

# QUANTIFICATION OF THE FARM WATER SAVINGS WITH AUTOMATION

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## ABSTRACT

*Automation of border-check irrigation is encouraged in the Shepparton Irrigation Region under the Shepparton Irrigation Region Implementation Strategy to save labour and improve efficiency. Landowners who are exposed to automation believe that automation improves their lifestyle and saves water in most circumstances (Maskey and Lawler, 2002). While the labour savings can be readily calculated, the potential for water savings has been less well understood. This desk top study conducts a brief investigation to quantify any water savings from automation. The study shows that automation appears to have contributed to water savings of 5 to 9 percent. The results are based on a simple method of analysis that did not measure all parameters and the savings should be regarded as indicative only. However, this result is supported by an Analytical Irrigation Model (Austin and Prendergast, 1997) which suggests a similar potential reduction in deep drainage through reducing excessive irrigation application times, which is likely to be the main water loss saved by automation.*

## INTRODUCTION

The automation of border-check irrigation involves the use of a mechanical device to operate supply channel structures so that the flow of water onto irrigation bays can be changed in the absence of the irrigator doing this manually.

The use of automatic irrigation is encouraged in the Shepparton Irrigation Region by the Goulburn Broken Catchment Management Authority. The Shepparton Irrigation Region Implementation Strategy conducts the Automatic Irrigation Project which aims to improve water use efficiency through the use of automation to allow more accurate and timely operation of farm irrigation systems. The project includes an extension component that provides advice to landowners together with a financial incentive.

Irrigators are able to operate border-check systems to achieve optimum water use efficiency but this requires a high labour input by the irrigator. Under these conditions, irrigators will irrigate relatively small areas at one time with one or two bays being irrigated at a time.

When labour is not readily available, particularly through the night or at times when other farm activities demand the attention of the labour, irrigators will open more bays and “slow down” the irrigation by irrigating larger areas. Under these lower flow conditions, the water use efficiency can be reduced through greater infiltration of water into the soil being irrigated and potential for deep drainage to groundwater.

A previous study (Maskey and Lawler, 2002) was carried out to understand the benefits of automation from landowners' perspectives. This study provided evidence that automatic irrigation does save labour and improve irrigation efficiency as a result of irrigation operations being carried out at optimum times, rather than when labour is available. However, the challenge for this study was to investigate if any water savings through automation can be quantified.

This project was conducted with funding assistance from Water for Rivers as a part of their investigations into the feasibility of funding a project aimed at increasing the adoption of automatic irrigation. Water for Rivers is a Public Company formed by the Commonwealth, New South Wales and Victorian Governments to provide funding for projects to achieve water savings. The water savings gained are used to improve environmental flows in the Snowy River and the River Murray. Water for Rivers had received a project proposal that claimed savings of up to 30% could be achieved with the introduction of automatic irrigation in farm systems. Water for Rivers was keen to validate the accuracy of this claim.

## **OBJECTIVE**

To conduct a short investigation to quantify any water savings through the adoption and use of automatic irrigation on border-check irrigated pastures.

## **METHODOLOGY**

A desk-top study was carried out using water use records obtained from Goulburn-Murray Water, with the landowners' authorisation. These records can indicate any change in the water use and irrigation management that could be attributed to automation. The water use data was then compared to climatic data that applied to the properties concerned. The climatic data was used to calculate plant water use for each year, as the calculated plant water use varies with seasonal conditions.

In order to carry out this investigation, the project team determined that an automated area needed to be:

- properly designed, laser graded and efficiently irrigated by the same manager before and after the adoption of automation;
- supplied from a single metering point which supplies only the area automated;
- growing perennial pasture; and
- automated at one time, preferably with several years of data since automation.

At the start of this project it was decided to examine up to ten properties which had installed automatic irrigation with assistance from the Automatic Irrigation Project. However, only two sites were investigated. These were the only sites that could be found that met the above criteria. The two landowners were interviewed to confirm the suitability of their sites for the investigation, and to obtain any additional relevant information.

### **Water use**

The Goulburn-Murray Water records provided accurate information on the number and date of irrigations and an estimated water use at each irrigation. The water use records also contained water use measurements collected through the irrigation season and at the end of the season. Water use for each irrigation has been extrapolated from the recorded data. While the specific water use measured onto the properties by Dethridge meter outlets may be inaccurate, it should be consistent from season to season, and before and after automation.

