TENSION MEMBRANE STRUCTURES WITHOUT TEARS

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(Structurflex has been fabricating and installing fabric structures since 1982. Work has been completed in New Zealand, Australia, the Middle East and South East Asia. Mike Ure is a founding Director of the company.)

INTRODUCTION

Tension Membrane Structures, once designed cannot be readily altered. Small changes in the location of reaction points, even in the order of 20mm, may require total redesign of the whole structure. My fourteen years in the industry have revealed many examples of recurrent procedural errors that, while the end result may have been satisfactory, have cost the client, the consultant or the contractor. Adherence to a logical, documented procedure ensures either more economical structures or increased profitability. Both results are desirable.

Our company makes regular use of a paper entitled ”Problems Identified with Design and Construct Tenders” given to the Membrane Structures Association by Bryan Dowling. It is my intention to expand on that paper and suggest a process control that can be documented, issued and controlled by one of the parties to the contract. The objective of the control is to ensure that details are resolved in the order that ensures minimal re–work or time wastage.

While these procedures are generally understood by the end of a contract, the Tension Membrane Industry has become almost mainstream and thus many more consultants and contractors are encountering tension membrane structures for the first time. This paper suggests a method that hopefully will allow all parties to remain in harmony throughout a contract and result in effective, efficient expedition of the works.

PROJECT CONTROL

In Australasia it is common for the fabricator to take the lead in controlling the project and it is common for the fabricator also to be the installer. When the project is under the control of a head contractor, or other party there is the same, almost invariable, sequence of events that makes up a Tension Membrane Structure project. Our strong suggestion is that one of the parties to the contract documents this sequence, and issues it in a controlled manner to all parties involved.

Table 1 shows the sequence that should be applied from the initial exploratory discussions to ensure the potential project is on track from the beginning.

Steps 1 to 5 need to be completed to allow a structure to be costed, and its fitness for purpose assessed. Structures that proceed, without completion of the process to this stage, risk cost over runs and dispute. Most experienced fabricators and their engineering consultants are able to provide indications of reactions, fabric types, and detailing, from experience, and a rough geometric set out involves little architectural time.

The Architect should carefully consider the indicative detailing provided in step 2 and make his or her requirements or requests known.

If the project is of significant size (say over $100,000 membrane cost) we would recommend that the client, or his consultant, purchase accurate reaction loads from a specialist engineer before requesting final pricing or going to tender. Large membranes impose very significant loads on the

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support structure, and cost implications can be evaluated only after the magnitude of these loads is established. We know that our clients have frequently had cost overruns because they did not adequately address this at an early stage. Accurate reactions are needed for accurate costing.

Steps 6 and 7 are straight forward. Steps 8 and 9 require input from both architect and engineer in an interactive manner.

While working through steps 6 to 9 the parties must keep in mind that this work is defining the final form of the structure, and that once patterning has commenced any changes could require complete and costly redesign. Great care must be taken to understand the relationships of fixing points, fabric work points, steel work points and set out points, the definitions of which vary widely in practise.

The attached drawings (appendices 1,2,3) are good examples of these relationships. This is a small entrance canopy designed by New Zealand Architect, Warren Wiggins with Wade Lester as the specialist engineer.

Appendix 1 is the final geometric set out. Note that geometric set out is the building face on one edge but the centre of the columns on the other.

Appendix 2. This is issue C of the details. Note that an error has been made, in that the set out is taken from the edge of an RHS affixed to the face of the building, not the building face.

Appendix 3 corrects the above error. Fabric work points are labelled and are under lined and the steel work point on the column is labelled and double underlined. Study and comparison of the geometric set out, and fabric work points will show that the inter–relationships are not always logical, but are often one parties interpretation of another parties intent. Architect, Engineer and Fabricator must carefully study, and understand each drawing before approval.

