
- The Index of Economic Resources, one of the ABS Socio-Economic Indexes for Areas (SEIFA) indices, of the CCD.

All CCDs are given a score and categories are derived using disjoint cluster analysis.

The Griffith approach allows CCDs to be grouped into zones of relative access (ZORAs) in relation to a particular service. He has applied the methodology to establishing levels of accessibility to education services in non-metropolitan areas in the Northern Territory, Queensland, Western Australia and South Australia.

5.2 Approaches to Conceptualising Remoteness

In conceptualising remoteness there appear to be two quite different approaches:

- A geographical approach which defines remoteness in terms of environmental parameters influencing access. Remoteness is defined in terms of the physical distance separating the base spatial unit (e.g. Localities, SLAs, and CCDs) from nodes of activity. The major focus is on how distance restricts opportunities for interaction.
- A sociological approach, which concentrates upon how perceptual, behavioural and socio-economic characteristics of inhabitants of an area impinge upon accessibility to services.

While it is clear that socioeconomic disadvantage can greatly exacerbate locational disadvantage, in a general classification system it was considered to be preferable to adopt an unambiguously geographical approach to defining remoteness, for the following reasons:

- Including locational and socio-economic disadvantage in a single measure of remoteness means that one can never be sure of the extent to which an area is locationally disadvantaged verses the extent to which it is socio-economically disadvantaged. This would create difficulties in developing appropriate programs to overcome or ameliorate the disadvantage. Faulkner and French make a similar point in opting for a geographical approach to defining remoteness. They argue that incorporating other elements:

  > *… would only cause confusion because it fails to discriminate between, for instance, areas on the fringe of the metropolis occupied by transport disadvantaged people and others in areas where inaccessibility is more attributable to scarcity of settlement and long distances to major urban centre.*

- There is also a danger of the 'ecological fallacy' influencing policy if there is ambiguity about whether locational or socio-economic elements have more effect on accessibility in a particular area. Different people in the same location can experience different degrees of service accessibility according to their income, personal mobility, attitudes, the services they perceive as most required etc. Hence appropriate policy interventions to deal with remoteness should first identify geographically remote areas, then target interventions to the most appropriate and disadvantaged groups within those areas (i.e. adopt a two-stage approach).
- It is also necessary to separate the variables in order to investigate their relationship, that is, the extent to which physical remoteness goes hand in hand with socio-economic status.

The point here is not that socio-economic factors should not be taken into account in studies of accessibility to services. Indeed, they should be taken into account in such studies. However, it would seem that a general index or classification of remoteness would be more suitable for a wide variety of applications if unambiguously based on the distance people from an area have to travel to access services. Since it is recognised that people will differ in their ability to meet these costs, program interventions should target groups as well as areas.

For the purposes of establishing such a general index of remoteness, then, it would seem most appropriate to use a geographical basis for defining remoteness, as used by Faulkner and French and in RRMA. The former accordingly defined remote communities as:

> *… spatially defined communities which are distant from urban centres where supplies of goods and services, and opportunities for social interaction are concentrated.*

Thus regions with urban centres may still be remote if the range of goods and services available at those centres is limited and the region is distant from larger urban centres.

Hence the ARIA model was developed on the basis of a geographical approach.

5.3 Australian Standard Geographical Classification Review

In 1996-97, the ABS undertook a comprehensive review of the ASGC. The ASGC is the standard geographical classification structure that guides all government and many private data collection and publication exercises. The ASGC consists of several classification hierarchies, each based on building blocks of either CCDs or SLAs. The principal hierarchy had existed for a long time, and there were suggestions that the structure (a hierarchy with SLAs, based on Local Government Areas, aggregated to Statistical Subdivisions, Divisions and States/Territories) no longer met the needs of a changing society and economy. There had been considerable changes in personal mobility, types of work undertaken, and lifestyles since the original ASGC was developed.

