**Introduction**

The maintenance and repair cost coefficient (M&RCC) has been defined as the quotient between the mean hourly cost of maintenance and repair of a machine and its purchase value (Frank, 1977). It is therefore expressed in \[\text{h}^{-1}\]. The M&RCC of a machine includes the costs of lubricants and replacing worn parts, but does not account for parts replaced because of accidental breakage. Also included in the M&RCC are the general labour costs generated by maintenance procedures along with costs related to specialised man power needed to replace worn parts. The M&RCC of agricultural machinery is widely used in cost evaluations such as calculating gross farming costs.

The M&RCCs of transverse cylinder grain harvesters used in Argentina were calculated on two occasions: in 1962, at a technical meeting of the Seminary of Costs of Agricultural Machinery\(^1\), and in 1978 by Pizarro and Cacciamani, technicians of the Agricultural Economics Section of the Estación Experimental Regional Agropecuaria Pergamino (Pergamino Farming Regional Experimental Station) of the Instituto Nacional de Tecnología Agropecuaria (INTA) (National Institute of Farming Technology). Both these evaluations were based on personal and professional criteria related to the three

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\(^1\) This unpublished estimate was proposed by the Seminary’s participants (R. Frank, University of Buenos Aires, 2002, personal communication).
The main points: mean hourly oil lubrication costs, mean hourly grease lubrication costs and mean hourly miscellaneous repair costs. Table 1 shows the costs of these components calculated on these two occasions. The evaluation performed in 1962 refers to a generic machine with a 4.8 m (16 foot) wheat platform, assigned a useful life of 5000 hours. The estimates made in 1978 were based on the costs of a generic harvester used in the Pergamino region (Buenos Aires province) with no specification made of the make or model, nor the working width; its useful life being estimated at 10 years. Neither estimate discriminated between costs generated by the harvester and the platform. Despite both being very general estimates, the M&RCCs were within some 1.1 \times 10^{-5} h^{-1} of each other.

The North American literature quotes the following M&RCCs for transverse cylinder harvesters: 16.488 \times 10^{-5} h^{-1} without lubricants\(^2\) [Bowers (1970), pages 12-14 of the appendix; Bowers (1975) page 91] for machines of 2000 h of useful life; 27 \times 10^{-5} h^{-1} [Hunt (1977), page 69 and (1995), page 74, according to a table attributed to Kepner] for an estimated useful life of 2000 h; 18.58 \times 10^{-5} h^{-1} [Hunt (1977), page 71, calculated by regression for a maximum useful life of approximately 3000 h]; 13.371 \times 10^{-5} h^{-1} [Hassan and Larson (1978), from an evaluation conducted in the state of Arizona], 11.298 \times 10^{-5} h^{-1} [Hassan and Larson (1978), expected value according to the regression in the expression used by the American Society of Agricultural Engineers, ASAE]; and 25 \times 10^{-5} h^{-1} [Kepner et al. (1980), page 34] for harvesters of a useful life estimated at 2000 h.

In the last few years, grain harvesters have increased in their work capacity and new machines with axial threshing systems have emerged. The aim of the present study was: a) to review M&RCCs calculated for transverse cylinder machines and to provide a first M&RCC estimate for an axial cylinder machine in Argentina; b) to establish confidence intervals for these estimates; and c) to determine whether grain, sugar cane and cotton harvesters show any long-term tendency, following the line of work initiated in a previous study by the present author (Frank, 2002).

### Material and methods

Two representative harvesters were selected: the Deutz-Fahr Optima 550 which has a transverse cylinder and a 6.9 m (23 foot) platform for wheat/soy or a maize Mainero 2000 platform for 10 furrows at 70 cm, and the CASE Axial Flow 2188 with a wheat/soy 9 m (30 foot) platform or CASE 1083 maize platform\(^3\) for 8 furrows at 70 cm. Based on operation and maintenance manuals and conversations with the technical service heads of both suppliers (AGCO and CASE-New Holland, respectively), repair and maintenance costs were estimated and are provided in annexes to this paper. Prices and salaries were derived from: a) spare part and lubricant prices quoted or recommended by the manufacturer (as effective in July 2001, not including value added tax, VAT); b) new purchase prices for each harvester and their corresponding platforms (harvesting cutterheads) in the same marketing conditions; c) a mean hourly machine operator salary equivalent to the gross salary (i.e., the basic wage plus extras, and company contributions) of the category «tractor operator» stipulated by the Comisión Nacional de Trabajo Agrario (National Agricultural Work Commission) and resolutions of the Administración Federal de Ingresos Públicos, AFIP (Federal Administration of Public Income); d) a modal value was assigned to the workshop-hour (excluding VAT) according to conversations with dealer repair services of the suppliers AGCO and CASE-New Holland. The mean «basic» salary of the «tractor operator» category (including no extras or social security contributions) varied according to the province, thus the simple mean for the

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\(^{2}\) According to the author’s data, a value of 2.160 needs to be added to the M&RCC for maize and sorghum harvesters and one of 1.350 for fine grain harvesters. For this calculation, a cost in lubricants corresponding to 15% of the fuel costs was considered. With lubricants, M&RCCs are 17.838 for fine grain machines and 18.648 for maize and sorghum harvesters.