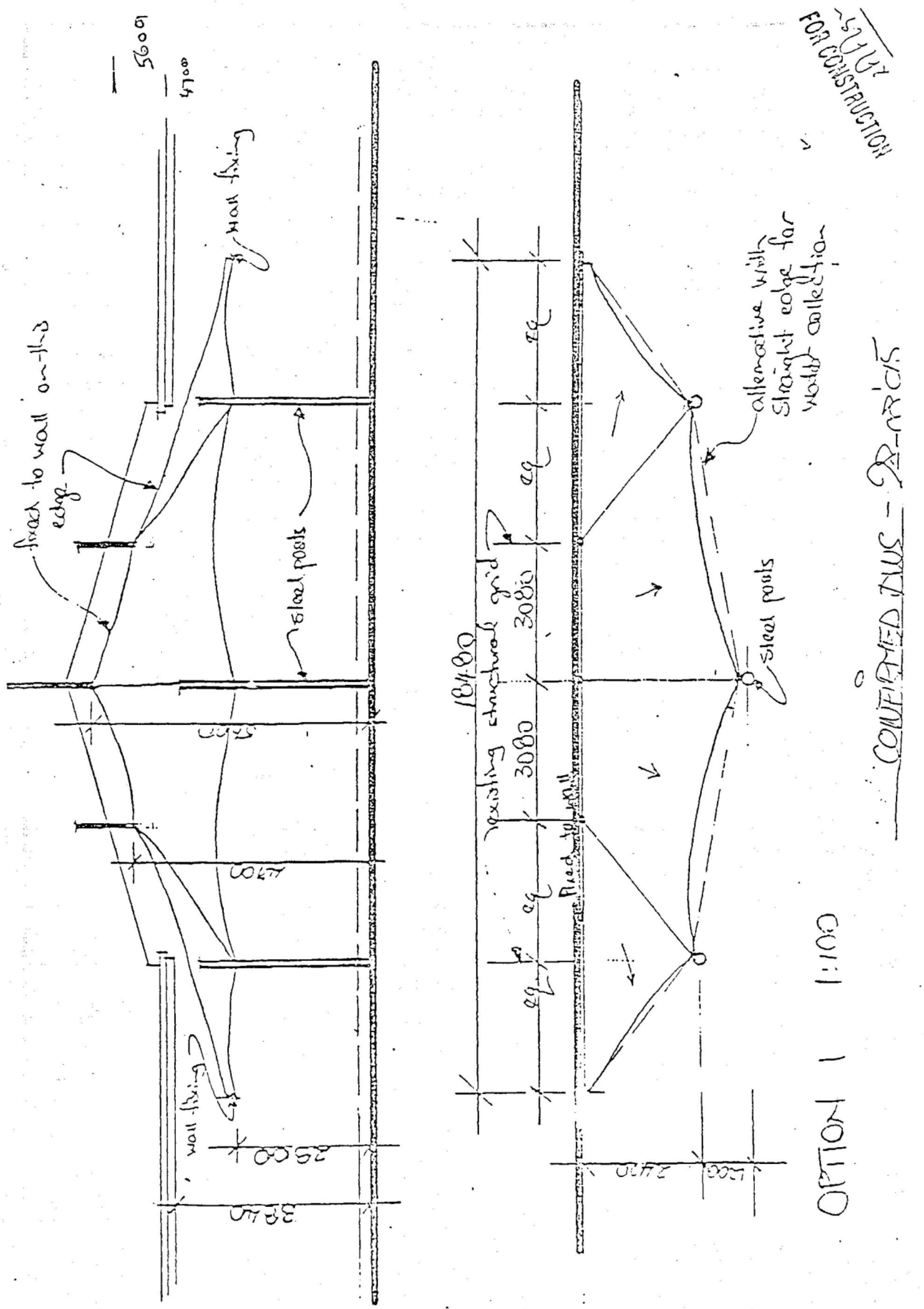
This job proceeded well and was installed without problem.

Tension Membrane Structures are stimulating projects that should progress smoothly resulting in a satisfactory outcome to all involved.