The ABS established an internal group to undertake the review, and it produced a report that suggested considerable change to the system. Among the group's recommendations were that the SLA be abandoned as a basic unit in the system because:

- It varies greatly in size and homogeneity;
- Its boundaries change significantly, especially so in the 1990s; and
- In many cases it does not constitute a community of interest.

The National Key Centre for the Social Applications of Geographical Information Systems at the University of Adelaide (GISCA) was commissioned by the ABS to assist the review in the following areas:

- Criteria used to delineate urban areas;

- Criteria used to describe remoteness; and
- Advice on other classificatory systems in the new ASGC and their conceptual basis.

This work was completed in May 1997, with GISCA publishing a substantial report.[5] One of its recommendations was to develop methodologies, using GIS techniques, to measure remoteness in Australia.

The ABS subsequently decided not to proceed with many of the recommended changes to the ASGC (including defining remoteness, and changes to the SLA structure).

5.4 Commencement of the ARIA project

Work in the then Department of Health and Family Services on updating the RRMA had been deferred in anticipation of the ABS producing a definitive standard measure of remoteness. Following the ABS decision not to proceed with this, the Department decided, rather than simply recalculating the RRMA using 1996 Census data, to approach GISCA with a view to their undertaking a remoteness project.

This project would build on the approach taken in the RRMA. However, it would also take advantage of the capabilities of GIS technology and greater data availability to address some of the concerns that had arisen, and allow validation of some apparently arbitrary aspects (such as the number and weighting of component variables). In order to maximise the likelihood of the outcome being accepted as a national standard, a steering committee for the project was set up comprising representatives of the main user Departments, as well as the ABS.

6 Basic Approach

6.1 Overview and terminology

ARIA (Accessibility/Remoteness Index for Australia) measures remoteness in terms of access along the road network from 11,340 populated localities to four categories of service centres. Localities that are most remote have least access to service centres; those that are least remote have most access to service centres. Consequently these terms are used to refer to the ends of the ARIA continuum.

ARIA is intended as a strictly geographic measure of remoteness and the term ‘rural’ was avoided because this has a specific use as a section of state in the ASGC. ARIA values are calculated initially for populated localities. These values are then interpolated to a 1 km grid spanning the whole of Australia, and averages calculated for larger areas - so that each areal unit (populated locality, grid cell, CCD, SLA and postcode) has an ARIA value.

[5] See eg GISCA Monograph Series 3 *Rethinking the ASGC: Some Conceptual and Practical Issues* (Hugo 1997).

Populated Localities refer to the primary areas being classified; these are based on the AUSLIG 'Populated Centres', but the term has been changed slightly to avoid confusion with 'urban centres' (as defined by ABS), which are the source of services. If one thinks of ARIA as based on the distances people have to travel to obtain services, then populated localities are where they are coming from, and service centres are where they are going to.

Service Centres are ABS-defined Urban Centres with a population of 5,000 or more as at the 1996 Census. The 201 service centres are in fact a subset of the 11,340 populated localities (see Appendix C for a list of the service centres).

Urban Centre, Census Collection Districts, and **Statistical Local Areas** are standard ABS ASGC administrative units. Details can be obtained from the annual ABS publication *Australian Standard Geographical Classification* (Cat. no. 1216.0).

Although ARIA covers all Australia, the principal focus of the project was to measure access to services in non-metropolitan areas. This is not to deny the importance of service-access issues within major urban areas. However, to analyse accessibility within these major urban areas would require a more detailed data set than that used in this project. The ARIA index does, however, provide a value for all areas in Australia, including all metropolitan and urban centres.

6.2 Aims

If the index and classifications based on these values were to be accepted as national standards, it was considered that the approach would need to be:

- Comprehensive, dealing with all non-metropolitan areas of Australia without producing anomalous results or the need for artificial adjustments;
- Sufficiently detailed (in terms of level of application) to avoid anomalies arising from aggregating heterogeneous areas;
- As simple as possible, given the computational requirements arising from the above, that is, avoiding methodological refinements that made little difference to the outcome;
- Transparent and defensible—not a 'black box';
- Intuitively plausible in its results—it should make sense 'on the ground'; and
- As far as possible, without compromising the above, stable over time: the remoteness score of an area should change if and only if it becomes more or less remote (for example, a nearby population centre grows or shrinks significantly), not simply due to administrative boundary changes.