Run-off was not measured, and in both cases was collected in drainage reuse systems. However, on Farm 1 the collected water was used elsewhere on the farm; on Farm 2 it was reused on the site. The water used on Farm 2 may be overstated, but was not obvious in the data.

### **Water requirement**

Pasture water requirements were calculated from evaporation recorded at Department of Primary Industries, Tatura and local rainfall records. While the properties are 70 km and 30 km respectively from Tatura, the evaporation data at Tatura was considered to be representative for the two sites, and any error should be consistent. Pasture evapotranspiration (ET) was assumed to be 80 % of the pan evaporation ( $E_{pan}$ ) values.

Rainfall data from recording stations 15 km and 2 km respectively from the sites has been used to account for local variability. While this should be much more representative of rainfall at the sites than the Tatura records, it may still be an inaccurate measurement of rainfall at the sites, particularly for thunderstorm events, but should indicate when rain events occurred. 80 % of the recorded rainfall was assumed to be effective.

### **Modelling**

In addition to the assessment of farm water use data, the Analytical Irrigation Model (Austin and Prendergast, 1997) was used to assess the impact of irrigating with lower flow rates than optimum, which was likely to be the main cause of losses, as outlined above. Given inputs of flow rate, time of application, bay dimensions and soil infiltration rates, the model calculates the amount of runoff and the depth of infiltration occurring. This modelling was conducted to determine if the observed results were consistent to the modelled results.

## RESULTS

Table 1 provides a summary of water use at two sites before and after the adoption of automatic irrigation. The data for 2002/03 has not been included as this was a year of very low water allocation due to drought.

**Table 1 Summary of water use at two sites pre and post adoption of automatic irrigation**

	Farm 1		Farm 2	
<b>Area of site</b>	15 ha *		18 ha **	
<b>Soils</b>	Cobram sandy loam		Lemnos loam with some patches of Shepparton fine sandy loam	
<b>Automated</b>	For 2001/02 season		For 2002/03season	
	Pre automation Average of 96/97, 97/98, 98/99, 99/00	Post Automation Average of 01/02, 03/04, 04/05	Pre automation Average of 99/00, 00/01, 01/02	Post Automation Average of 04/05, 05/06
<b>Av No. of irrigations per year</b>	24	25.7	14.3	15
<b>Typical summer interval</b>	6 – 7 days	6 – 7 (days)	8 – 9 (days)	8 – 9 (days)
<b>Bays irrigated simultaneously</b>	“several”	1	2 – 3	1
<b>Bay application time</b>	Up to 8 hr	1 to 4 hr	6 – 8 hr	3.5 hr
<b>Av Water use</b>	<b>9.6 ML/ha *</b>	<b>8.7 ML/ha *</b>	<b>7.4 ML/ha**</b>	<b>7.4 ML/ha**</b>
<b>Av application</b>	40 mm *	34 mm *	51.8 mm**	49.3 mm**
<b>Av ET- 0.8R over irrigation period</b>	948 mm	935 mm	797 mm	836 mm
<b>Av ET-0.8R per irrigation</b>	39 mm	37 mm	56mm	56 mm

\* The landowner estimates that the portion of the 15 ha actually irrigated increased from 75 % before 2001/02 (when automated) to 90% after as a result of associated farm channel works when the automation was installed.

\*\* The landowner estimates that 1.0 ha of site was not irrigated before automation (but was after) because bays were usually irrigated short because of lower than optimum bay flows being used. This was corrected with automation.

Two sets of graphs are attached for both sites in the Appendices.

- Appendix 1 shows a summary showing the number of irrigations, the average irrigation application and the average ET-R interval for several years before and after automation; and
- Appendix 2 shows a cumulative ET and irrigation plus rainfall, and rainfall events for representative years before and after automation.

## Modelling

Table 2 shows additional infiltration, or deep drainage, modelled as occurring as a result of slowing irrigation by irrigating two bays rather than one, which results in half of the optimum flow rate being used. The optimum flow rates are those determined by the model to give the best irrigation efficiency and uniformity for the specified conditions.