\(^{3}\) We considered the most commonly used harvester/platform combinations as defined by each manufacturer.
provinces Buenos Aires, Córdoba, Entre Ríos and Santa Fe was used. Table 2 details the components of the tractor operator salary for these provinces.

The exchange rate applicable at the time of study (July 2001) was 1US$=1$, according to the Conversion Law (No. 23.928/91) approved in April 1991 and rescinded in January 2002.

Table 2. Mean tractor operator salary for the provinces of Buenos Aires, Córdoba, Entre Ríos and Santa Fe

| Component                                      | Buenos Aires | Córdoba | Entre Ríos | Santa Fe |
|------------------------------------------------|-------------|---------|------------|----------|
| Basic tractor operator salary [$/month]        | 317.51      | 300.60  | 300.60     | 300.60   |
| Extras (extra pays, holiday pay and pay rises) | 14.41       | 14.41   | 14.41      | 14.41    |
| Tax and other employer contributions [%]       | 23.00       | 23.00   | 23.00      | 23.00    |
| Social security [%]                            | 18.50       | 18.50   | 18.50      | 18.50    |
| Total salary [$/month] (22 workdays/month)     | 495.05      | 468.68  | 468.68     | 468.68   |

* Decree 814/01 of the Poder Ejecutivo Nacional established a 21% employer contribution for production companies effective from July 1, 2001.

Table 3 provides details of the maintenance and repair costs of the harvesters Deutz-Fahr Optima and CASE Axial Flow 2188 according to Central Product Classification (CPC version 1.0 from United Nations) for 1998, and the purchase value of each machine. The ori-

Table 3. Details of the maintenance and repair costs of the Deutz-Fahr Optima and CASE Axial Flow 2188 grain harvesters

| CPC   | Description                                      | Deutz-Fahr | CASE |
|-------|--------------------------------------------------|------------|------|
| 31210 | Sawn wood (edges and blocks)                     | —          | 0.0120 0.09 |
| 33310 | Gasoline (common, super, and laboratory grade)   | —          | 0.0046 0.03 |
| 33380 | Motor, transmission and hydraulic oil             | 0.7419    | 0.7971 5.87 |
| 33380 | Grease-various types                             | 0.8268    | 0.1547 1.14 |
| 33380 | Break fluid and additives                        | 0.0004    | 0.3341 2.46 |
| 34210 | Refrigerant gas for A/C                          | 0.0102    | 0.0375 0.28 |
| 36113 | Other new rubber tyres                           | 0.6224    | 1.1953 8.81 |
| 36240 | Vulcanised rubber belts or bands                 | 1.7747    | 0.9170 6.76 |
| 36310 | Plastic bars                                     | 0.0005    | —      — |
| 36330 | Ratchets or membranes (plastic)                  | 0.0025    | —      — |
| 42991 | Chains and their iron or steel components        | 0.1800    | 1.81   —  |
| 43151 | Parts and pieces of piston engines (injectors, valves, rings, pistons etc.) | 0.0358 | 0.36 | 0.6015 4.43 |
| 43310 | Ball or roller bearings                          | 0.2992    | 1.4653 10.80 |
| 43320 | Transmission shaft; gear boxes and reducers; clutches and shaft couplers | 0.1234 | 1.24 | —      — |
| 43915 | Oil filters                                      | 0.1333    | 0.5739 4.23 |
| 43915 | Fuel filters                                     | 0.0271    | 0.1727 1.27 |
| 43915 | Air filters                                      | 0.0511    | 0.2697 1.99 |
| 44130 | Harvesters: conveyors                            | 2.0341    | 3.8663 28.49 |
| 44130 | Harvesters: cutter-blades and platform           | 0.4293    | 1.4477 10.67 |
| 46420 | Electric battery                                 | 0.1405    | 0.1493 1.10 |
| 46910 | Lamps, bulbs, thermal emitters and devices not listed above | 0.0068 | 0.07 | 0.1034 0.76 |
| 87159 | Machinery and equipment maintenance and repair services not listed above | 0.8966 | 8.99 | 0.8090 5.96 |

no number Machine operator labour costs

| Total [$ h⁻¹] | 9.9706 100.0 | 13.5726 100.0 |
| Purchase value [$] | 149.157 | 190.000 |
noriginal estimates are detailed in the annexes. Given that both machines are sold with a wheat/soy platform, this combination was used as reference. Estimates for the maize platform are separately listed in the annexes.

The quotient between the mean hourly maintenance and repair cost and the purchase value of each machine gives an M&RCC for the Deutz-Fahr of 6.685 \(10^{-5}\ h^{-1}\) and a coefficient of 7.143 for the CASE \(10^{-5}\ h^{-1}\), including costs for the wheat platform in both cases.