6.3 Assumptions

The fundamental assumptions underlying the ARIA, RRMA, and the earlier work by Faulkner and French can be summarised as:

> *… remoteness can be interpreted as access to a range of services, some of which are available in smaller and others only in larger centres; the remoteness of a location can thus be measured in terms of how far one has to travel to centres of various sizes.*

Remoteness is thus seen as a geographic variable, a characteristic of places rather than directly of populations.

6.3.1 Population size as a proxy for service availability

The assumption that the range of services available from an urban centre depends on its population underlay the whole approach of developing a *standard* geographical classification. However, little empirical validation of this assumption had been undertaken.

To test this assumption, a database of populated localities was constructed, containing service and population information.

Services information was obtained from Desk Top Mapping Services Pty Ltd. This information is obtained from Telstra White Pages and Yellow Pages, as well as the Universal Business Directory. Services were grouped into 20 categories on the basis of Australian and New Zealand Standard Industrial Classification (ANZSIC) industry codes.

While these data have some limitations that would constrain their usefulness as a source of data on specific services or locations (coverage, duplications, lack of classificatory rigour), they were considered sufficiently accurate for a generic validation of these assumptions.

Population data were obtained from the ABS based on the 1996 Census of Population and Housing.

Analysis showed that there was a limited relationship between population size and the availability of many commercial services. However, there was quite a strong relationship between population size and availability of services such as health and education, where government had a role in provision, funding or planning. Additionally, there appeared to be distinct categories of centres clustered in particular population ranges, with natural breaks in the population distribution.

6.3.2 Road distance as an access indicator

Other attempts at classifying remoteness have looked at access to services as part of a broad measure of socio-economic disadvantage, or attempted to identify the number of services within a given time or distance radius.

The latter approach would provide a good measure of access to a range of services, and hence the level of choice available in a given area. In the Australian context, however, while choice is undoubtedly important (at least for some service types), it is less important than having minimum access to at least some services. Access to a second service of a given type is therefore considered by most Australians as much less important than access to the first.

It would be difficult to combine the approach of including distances to centres of various sizes—seen as an essential element of a multipurpose or standard classification—with consideration of multiple centres in each category. Further, to do so would certainly violate the aim of simplicity, both in theory and practice. Accordingly this study, like the RRMA, has focussed on *minimum* distance to centres in various categories (this does to some extent cover the choice aspect, since larger centres would have more services of a given type).

Outside metropolitan Australia, road transport is the predominant way of getting around. It is true that not everyone has access to private motor vehicles; however the function of ARIA is to provide a measure of the accessibility of an area, not to provide a complete picture for individuals. Public transport is also most commonly road-based (buses).

While air transport is increasingly relevant to delivery of some services, it is generally an exceptional rather than the principal mode of access. The case of areas which have no road access to some or all categories of service centre is covered under 7.4.3 'Special cases: Islands' below.

6.3.3 Greater subsumes less

It is assumed services available at smaller centres are also available at larger centres, so that if a populated locality is close enough to a larger centre, distances to other smaller centres cease to have an effect on its access to services and hence remoteness. This has a bearing on the calculation of minimum road distances, the basic measurements underlying ARIA.

7 ARIA Methodology

7.1 Summary

The ARIA methodology uses GIS capabilities to produce a continuous variable with values between 0 and 12, where 0 indicates areas of highest accessibility and 12 indicates areas of highest remoteness.

The basic spatial unit for which remoteness was measured was the populated locality, derived from AUSLIG's 1:250,000 topographical series. The finer resolution offered by using populated localities (11,340 locations) as the basic spatial unit for the calculation of ARIA values overcame the problems of internal heterogeneity in the large SLAs, postcodes and even CCDs in much of non-metropolitan Australia.