**Table 2 Effect of flow rate on infiltrated depth**

	<b>Final infiltration rate</b>	<b>1 mm/h</b>	<b>3 mm/h</b>	<b>6 mm/h</b>
1 bay	Optimum flow rate (ML/d)	4	7	11
	Application time (h: m)	3:25	2:15	1:40
	Average Infiltrated depth (mm)	37	43	49
2 bays	Half flow rate (ML/d)	2	3.5	5.5
	Application time (h: m)	7:00	4:55	3:40
	Infiltrated depth (mm)	38	46	54
<b>Increased infiltrated depth</b>		<b>3%</b>	<b>7%</b>	<b>10%</b>

Assumptions: Bay 300 m long, 50 m wide, slope 1:700  
Crackfill of 30 mm, Manning's n of 0.3, Runoff of 1 to 3 %

## DISCUSSION

- In developing this project, it was accepted that the proposed method of analysis was a relatively crude process compared to an in-depth research project that would measure all inputs and outputs of water to determine savings. The study did not measure runoff, deep percolation of water, or pasture production. It was agreed that the project should be able to provide an indication of any water savings being made.
- The project has shown some evidence (Table 1) of farm water savings after automation, but it was based on a method of analysis that has limits:
  - On Farm 1**, water use (per ha) decreased by 9%, while the seasonal irrigation requirement (Av ET-0.8R) stayed approximately the same.

While water used on the site actually increased following automation, this appears to be the result of the area irrigated increasing as a result of farm channel works completed at the time of the installation of automation. The landowner estimated that the portion of the 15 ha site actually irrigated increased from 75% to 90%. The resulting water usage per ha was lower, which may be attributed to the automation, which allowed better irrigation management.

In particular, the average application depth has been reduced from 40 mm to 34 mm following automation, largely as a result of the reduced application times on the relatively light soil. The slightly reduced average irrigation interval (Av ET-0.8R per irrigation) would also have contributed to this reduction, but resulted in an increased number of irrigations.

- On Farm 2**, water use (per ha) did not change after automation, while the seasonal irrigation requirement (Av ET-0.8R) for the seasons studied increased by 5%. This may be interpreted as a reduction in water usage, attributable to automation.

Water usage on the site actually increased slightly, but the landowners estimated that about 1 ha was not irrigated before automation due to low flow rates used for irrigation. The increase in area irrigated results in water usage per hectare remaining constant, despite the increased area irrigated and thus increased water requirement.

While the number of irrigations per season increased slightly with the increased irrigation requirement, the average application depth reduced slightly, presumably as a result of the reduced application time enabled by automation.

- The relatively simple modelling indicates potential water savings of 3% to 10% (depending on soil type) through using the optimum bay flow rate on one bay rather than two. Using an appropriate bay flow rate is particularly important on lighter textured soils, where deep drainage losses can be significant with excessive ponding times.

While there are many possible variations on the model assumptions and outcomes, the model illustrates some typical situations that automation is likely to be applied to.

The potential savings indicated are consistent with those found on the two farm sites, tenuous as they are. Farm 1 is on lighter texture soils than Farm 2, and it appears to have made greater savings.

4. Both landowners have claimed a productivity increase following automation; presumably as a result of better meeting pasture water needs. This could occur as an increase in dry matter production or improvement in the species composition of the pasture, clover in particular. However, quantification of any change in productivity was not possible with this investigation.

Farmer 1 emphasised that while he had substantially improved productivity across the farm, automation was only part of the improvements made resulting in the productivity improvement. While automation made further improvements, such as better fertilizer application and better grazing management possible, it was only part of the package.

It is likely, but beyond this investigation, that improved pasture growth has masked the improvement in irrigation efficiency attributable to automation. The better pasture growth is likely to use more water, and the apparent reduction in water use per ha, may mask a greater reduction in deep seepage losses. That is, the 0.8 crop factor assumed to estimate pasture water use from evaporation data may be less before automation than after.

5. The summary graphs show a considerable variation from season to season, which make valid conclusions difficult.
6. The cumulative ET, irrigation and rainfall graphs, while illustrating irrigation patterns and management well, do not allow any conclusions about the impact of automatic irrigation.

Well-managed irrigated pasture should result in the irrigation plus rainfall graph closely following the cumulative ET graph. Where water use exceeds pasture requirements, the cumulative water use line will be greater than the cumulative ET line. Where water use is less than pasture requirements, the pasture is stressed for at least part of the time and the cumulative water use is less than the cumulative ET line.