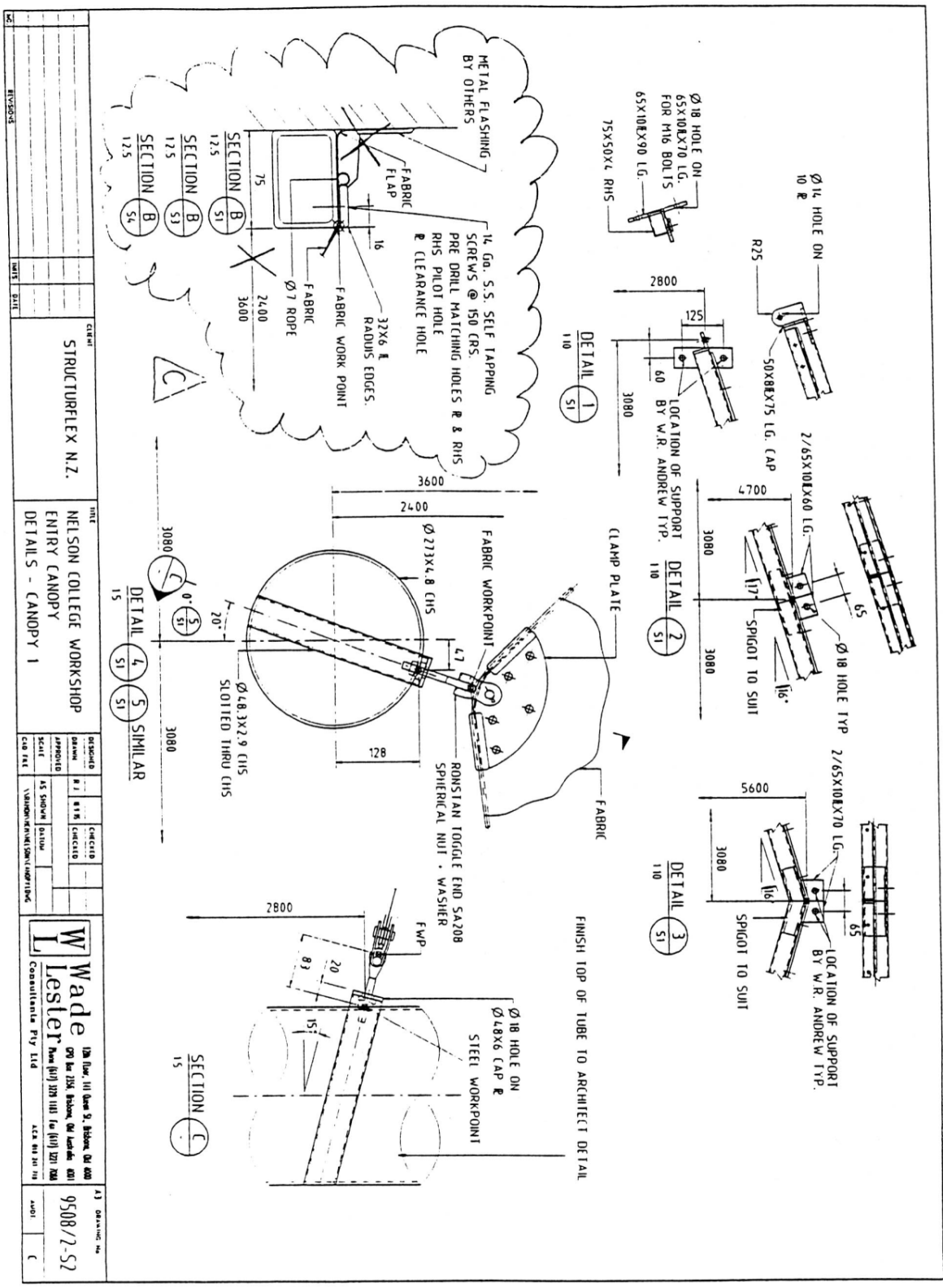
TABLE 1

	PROCESS	OBJECTIVE	RESPONSIBILITY
1.	Very rough Geometric Set Out giving approximate locations X, Y and Z of the reaction points	To indicate the shape of the membrane and allow early indication of practicality	Architect
2.	Typical Detailing of Reaction Points on support structure and membrane	To give an indication of the practicality of fixing the membrane to the support structure, and allow the architect the opportunity of commenting on detailing.	Architect Engineer Fabricator
3.	Indicative Reaction Loads	To allow basic design of the support structure, sizing of members, cables, membrane plates etc.	Engineer
4.	Fabric specification (mechanical and coating)	To allow pricing of the Membrane	Engineer Fabricator Architect
5.	Rough installation plan	To give confidence that the structure can be erected, and safely.	Fabricator Installer
All of the above steps must be completed to accurately price the works, and to allow all parties the Client, Architect and Fabricator a full understanding of the design and the cost implications for the fabric structure and the support structure.			
6.	Final Geometric Set out, precise locations of the reaction points	Until this has been completed no final work can be done on design, loads or detailing.	Architect
7.	Final Reactions	To allow final design of the support structure to accept the given loads.	Engineer
8.	Fabric work points	To define how the membrane interfaces with the reacting structure and the required connecting detail.	Engineer Architect
9.	Final Detailing of Membrane Plates, Cable Connections, Support Structure Fixing Points etc.	To allow hardware to be manufactured, and fixing points manufactured and affixed to the support structure.	Engineer Architect
All of the above steps must be completed before patterning can commence. It must be realised that after patterning has commenced any changes to the geometric set out, fabric work points, or final detailing could require complete and costly redesign.			
10	Patterning	To define the shape of the individual panels that make up the membrane structure.	Engineer
11.	Fabrication	To weld the individual panels to make up the whole.	Fabricator
12.	Installation	Completion of the project.	Fabricator Installer