GIS network analysis was used to calculate actual distance travelled by road (rather than straight-line distance, as in RRMA) from each of the populated localities to each of the service centres (201 centres). This avoided anomalies in areas where natural barriers (mountains or waterways) constrained access to population centres.

An ARIA value was then calculated for each of the populated localities.

(Although it provides benefits in accuracy even at the SLA level, calculating the index at the locality level allows users to gain the full benefit of the additional precision of using road distances.)

The ARIA values from the localities were then interpolated on to a 1 km grid covering the whole of Australia. From this grid ARIA values were aggregated to the standard units of CCD, SLA and postcode. However, ARIA could be aggregated up to any administrative unit and a remoteness value can be calculated for that unit, allowing remoteness to be assessed and combined with other data items more flexibly.

7.2 Establishment of GIS database

To calculate the index values, a GIS database (based on the populated localities database referred to above) was constructed, containing:

- Service information;
- Road network;
- CCD, SLA and postcode boundaries; and
- Population data.

The road network and populated localities were obtained from AUSLIG using their comprehensive 1:250,000 topographic data set.

Services information was obtained from Desk Top Mapping Services Pty Ltd, as described above.

Census Collection District boundaries, Statistical Local Area boundaries, postcode boundaries (CCD-derived) and population data were obtained from the ABS.

7.3 Service centres

The relationship of population to service delivery was analysed for populated localities. On the basis of this analysis, all populated localities with a population of greater than 5,000 (designated ‘service centres’) were grouped into categories.

The four categories were:

A. more than 250,000 persons

B. 48,000 to 249,999 persons

C. 18,000 to 47,999 persons

D. 5,000 to 17,999 persons

7.4 Distance calculations

Distances from each of the populated localities to all of the service centres were calculated using the road transport network. (Although it would only be necessary to measure the distance from each locality to the nearest service centre in each category, all possible distances were calculated, allowing maximum flexibility in developing the index and classification).

7.4.1 Road type

The distance measures did not take into account the type of road. It was felt that there was no clear quantifiable relationship between road type and travel time. Road quality could be subject to short-term variation; and any detailed analysis incorporating road type would be unlikely to affect the outcome materially (unless, of course, roads become impassable- as occurs in the wet season in northern Australia).

7.4.2 Distances within service centres

The methodology used treats services as located at the GPO of each of the service centres. As well as being a practical necessity, this makes little difference to access measures for people living outside service centres.

For people living *within* service centres, however, their road distance to the GPO may have little bearing on service accessibility. Further, public transport would need to be considered.

Accordingly, distances within service centres (based on ABS-defined urban centre boundaries) were disregarded in the calculation of the index (although there is undoubtedly scope for productive studies of intra-urban service access issues). Where a populated locality was within a service centre in the relevant category, it was assigned a distance value of zero for that category.

7.4.3 Special cases: Islands

The separation of islands from the mainland road network resulted in most islands, with the exception of Tasmania, having no road distance measurements for any of the distance class categories. Tasmania had values for all but the level A category. Two methods to assign distance values to island localities were developed to deal with this problem, one for Tasmania, and one for all other islands with identified localities.

The frequency of major airline travel to Tasmania, and the existence of distance measurements for all but Class A distance categories, made it distinct from other islands. The method used to calculate remoteness for Tasmania used the Class B distances, calculated to Hobart and Launceston, and added a factor that would account for the distance and cost of travel between these centres and Melbourne, the closest Class A centre. That factor was 500 km.

The calculation of distance measurements for other islands with identified localities was decided after careful consideration of several different methods. The method that was considered most appropriate was a graduated weighted distance rule. The rule was based on the assumptions that:

- All islands separated from the mainland (that is, without bridges) were more remote than any point on the mainland equally distant from urban centres; and
- The additional cost (financial, time or other) of travelling from an island to the mainland would initially be high and then taper off as the distance travelled increased, although the cost of travel would always be higher than the cost of road travel.