In practice, the closeness of the lines depends on the accuracy of the ET assumptions, the area actually irrigated and the accuracy of the irrigation and rainfall measurements. There are unexplained changes between seasons at both sites that confuse any impact of automation.

7. There are substantial differences in management between the two sites:
  - Farm 1 is irrigated relatively frequently because of the light soil type, resulting in a high number of irrigations per season and a low average depth of application. The pasture is unlikely to be stressed, and water use could be excessive, particularly if irrigation management is not good. Any deep seepage losses occurring over the 25 or more irrigations could be significant. However, this does not appear to be excessive.
  - Farm 2 is irrigated at a relatively long irrigation interval, which is likely to result in pasture being stressed as the soil moisture deficit increases and the site appears to be under-irrigated. Automation could have allowed more frequent irrigation and an increase in dry matter production and quality, but this does not appear to have been taken advantage of.
  - The difference in the amount of water used between the sites (9 ML/ha/y and 7.4 ML/ha/y) is largely due to the frequency of irrigation, but could also be partly due to a metering difference between the sites.

## **CONCLUSIONS**

1. Automation appears to have contributed to a reduction in water use of 9% and 5% on the two sites respectively. However, the results are based on a simple method of analysis that did not measure all parameters and the reduced water use should be regarded as indicative only. This is supported by the Analytical Irrigation Model which suggests a similar potential reduction in

2. The reduction of surface drainage volumes with automation is not regarded as having potential to save significant water where it is collected in a drainage reuse system and reused. In the absence of a drainage reuse system, significant water could be saved, depending upon the management of the site. The use of a drainage reuse system is recommended with the use of automatic irrigation to ensure that any failures of the automation equipment do not result in water leaving the property.
3. The project highlights the limitations of using a simple method of analysis that does not measure all parameters and relies on the memory of the landowners regarding the areas being irrigated. A more detailed project would be required if a more definitive answer was required.
4. The project has focused on the water savings from the use of automation. However, the labour savings have been reported to be the greatest benefits from automation (Maskey and Lawler, 2002). Improved lifestyle because of automation has been reported as to why people initially adopt this technology.

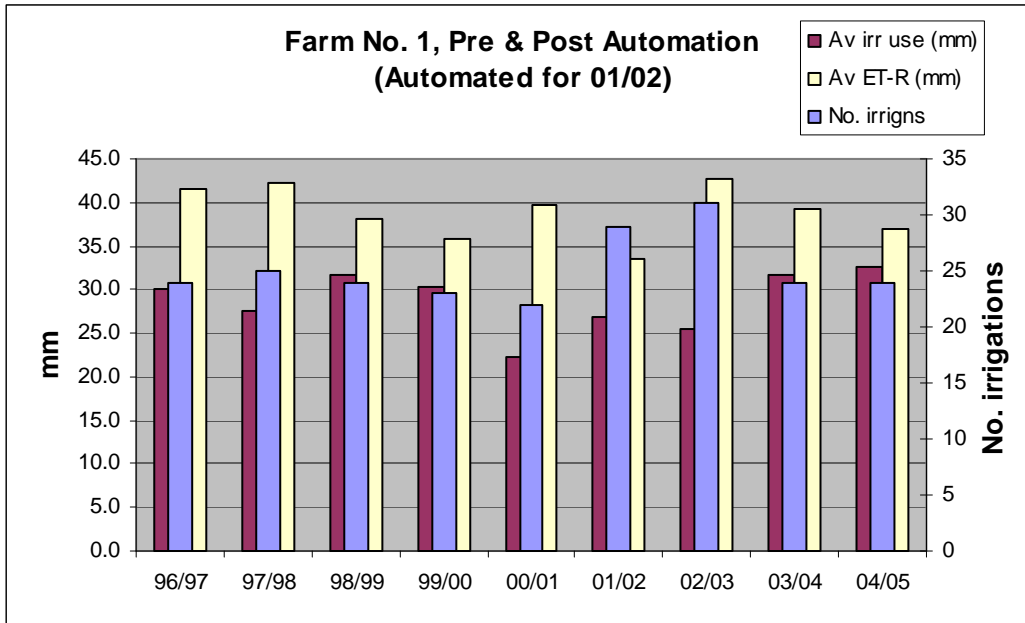
With automation, the irrigator is not required to constantly check the progress of water down the bays and the landowner is able to be away from the property, relax with the family and sleep through the night.