As already mentioned, this analysis attempts to extend the findings of a previous report on sugar cane and cotton harvesters. In an effort to make both reports comparable, the M&RCC was calculated for machines of different age. This was done by adding mean hourly repair or replacement costs of parts of similar replacement age and dividing this sum by the purchase price of the machine. Table 4 shows data for selected ages.

Next, regression functions for marginal costs were fitted as a function of machine age according to the following procedure:

a) Cumulative cost series were established according to the age of each machine. The corresponding incremental quotients \(\Delta y/\Delta x\) were calculated, where «x» is the mean age in hours and «y» the total cumulative cost of all the repairs. Different functions were fitted to explain \(\Delta y/\Delta x = f(x)\). The potential function was found to best fit the data series. Goodness of fit was measured using the adjusted determination coefficient \(R^2\). In this first stage, regression coefficients were determined using the ordinary least squares (OLS) estimator \(\beta_{OLS}=[X^TX]^{-1}X^TY\), where \(\beta_{OLS}\) is the regression coefficient matrix and \(X\) and \(Y\) are the corresponding transformations of \(x\) and \(\Delta y/\Delta x\) used to linearise the different functional forms.

b) Once the potential function had been selected, the coefficients were recalculated using the generalised least squares (GLS) estimator \(\beta_{GLS} = (X^\Omega^{-1}X)^{-1}X^\Omega^{-1}Y\), where \(X\) and \(Y\) are the matrices mentioned above and \(\Omega\) is a diagonal matrix made up of the squared errors \(U^*\) of the OLS model, to correct the bias due to heteroscedasticity in estimating the standard deviation of the regression coefficients. Pindyck and Rubinfeld (1981) and Judge et al. (1985), theoretically reviewed the estimator \(\beta_{GLS}\), whose use for calculating maintenance and repair costs was subsequently validated by Frank (2002). The variance-covariance matrix of the coefficients of regression \(\beta_{GLS} = \Sigma^2(\beta_{GLS}) = (X^\Omega^{-1}X)^{-1}\). Table 5 shows the results obtained.

The functions calculated correspond to the expression \(Y_i = X_i\beta + U_i\). If we denote the potential function exponent \(\beta_1 = \lambda_1\) and the ordinate at the origin \(\beta_0 = \ln(\lambda_0)\), and \(X_i=\ln(x_i)\) and \(Y_i = \ln(\Delta y/\Delta x_i)\), the differential equation can be resolved as:

\[
\frac{dy}{dx} = \frac{\lambda_0 x^{\lambda_1}}{\lambda_1 + 1} + C \quad \text{for } (\lambda_1 \neq -1)
\]

Table 4. Partial coefficients of maintenance and repair for Deutz-Fahr and CASE Axial Flow 2188 harvesters according to the platform and age of the machine

| Age [h] | M&RCC [10^{-5} h^{-1}] |
|---------|-------------------------|
|         | Deutz-Fahr              | CASE Axial Flow 2188 |
|         | Wheat/soy 6.9 m platform Maize plt. 10 furrows at 70 cm | Wheat/soy 9 m Maize plt. 8 furrows at 70 cm |
| 1 000   | 4.759 4.452             | 1.654 3.018          |
| 2 000   | 5.700 6.205             | 4.573 5.891          |
| 3 000   | 5.799 6.369             | 6.092 7.425          |
| 4 000   | 6.377 6.777             | 6.318 7.654          |
| 5 000   | 6.533 6.937             | 6.358 7.694          |
| 5 500   |                        | 6.550               |
| 6 000   | 6.558 6.963             | 6.810 7.957          |
| 7 000   |                        | 6.810 7.957          |
| 7 500   | 6.567 6.967             | 6.812 7.959          |
| 9 000   | 6.629 7.031             | 7.143 8.294          |
| 10 000  |                        |                    |
| 12 000  | 6.656 7.058             |                    |
| 15 000  | 6.685 7.082             |                    |
where $C$ is a constant equal to zero, since the cost of maintaining a new machine is null.

c) Based on the deviations of the regression coefficients and the regression error for an age $x_i$ at the end of the machine’s useful life, it was considered that

$$
\sigma^2(Y_i) = X_i \sigma^2(\beta_1) + \sigma^2(\beta_0) + 2X_i \sigma(\beta_1; \beta_0) + \sigma^2(U_i).
$$

This expression allows us to calculate the variance of $Y_i$ to simulate possible M&RCC values using the following equation obtained by resolving the differential equation:

$$
M&RCC = \frac{e^{Y_i} + Z_i \sigma(Y_i)}{1 + (\beta_1 + Z_i \sigma(\beta_1)) V_N}
$$

where $z$ is a normally distributed random variable and $V_N$ is the cost of the new machine. Generating random $z$ values gives a distribution of results that serves to establish a confidence interval for the M&RCC. In our case, we chose to perform 1000 repetitions of $z$, from which we obtained the confidence intervals for $P(A < M&RCC < B) = 0.9$ presented in Table 6.