Thus a weighted distance measure was developed to reflect the additional cost of travelling from an island locality. **Table 1** shows the graduated weights that were used. The weights were applied to the distance measurement from the centroid of island localities to the closest mainland point. The island locality point or points would then assume the distance values of that closest point with the addition of the weighted distance measurement.

Table 1: Graduated weighted distance used for islands.

Distance (km)	Weight
0-10	10
>10-20	5
>20-50	3
>50	2

7.4.4 Calculation of minimum distances

The minimum distance from each populated location to the nearest service centre in each of the four categories was extracted from the base distance measurements. This gave four measurements per locality, each representing the minimum distance to a service centre in a particular category (populated localities within a service centre in the relevant category were given a distance value of zero for that category, as described above).

This was further adjusted by substitution of minimum distance to larger centres for minimum distance to smaller centres where the former was less (see section 6.3.3). It was assumed that if a location was closer to, say, a Category B Centre of 100,000 than the nearest Category C Centre of 30,000, then services which would otherwise be provided by Category C Centre would instead be obtained from the closer Category B Centre.

Each measurement recorded the origin and the destination locality and the distance.

Figure 1 (Appendix D); shows the populated localities, service centres, and major road network.

Statistics for the mean and standard deviation were calculated for distances to each of the four categories. **Table 2** shows these values.

Table 2: Average Distance Statistics for Australia (km)

Category	Mean	Maximum	Minimum	SD
A	413	3554	0	519
B	239	2058	0	286
C	139	1867	0	197
D	88	1195	0	138

7.5 Combining distance scores

Clearly the four index values cannot be simply summed, or else Category A distances would overwhelm the effect of other distance variables.

RRMA combined ‘standardised’ scores (i.e. converted to a common mean and standard deviation). However, while this approach would be valid for normally distributed variables, the ARIA values are strongly skewed, with many localities clustered close to service centres, and smaller numbers at greater distances.

Accordingly, it was decided to convert each distance to the form of a ratio to the mean (i.e. divide by the mean for that distance category) in an attempt to standardise the distance values across each of the four levels.

7.5.1 Ratio calculation

The ratio of the minimum distance to each of the four service centre levels to the mean was calculated for each of the 11,340 populated locations. Distances for localities *within* service centres in the relevant category were then set to zero (see section 7.4.2.)

7.5.2 Use of threshold

Even with the scores converted to ratios to the mean, in some cases the distance to the nearest service centre in a particular category (for example, from parts of the NT to Adelaide, the nearest Category A centre) still overwhelmed the effect of distance to centres at other levels. It seemed intuitively that, at least beyond a certain point, the relationship between distance and remoteness was no longer linear. (This could perhaps have been addressed by converting each of the distance factors to a logarithmic scale, but this would have added greatly to the complexity of the computation, and militated against transparency).

To remove the effects of extreme values from the index, therefore, a threshold was applied. That is, all localities beyond a threshold distance from a category of centre were to be considered ‘remote’ in terms of access to that category, and given a value for that category equal to the threshold value. It was decided that, for simplicity, the threshold should be expressed as an integral multiple of the average distance for a category, representing smaller distances for smaller centres, as people would be prepared to travel farther to larger centres.

However, the threshold ratio could not be set too low. An important requirement of ARIA was to distinguish as much as possible between the most remote areas in terms of access to services. A threshold ratio less than 3 would have meant, for example, that the number of localities with the maximum ARIA value (which could therefore not be differentiated in terms of remoteness) would increase.

Accordingly, a threshold ratio of 3 was chosen. Three times the mean distance to a category A service centre (1,239 km) also seemed a reasonable maximum distance for a person to travel to such a centre in a long day's drive. The ratio of 3 yields a maximum distance of 717 km to category B, 417 km to category C, and 264 km to category D centres.

The use of the threshold resulted in the threshold-limited ratios ranging from 0 to 3.0 for each of the four categories, making them more comparable than the previous simple ratio approach.

7.5.3 Combining ratios

RRMA used differential weightings designed to approximate the equal weights given to a slightly different classification of urban-centre size categories in Faulkner and French. There was no obvious reason why differential weights should be applied to the ARIA ratio values.