Automatic irrigation increases the reliability of the irrigation system being operated at optimum levels of water use efficiency by reducing the risks of human error through mistakes and not attending to the irrigation system by being busy with other activities.

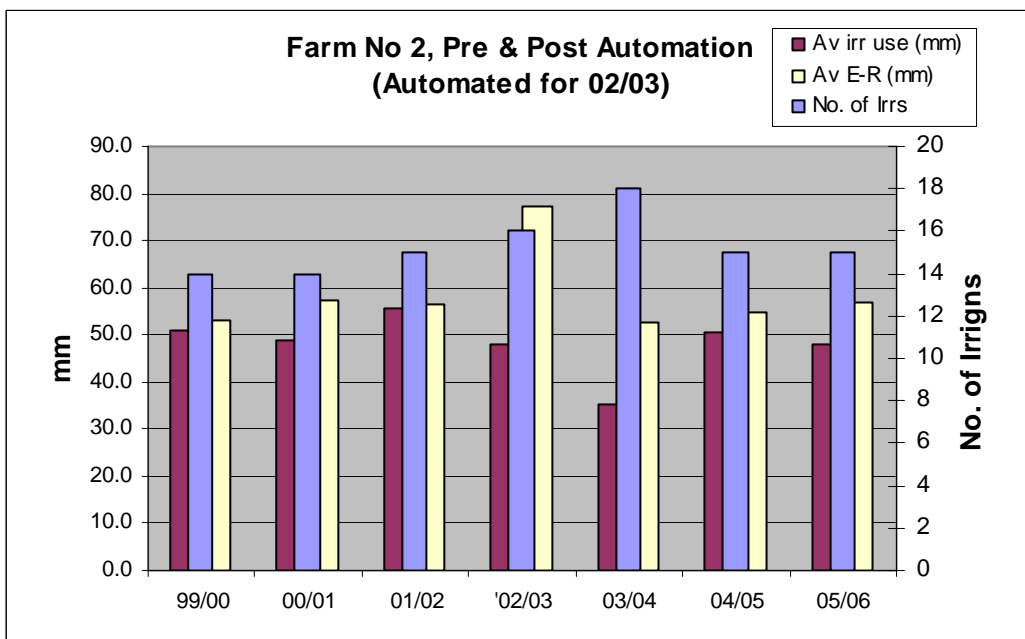
## **REFERENCES**

- Austin, N and Prendergast, JB (1997), **Use of kinematic wave theory to model irrigation on cracking soil**. *Irrigation Science* 18, 1 – 10.
- Maskey, R and Lawler, D (2002), **Attitudes of farmers about the automation of flood irrigation**. Department of Primary Industries, Tatura

APPENDIX 1  
**Summary Graphs**  
**Farm 1**



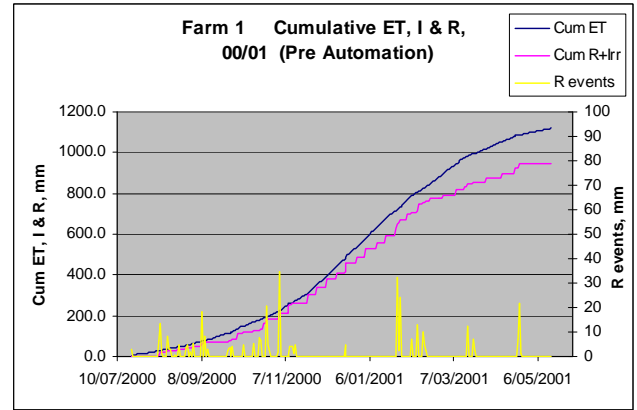
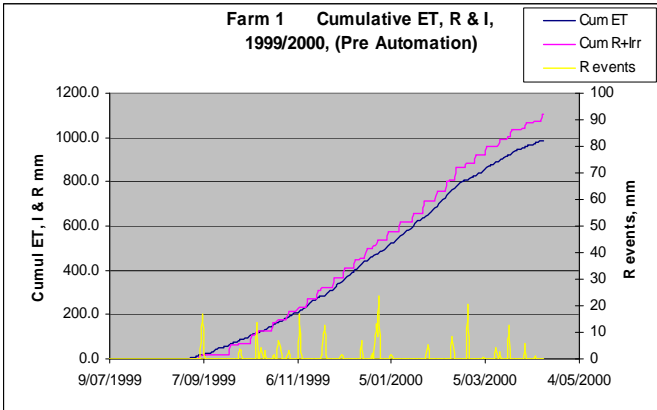
**Farm 2**