The confidence interval was established from the empirical cumulative probability function derived from simulation. The functional form of the model used in the simulation suggests that the M&RCCs do not show a normal distribution. This presumption can be observed in Figures 1A and 1B, which provide empirical probability distributions of the M&RCCs of both harvesters for wheat/soy and maize platforms. It may be observed that the distribution of the M&RCC is right-asymmetric (positive asymmetry).

In the last stage of the study, we determined whether the M&RCCs of different harvesters showed any long-term trends. To this end, we constructed a $X$ matrix including $26 \times 5$ independent variables and a $Y$ matrix containing M&RCCs expressed as units of $10^{-5}$h$^{-1}$. The independent variables were 4 binary variables (3 indicative of the type of harvester and a fourth variable indicating the country where the coefficient was calculated) and a discrete variable referring to the year in which the M&RCC was calculated, counted from the year 1960 which was taken as zero. Both matrices are provided in Table 7. The criteria used to assign a year to each M&RCC was that of the oldest bibliographic reference for each case. In addition, if there were appreciable differences in the useful life assigned by North American and Argentinian authors to the different harvesters, costs at 3,000 h were taken as the cost coefficient in an effort to use comparable figures, provided local references contained this information.

Assuming a heteroscedastic structure of the residuals, regression coefficients and their corresponding t statistics* are presented in Table 8.

It may be observed that all the coefficients were significant at a rejection level $H_0: \beta_i=0$ of 5%. These findings indicate that the M&RCCs calculated for Argenti-

| Platform | Regression estimator | Deutz-Fahr harvester | CASE harvester |
|----------|----------------------|----------------------|---------------|
| Wheat/soy | $\beta_1^T$ | 0.1185 | 0.5564 |
|           | $\sigma^2(\beta_1)^T$ | 0.0249 | 0.0081 |
|           | t statistic* | 4.7511 | 69.068 |
| Maize    | $\beta_1^T$ | 0.1126 | 0.3509 |
|           | $\sigma^2(\beta_1)^T$ | 0.0396 | 0.0643 |
|           | t statistic* | 2.8423 | 5.4534 |

| Harvester | Platform | A  | B  |
|-----------|----------|----|----|
| Deutz-Fahr| Wheat/soy | 5.689 | 7.319 |
|           | Maize     | 5.971 | 7.921 |
| CASE      | Wheat/soy | 3.766 | 10.239 |
|           | Maize     | 5.218 | 11.383 |

* Indicates an estimator of the true value.

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4 In an effort to standardise results we selected an age of 12,000 h for both harvesters to establish the confidence intervals for their M&RCCs.

5 As all measures came from different experimental conditions, a pure heteroscedastic error structure was assumed, and the Durbin-Watson test on residuals was performed. The Durbin-Watson test yielded no conclusive evidence of autocorrelation among residuals ($d^*=1.69; d_L=0.979$ and $d_S=1.873$).
na are lower than those reported by North American authors. Moreover, a generally decreasing tendency in the M&RCC was observed for the grain, sugar cane and cotton harvesters. The effective yearly reduction rate for each type of harvester in Argentina can be determined from the M&RCC estimated for the years 0 and 41 using the expression \( \left[ \frac{E(M&RCC_{41})}{E(M&RCC_{0})} \right]^{\frac{1}{41}} - 1 \) × 100. This procedure gives the rates: –2.237%, –1.081%, and

**Figure 1.** Graph of the empirical probability distribution of M&RCCs for: A) The Deutz-Fahr Optima 550 harvester with a wheat/soy platform (outlines) or maize platform (shaded grey). B) The CASE Axial Flow 2188 harvester with a wheat/soy platform (outlines) or maize platform (shaded grey).

**Table 7.** Y matrix comprised of M&RCCs and X matrix comprised of independent variables

| Y matrix | Years since 1960 | Argentina | Sugar cane harvester | Cotton harvester | Grain harvester |
|----------|-----------------|-----------|---------------------|-----------------|----------------|
| 8.230    | 21              | 1         | 1                   | 0               | 0              |
| 12.21    | 16              | 1         | 1                   | 0               | 0              |
| 14.37    | 16              | 1         | 1                   | 0               | 0              |
| 30.00    | 25              | 1         | 0                   | 1               | 0              |
| 29.98    | 10              | 0         | 0                   | 1               | 0              |
| 30.00    | 20              | 0         | 1                   | 0               | 0              |
| 35.00    | 20              | 0         | 0                   | 1               | 0              |
| 26.00    | 17              | 0         | 0                   | 1               | 0              |
| 26.70    | 35              | 0         | 0                   | 1               | 0              |
| 12.59    | 29              | 0         | 1                   | 0               | 0              |
| 10.73    | 29              | 0         | 0                   | 1               | 0              |
| 8.425    | 41              | 1         | 1                   | 0               | 0              |
| 8.879    | 41              | 1         | 0                   | 1               | 0              |
| 11.04    | 2               | 1         | 0                   | 0               | 1              |
| 10.82    | 18              | 1         | 1                   | 0               | 1              |
| 17.84    | 10              | 1         | 1                   | 0               | 1              |
| 18.65    | 10              | 0         | 1                   | 0               | 1              |
| 27.00    | 17              | 0         | 0                   | 1               | 1              |
| 18.58    | 17              | 0         | 0                   | 1               | 1              |
| 13.371   | 18              | 0         | 0                   | 0               | 1              |
| 11.298   | 18              | 0         | 0                   | 0               | 1              |
| 25.00    | 20              | 0         | 0                   | 0               | 1              |
| 5.799    | 41              | 1         | 0                   | 0               | 1              |
| 6.369    | 41              | 1         | 0                   | 0               | 1              |
| 6.092    | 41              | 1         | 0                   | 0               | 1              |
| 7.425    | 41              | 1         | 0                   | 0               | 1              |
−1.727 for grain, sugar cane and cotton harvesters, respectively. The mean yearly effective rate for all the harvesters is given by expected M&RCCs for the years 0 and 41 assigning binary variables the value of 0.33. The effective yearly rate calculated in this manner was −1.536%.