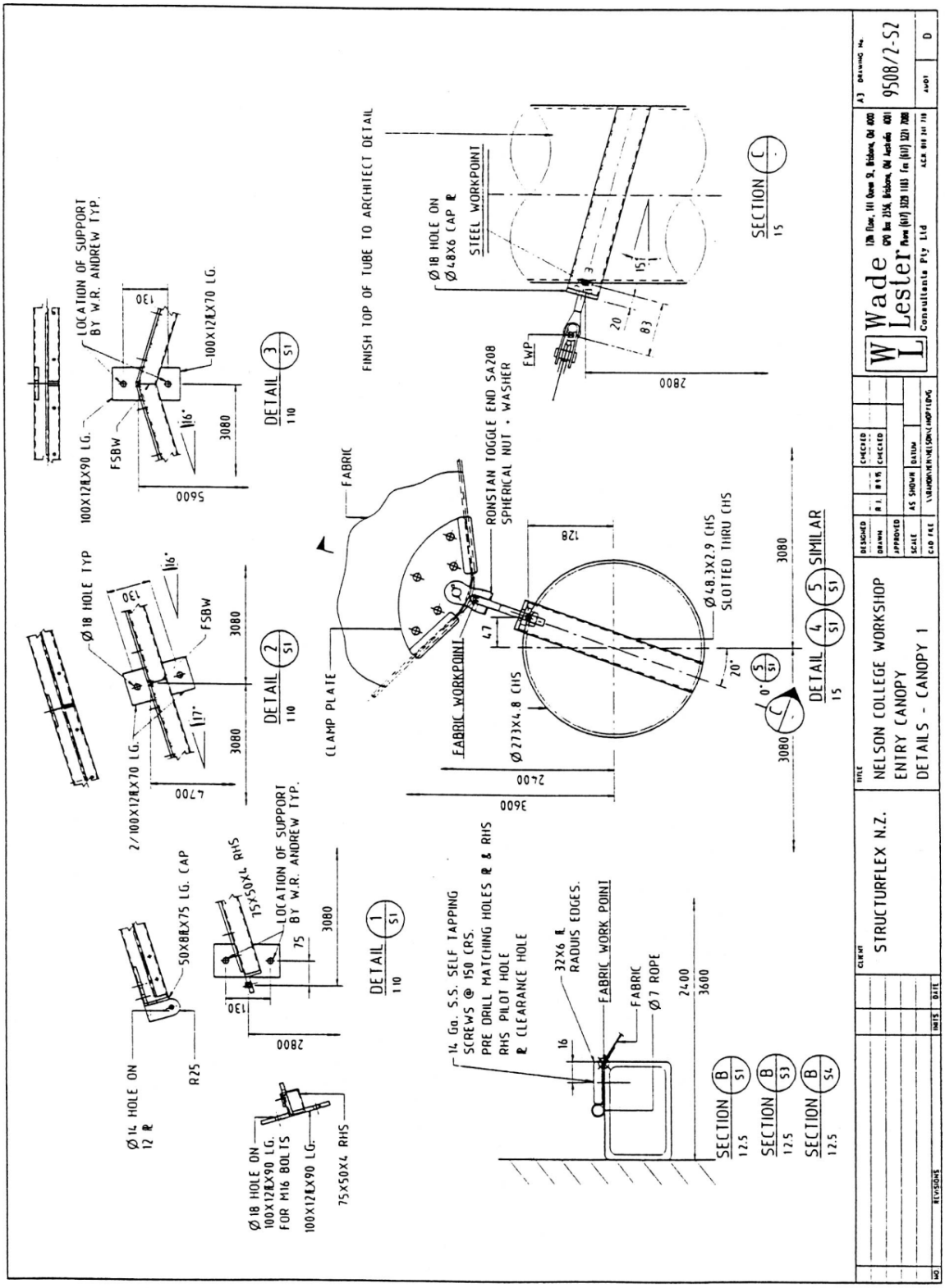
APPENDIX 1



APPENDIX 2



APPENDIX 3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STRUCTUREFLEX N.Z.
NELSON COLLEGE WORKSHOP
ENTRY CANOPY
DETAILS - CANOPY 1
Wade Lester Consultants Pty Ltd
9508/2-S2
FINISH TOP OF TUBE TO ARCHITECT DETAIL
STEEL WORKPOINT
RONSTAN TOGGLE END SA208
SPHERICAL NUT + WASHER
FABRIC WORKPOINT
CLAMP PLATE
FABRIC
Ø 273X4.8 CHS
Ø 48.3X2.9 CHS
SLOTTED THRU CHS
LOCATION OF SUPPORT
BY W.R. ANDREW TYP.
100X12tX90 LG.
100X12tX70 LG.
2/100X12tX70 LG.
Ø 18 HOLE TYP
FSBW
50X8tX75 LG. CAP
Ø 14 HOLE ON
12 ℄
R25
75X50XL RHS
Ø 18 HOLE ON
100X12tX90 LG.
FOR M16 BOLTS
14 Ga. S.S. SELF TAPPING
SCREWS @ 150 CRS.
PRE DRILL MATCHING HOLES ℄ & RHS
RHS PILOT HOLE
℄ CLEARANCE HOLE
32X6 ℄
RADIUS EDGES.
FABRIC WORK POINT
FABRIC
Ø 7 ROPE
SECTION B 12.5
SECTION C 15
DETAIL 1 110
DETAIL 2 110
DETAIL 3 110
DETAIL 4 15
DETAIL 5 15
SIMILAR