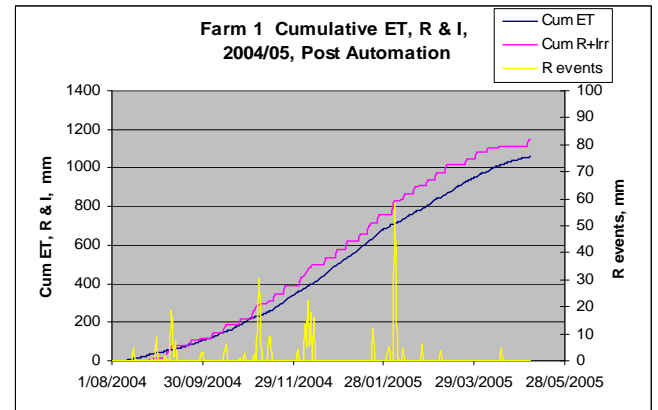
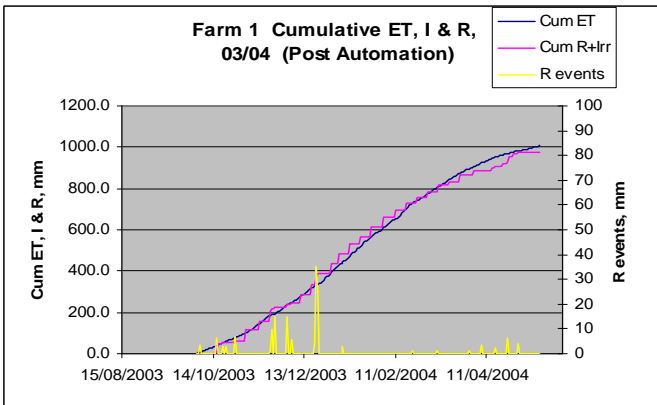
## APPENDIX 2

### Cumulative Water use, pasture water requirement, before and after automation

#### Farm 1, Before automation



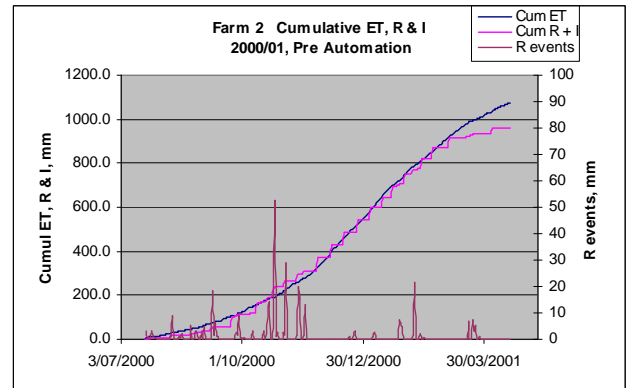
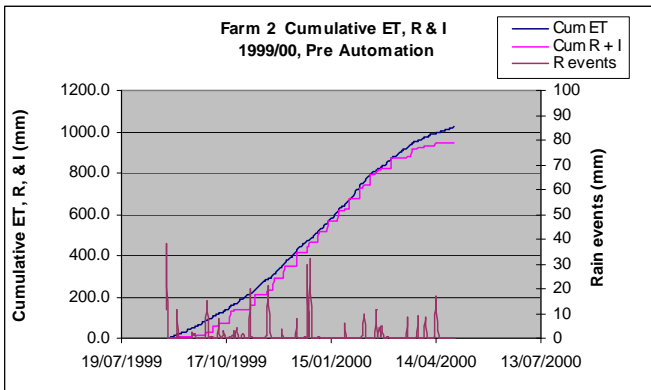
#### Farm 1, After automation



## APPENDIX 2 (continued)

### Cumulative Water use, pasture water requirement, before and after automation

#### Farm 2, Before automation



#### Farm 2, After Automation