**Discussion**

On simple inspection of the results, it would appear that the coefficients of maintenance and repair for the current transverse cylinder machines are lower than those generally reported for Argentina, given that the latter fall outside the confidence limits estimated by the simulation process. Further, all the values cited in North American references also escape our confidence interval.

The CASE axial harvester showed a higher M&RCC than the traditional Deutz-Fahr harvester. The transverse cylinder harvester was related to higher costs in lubricants and belts, while the axial harvester clearly generates more costs in replacing bearings. Machine operator costs were higher for the traditional harvester, being associated with more lubrication tasks. This does not necessarily indicate the greater technical complexity of one system or another, but may rather be attributed to differences in the particular designs used by each manufacturer. In other words, focusing on one particular type of machine can lead to biased results. The results presented here should therefore be backed up by more extensive studies involving larger sample sizes.

The fall in the M&RCC over time need not necessarily be explained by an increased durability of the different spare parts or by a long-term tendency of the price of spare parts to drop relative to the price of the new machine. It could be that the fall is related to the behaviour of some other factor (e.g., the working width) that varies over time. Unfortunately, the scarce reference made to the technical characteristics of these machines in the past precludes drawing any further conclusions regarding this point.

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**Annex 1. Deutz-Fahr Optima 550 harvester**

| Maintenance and repair items | Periodicity [h] | Materials [quant.] | General labour [$ h⁻¹] | Specialised labour [$ h⁻¹] | Total [$] | Mean [$ h⁻¹] |
|------------------------------|-----------------|--------------------|-------------------------|-----------------------------|-----------|--------------|
| 1. Deutz BF6L 913C engine (220 HP) | | | | | | |
| Change engine oil: oil API CF-CF4 (ACEA D4-D5) (1) | 15 000 | 38 | 3 | 0.20 | 2.70 | 106.53 | 0.0071 |
| Change engine oil: oil (2) | 15 000 | 38 | 3 | 0.20 | 2.70 | 106.53 | 0.0071 |
| Change engine oil: oil (3) | 300 | 38 | 3 | 0.20 | 2.70 | 106.53 | 0.3551 |
| Change oil filter (1) | 15 000 | 1 | 12 | 0.20 | 2.70 | 12.60 | 0.0008 |
| Change oil filter (2) | 15 000 | 1 | 12 | 0.20 | 2.70 | 12.60 | 0.0008 |
| Change oil filter (3) | 300 | 1 | 12 | 0.20 | 2.70 | 12.60 | 0.0020 |
| Check oil level (1) | 15 000 | 0.10 | 2.70 | 0.27 | 0.0000 |
| Check oil level (2) | 15 000 | 0.10 | 2.70 | 0.27 | 0.0000 |
| Check oil level (3) | 10 | 0.10 | 2.70 | 0.27 | 0.0270 |
| Check valve gap with engine cold (1) and (2) | 7 500 | | 0.30 | 12.00 | 3.60 | 0.0005 |
| Check valve gap with engine cold (3) | 600 | | 0.30 | 12.00 | 3.60 | 0.0006 |