Accordingly, in the interests of simplicity and transparency, a single remoteness measurement for each populated location was calculated by the unweighted addition of the four (threshold-limited) ratio values for each of the four levels of centre.

This gave a continuous variable with values of between 0 and 12 as the measure for remoteness.

Maps showing the remoteness values for all populated localities, using a threshold of 3 for each of the four levels of service centre are available from Health and Aged Care's Internet site (http://www.health.gov.au/ari/aria.htm) **Figure 1** (Appendix D); shows the final ARIA value for each populated locality.

7.6 Interpolation to a 1 km grid

The limitation of an index based only on 'inhabited localities' was that, unlike an index based on, say, SLAs, it was not exhaustive—most of Australia, and many inhabitants of the remotest areas, would not be covered.

This was overcome by using a 'grid-cell' approach: the values of remoteness were interpolated onto a 1 km notional grid across the whole of Australia. The interpolation procedure was an Inverse Distance Weighted algorithm which used the remoteness values of the six nearest localities,[6] weighted by the distance of each point to the cell being analysed, to assign a remoteness value to that cell. (Where a cell was within a service centre in the relevant category, it was however assigned a distance value of zero, as above).

[6] Except in the case of islands, where a value based on the island localities only was used.

The interpolation to a grid was a necessary step before remoteness values could be calculated for other spatial units - such as CCDs, SLAs or postcodes.

Figure 3 (Appendix D); shows the calculated grid overlaid with remoteness contours.

7.7 Aggregation to higher-level geographic units

Although ARIA was defined primarily at the 1 km-grid-square level, for some applications - such as production of national statistics, scores of higher-level regions (e.g. SLAs, postcodes) need to be calculated.

There was some debate about whether this should be done on a population-weighted basis, with more populous areas having more influence, or as a straight arithmetic mean of grid cells which lay wholly or predominantly within each higher-level unit.

As has been noted, the approach of ARIA in particular has been to view remoteness as a geographic concept, a characteristic of areas rather than populations, which supports the unweighted approach. In addition, there are a number of practical considerations:

- Population data for grid cells were unavailable (SLA and postcode values could have been calculated from CCD estimates—but CCD values would themselves have to be estimated on an unweighted basis);
- Stability—a population-weighted index would be affected by changes to the population distribution within an SLA, even if neither the SLA boundary nor the index value for any grid cell within the SLA changed; and
- Simplicity was a consideration.

Accordingly, calculations were done on the basis of a simple arithmetic mean, including all grid cells that were wholly or predominantly within the larger unit.

From the regular grid, an average value for remoteness was calculated for each CCD unit, SLA, postcode and Local Government Area in Australia.

Figure 4 (Appendix D); shows the ARIA value for 1996 SLAs. Other maps showing the ARIA value for postcodes and CCDs are available from the Department's internet site (http://www.health.gov.au/ari/aria.htm).

8 Remoteness Classification

8.1 Need for a classification

Although an index is ideally suited to some forms of research, the publication of statistics, and some forms of administrative application, require discrete categories. In particular, a number of government programs apply to people or services in remote areas, on the basis of the RRMA classification.

(It is, however, preferable to use the index at grid-cell level where possible, as this gives the most precise indication of degree of remoteness.)

8.2 Developing categories

A number of factors were taken into account in devising a set of categories:

- Natural breaks in the data;
- Balance across categories; and
- Broad compatibility with RRMA (see below).

8.3 Categories

On the basis of the above approach, the following categories were developed:

1. **Highly Accessible** (ARIA score 0 - 1.84) - relatively unrestricted accessibility to a wide range of goods and services and opportunities for social interaction.
2. **Accessible** (ARIA score >1.84 - 3.51) - some restrictions to accessibility of some goods, services and opportunities for social interaction.
3. **Moderately Accessible** (ARIA score >3.51 -5.80) - significantly restricted accessibility of goods, services and opportunities for social interaction.
4. **Remote** (ARIA score >5.80 - 9.08) - very restricted accessibility of goods, services and opportunities for social interaction.
5. **Very Remote** (ARIA score >9.08 - 12) - very little accessibility of goods, services and opportunities for social interaction.