| Check condition and tension of belts | 10 | | 0.05 | 2.70 | 0.14 | 0.0135 |
| Replace alternator belt | 12 000 | 1 | 155 | 1.00 | 2.70 | 157.69 | 0.0131 |
| Replace turbo-fan belts | 12 000 | 2 | 155 | 1.50 | 2.70 | 314.04 | 0.0262 |
| Drain water from trap and primary fuel filter (1) and (2) | 15 000 | | 0.05 | 2.70 | 0.14 | 0.0000 |
| Drain water from trap and primary fuel filter (3) | 10 | | 0.05 | 2.70 | 0.14 | 0.0135 |
| Clean water trap sieve (1) and (2) | 15 000 | | 0.15 | 2.70 | 0.41 | 0.0000 |
| Clean water trap sieve (3) | 300 | | 0.15 | 2.70 | 0.41 | 0.0014 |
| Change primary fuel filter element (1) and (2) | 15 000 | 1 | 6 | 0.10 | 2.70 | 5.90 | 0.0004 |
| Change primary fuel filter element (3) | 300 | 1 | 6 | 0.10 | 2.70 | 5.90 | 0.0017 |
| Change secondary fuel filter element (1) and (2) | 15 000 | 1 | 5 | 0.10 | 2.70 | 4.84 | 0.0003 |
| Change secondary fuel filter element (3) | 600 | 1 | 5 | 0.10 | 2.70 | 4.84 | 0.0081 |
| Clean air filter | 240 | | 0.30 | 2.70 | 0.81 | 0.0034 |
| Change air filter element | 1 200 | 1 | 42 | 0.20 | 2.70 | 42.3 | 0.0353 |
| Change air filter safety element | 1 200 | 1 | 20 | 0.20 | 2.70 | 20.0 | 0.0167 |
| Check/clean cooling vanes | 300 | | 1.00 | 2.70 | 2.70 | 0.0090 |
| Regulate oil dispensers of rocker arms (not applicable to new harvesters) | 7 500 | | 0.25 | 12.00 | 3.00 | 0.0004 |
| Check manifold attachment (1) and (2) | 7 500 | | 0.05 | 2.70 | 0.14 | 0.0000 |
| Check manifold attachment (3) | 600 | | 0.05 | 2.70 | 0.14 | 0.0002 |
| Check injection pump (1) | 15 000 | | 1.00 | 12.00 | 12.00 | 0.0008 |
| Check injection pump (3) | 3 000 | | 1.00 | 12.00 | 12.00 | 0.0040 |
| Check injectors (1) | 15 000 | | 1.00 | 12.00 | 12.00 | 0.0008 |
| Check injectors (3) | 1 200 | | 1.00 | 12.00 | 12.00 | 0.0100 |
| Replace injectors (primed and calibrated) | 6 000 | 6 | 36 | 0.67 | 12.00 | 223 | 0.0372 |
| Check turbofeeder and conduits are fast (1) | 15 000 | | 0.08 | 2.70 | 0.22 | 0.0000 |
| Check turbofeeder and conduits are fast (3) | 600 | | 0.08 | 2.70 | 0.22 | 0.0004 |
| Check radial and axial play of the turbofeeder (1) | 15 000 | | 0.25 | 12.00 | 3.00 | 0.0002 |
| Check radial and axial play of the turbofeeder (3) | 3 000 | | 0.25 | 12.00 | 3.00 | 0.0010 |
| Empty diesel tank | 750 | | 0.17 | 2.70 | 0.45 | 0.0006 |
| Check warning systems (1) | 15 000 | | 2.00 | 12.00 | 24.00 | 0.0016 |
| Check warning systems (3) | 750 | | 2.00 | 12.00 | 24.00 | 0.0320 |
| Engine rectification | 9 000 | | 70.00 | 12.00 | 840.00 | 0.0933 |

2. Transmission

| Check oil level of gear box, final gear reducers and differential (2) | 15 000 | 0.10 | 2.70 | 0.27 | 0.0000 |
| Check oil level of gear box, final gear reducers and differential (3) | 300 | 0.10 | 2.70 | 0.27 | 0.0009 |
| Change oil (first change at 300 h): oil API GL5 (MIL-L-2105 C), viscosity SAE 80W/90 | 15 000 | 16 | 3 | 0.30 | 2.70 | 53.73 | 0.0036 |
Annex 1 (cont.)

| Maintenance and repair items | Periodicity [h] | Materials [quant.] | General labour [h] | Specialised labour [h] | Total [$] | Mean [$ h⁻¹] |
|------------------------------|-----------------|-------------------|-------------------|------------------------|----------|--------------|
| Change oil (max. once a year) | 600             | 16 3              | 0.30 2.70         | 53.73                  | 0.0895   |
| Change transmission oil filter (first change at 600 h) | 600             | 1 16              | 0.20 2.70         | 16.63                  | 0.0277   |
| Change hydrostatic transmission oil filter | 900             | 1 16              | 0.20 2.70         | 16.63                  | 0.0185   |
| Change hydrostatic transmission oil | 2 000           | 38 3              | 0.30 2.70         | 126.49                 | 0.0632   |
| Clean radiator of hydrostatic transmission oil | 10              |                   | 0.25 2.70         | 0.68                   | 0.0675   |
| Check gear change mechanism and adjust if necessary (2) | 15 000          | 0.50 2.70         |                   | 1.35                   | 0.0001   |
| Check gear change mechanism and adjust if necessary (3) | 600             | 0.50 2.70         |                   | 1.35                   | 0.0023   |
| Check clutch oil level | 300             |                   | 0.08 2.70         | 0.22                   | 0.0007   |
| Replace engine-speed controller belt | 2 000           | 1 155             | 1.00 2.70         | 157.69                 | 0.0788   |
| Replace speed controller-clutch belt | 2 000           | 1 155             | 1.00 2.70         | 157.69                 | 0.0788   |
| Replace ball bearings of the differential (includes changing of ball bearings and roller) | 5 000           |                   | 15.00 12.00       | 180.00                 | 0.0360   |
| Ball bearings | 5 000           | 4 66              |                   | 264.52                 | 0.0529   |
| Roller | 5 000           | 1 58              |                   | 57.73                  | 0.0115   |
| Replace differential ratchets (labour costs along with ball bearings change) | 5 000           | 2 6               |                   | 12.37                  | 0.0025   |
| Repair clutch and axle (includes roller and axle change) | 5 000           |                   | 4.00 12.00        | 48.00                  | 0.0096   |
| Rollers | 5 000           | 2 83              |                   | 165.85                 | 0.0332   |
| Axle | 5 000           | 1 278             |                   | 277.58                 | 0.0555   |
| 3. Switches, levers etc. | | | | | |
| Check accelerator regime controller of the threshing cylinder (1) and (2) (takes 2 people 5 min) | 7 500          |                   | 0.16 12.00          | 1.92       | 0.0003   |
| Check accelerator regime controller of the threshing cylinder (3) | 300             |                   | 0.16 12.00         | 1.92       | 0.0064   |
| Check forward speed controller (1) and (2) | 7 500          |                   | 0.16 12.00         | 1.92       | 0.0003   |
| Check forward speed controller (3) | 600             |                   | 0.16 12.00         | 1.92       | 0.0032   |
| Check conditions and tension of chains and belts | 10             |                   | 0.08 2.70         | 0.22       | 0.0216   |
| 4. Hydraulic system | | | | | |
| Check all hydraulic functions | 10             |                   | 0.20 2.70         | 0.54       | 0.0540   |
| Check oil level | 10             |                   | 0.10 2.70         | 0.27       | 0.0270   |
| Change hydraulic system oil (2) | 15 000          | 25 3              | 0.17 2.70         | 67.97                  | 0.0045   |
| Change hydraulic system oil (3) | 900             | 25 3              | 0.17 2.70         | 67.97                  | 0.0755   |
| Change filter element (2) | 15 000          | 1 16              | 0.08 2.70         | 16.30                  | 0.0011   |
| Change filter element (3) | 900             | 1 16              | 0.08 2.70         | 16.30                  | 0.0181   |
| Clean tank breather (2) | 15 000          |                   | 0.17 2.70         | 0.45       | 0.0000   |
| Clean tank breather (3) | 600             |                   | 0.17 2.70         | 0.45       | 0.0007   |
| Regulate ascent and descent speed of the cutting head | 10             |                   | 0.08 2.70         | 0.22       | 0.0216   |
| Check hydrostatic steering (1) | 15 000          |                   | 0.17 12.00        | 1.99       | 0.0001   |
| Check hydrostatic steering (2) | 7 500           |                   | 0.17 12.00        | 1.99       | 0.0003   |
| Check hydrostatic steering (3) | 600             |                   | 0.17 12.00        | 1.99       | 0.0033   |
| Check and clean oil cooler | 10             |                   | 0.20 2.70         | 0.54       | 0.0540   |
| Check pressured oil hose joints (2) (along with general test) | 15 000          |                   |                   | 0.00       | 0.0000   |
| Check pressured oil hose joints (3) (along with general hydraulic function test) | 600             |                   |                   | 0.00       | 0.0000   |
| 5. Cutting head and transporter duct | | | | | |
| Check oil level of the mill activator hydraulic system | 10             |                   | 0.03 2.70         | 0.09       | 0.0089   |
### Annex 1 (cont.)