8.4 Relationship with RRMA

While no attempt was made to force the classification of individual areas to correspond to that under the RRMA, it was considered desirable that one or more of the categories correspond in size to the 'Remote Zones' (Remote Centres plus Other Remote Areas) of the RRMA. These two categories correspond most closely to the "Remote" plus " Very Remote" categories in the ARIA classification shown above.

9 Future Developments

As noted above, ARIA represents an attempt - perhaps the first - to deal with remoteness in terms of access as a separate dimension of areas, aside from other variables such as population,[7] demographic characteristics or population density of the area classified. This, in fact, increases the scope for examining the relationship between remoteness and such variables.

The design of the ARIA index ensures that it is relatively stable over time. However, it is envisaged that the index could be recalculated after each five yearly Census of Population and Housing, as new population data for Service Centres becomes available. See (Appendix A), Frequently Asked Question for more information.

[7] Populations of centres *serving* the area are taken into account, as outlined above.

Greater flexibility is being demanded in terms of the spatial units for which data are provided. In the longer term it is likely that many agencies, including the ABS, will adopt a practice of 'geocoding' (coding to latitude and longitude) their data collections. Spatial referencing of information to particular points on the earth surface would allow the use of totally flexible boundaries. One of the advantages of ARIA is that it can be applied to any level of geography, including geocoded latitude and longitude points. However, for many purposes, standards for boundaries will still need to exist to enable the comparison of statistics from different sources.

9.1 Health and Aged Care Internet site

Although this paper includes some data (1996 and 1999 SLA-level ARIA scores and categories), the Department's Internet site (http://www.health.gov.au/ari/aria.htm) is the primary vehicle for disseminating ARIA data. Use of the Internet allows users quick access to ARIA data. The website contains searchable databases that allow users to search for an ARIA score by a locality name, a SLA name or a ABS Postal Area code (very similar to postcodes). The website also contains a range of other information that can be downloaded separately, including colour maps and files containing ARIA data by localities, SLAs or postcodes. No copyright restriction is placed on the use of the data obtained from the Internet site, provided the source is acknowledged.

Geographic areas can change over time. The ABS publishes a new edition of the ASGC each year and each edition may contain changes to the various spatial units within it. Similarly, postcodes change over time. The Department's ARIA website will be updated regularly to include ARIA information for whatever geographic areas are required by the department.

The primary level of ARIA is the Populated Locality, with all ARIA values at other levels being derived from this, which in the case of larger units means calculating averages across relatively heterogeneous areas. However, the large number of Populated Localities makes them impractical to include in a hard-copy publication. Internet publication also allows the inclusion of additional localities as these are identified (though their scores will be based on averages of pre-existing localities, and will not affect surrounding grid-cell values).

9.2 Australian Standard Geographic Classification

The 2001 edition of the Australian Standard Geographic Classification (ASGC) has incorporated for the first time a concept of remoteness. This edition of the ASGC will also provide an expanded Section of State classification. The ABS publication (Information Paper: ABS Views on Remoteness Consultation, Australia; Cat. No. 1244.0.00.001; released 5 July 2001) describes the ABS approach of incorporating the concepts of urban/rural and remoteness into the ASGC.

The ASGC Remoteness classification has been based on a slightly modified version of ARIA, named ARIA+. See (Appendix A), Frequently Asked Question for more information.

The ABS will release 2001 Population Census data and future sample survey data based on this remoteness classification and has agreed to include data classified by remoteness in its Integrated Regional Database (IRDB).

In the future all administrative, survey or geographic data that is released by the ABS with a remoteness element will use ARIA+. Organisation that want to compare or use their own data with ABS data may need to also use ARIA+. The Department of Health and Aged Care is considering it's options in relation to the use of ARIA+, however it is likely that over time many users of ARIA within the Department will move to using ARIA+.