| Maintenance and repair items | Periodicity [h] | Materials [quant.] | General labour [h] | Specialised labour [$ h⁻¹] | Total [$] | Mean [$ h⁻¹] |
|-----------------------------|----------------|-------------------|-------------------|-----------------------------|-----------|---------------|
| Check the cutting head compensator (1) (includes checking beam, mill, conveyor, blade, chains and belts) | 15 000 | 4.50 | 12.00 | 54.00 | 0.0036 | |
| Check cutting head compensator (2) | 7 500 | 4.50 | 12.00 | 54.00 | 0.0072 | |
| Check cutting head compensator (3) | 600 | 4.50 | 12.00 | 54.00 | 0.0900 | |
| Check cutter-blade condition and functioning | 10 | 0.08 | 2.70 | 0.22 | 0.0216 | |
| Replace blade (for soy and furrow crops) | 600 | 1 | 184 | 2.70 | 184.00 | 0.3067 | |
| Replace blade (for wheat and fine grains) | 1 500 | 1 | 184 | 2.70 | 184.00 | 0.1227 | |
| Check blade activator oil level | 10 | 0.03 | 2.70 | 0.09 | 0.0089 | |
| Change blade reducer activator oil | 200 | 1.25 | 3 | 0.17 | 4.58 | 0.0229 | |
| Check belt and chain tension | 10 | 0.08 | 2.70 | 0.22 | 0.0216 | |
| Replace blade (for soy and furrow crops) | 600 | 1 | 184 | 2.70 | 184.00 | 0.3067 | |
| Replace blade (for wheat and fine grains) | 1 500 | 1 | 184 | 2.70 | 184.00 | 0.1227 | |
| Check blade activator oil level | 200 | 1.25 | 3 | 0.17 | 4.58 | 0.0229 | |
| Change blade reducer activator oil | 7 500 | 0.03 | 2.70 | 0.09 | 0.0000 | |
| Check safety lock on the screw conveyor (before 300 h) | 7 500 | 0.03 | 2.70 | 0.09 | 0.0000 | |
| Check safety lock on the screw conveyor (before 300 h) | 300 | 0.03 | 2.70 | 0.09 | 0.0003 | |
| Clean the panels of the feeder (before 300 h) | 7 500 | 0.03 | 2.70 | 0.09 | 0.0000 | |
| Clean the panels of the feeder (before 300 h) | 300 | 0.03 | 2.70 | 0.09 | 0.0003 | |
| Check the sifters, their fastness and sieves aperture (before 300 h) | 7 500 | 0.03 | 2.70 | 0.09 | 0.0000 | |
| Change hydraulic fluid (before 300 h) | 15 000 | 18 | 3 | 0.20 | 60.07 | 0.0389 | |
| Change hydraulic fluid (3) | 600 | 18 | 3 | 0.20 | 60.07 | 0.0389 | |
| Change hydraulic fluid cartridge (before 300 h) | 15 000 | 1 | 16 | 0.20 | 16.63 | 0.0011 | |
| Change hydraulic fluid cartridge | 600 | 1 | 16 | 0.20 | 16.63 | 0.0011 | |
| Grease all sites equipped with grease nipples (grease K2k DIN 51825) | 10 | 0.5 | 6 | 0.17 | 3.20 | 0.3204 | |
| Empty stone collecting tray (for soy and furrow crops) | 10 | 0.08 | 2.70 | 0.22 | 0.0216 | |

#### 6. Threshing and cleaning system

- **Adjust concave sleeve (1)**: 750 | 0.75 | 12.00 | 9.00 | 0.0120 |
- **Check threshing cylinder reducer oil level** (before 300 h) | 15 000 | 0.08 | 2.70 | 0.22 | 0.0000 | |
- **Check threshing cylinder reducer oil level (3)** | 300 | 0.08 | 2.70 | 0.22 | 0.0007 | |
- **Change threshing cylinder reducer oil** (oil MIL-L-2105 (API-GL 5), SAE 90) | 600 | 1 | 3 | 0.17 | 3.76 | 0.0063 | |
- **Check sifter revolutions** (before 300 h) | 15 000 | 0.05 | 2.70 | 0.14 | 0.0000 | |
- **Check sifter revolutions (3)** | 600 | 0.05 | 2.70 | 0.14 | 0.0002 | |
- **Check activation of the sieves gear-case and latex bearings (2) (the Optima model does not have these bearings)** | 15 000 | 0.00 | 0.0000 | |
- **Check activation of the sieves gear-case and latex bearings (the Optima model does not have these bearings)** | 300 | 0.00 | 0.0000 | |
- **Check the sifters, their fastness and sieves aperture** (before 300 h) | 15 000 | 1.00 | 2.70 | 2.70 | 0.0002 | |
- **Check the sifters, their fastness and sieves aperture (3)** | 300 | 1.00 | 2.70 | 2.70 | 0.0009 | |
- **Check and, if necessary, stretch grain elevator chain** | 10 | 0.08 | 2.70 | 0.22 | 0.0216 | |
- **Check fastness of unloading tube (2)** | 15 000 | 0.08 | 2.70 | 0.22 | 0.0000 | |
- **Check fastness of unloading tube (3)** | 600 | 0.08 | 2.70 | 0.22 | 0.0004 | |
- **Check tension and condition of belts and chains** | 10 | 0.30 | 2.70 | 0.81 | 0.0810 |
### Annex 1 (cont.)

| Maintenance and repair items | Periodicity [h] | Materials [quant.] | Materials [$] | General labour [h] | General labour [$ h⁻¹] | Specialised labour [h] | Specialised labour [$ h⁻¹] | Total [$] | Mean [$ h⁻¹] |
|------------------------------|-----------------|-------------------|---------------|-------------------|------------------------|------------------------|------------------------|----------|-------------|
| Replace belts (labour times are means for the entire set): | | | | | | | | | |
| — Engine-beater belt | 4 000 | 1 | 155 | 0.30 | 2.70 | 155.80 | 0.0390 | 310.79 | 0.3108 |
| — Beater- straw carrier countermarch belts | 1 000 | 2 | 155 | 0.30 | 2.70 | | 310.79 | 0.3108 | |
| — Engine-grain hopper emptying system belt | 4 000 | 1 | 155 | 0.30 | 2.70 | 155.80 | 0.0390 | | |
| — Threshing cylinder controller belt | 2 000 | 1 | 155 | 0.30 | 2.70 | 155.80 | 0.0779 | | |
| — Straw carrier countermarch-sifters countermarch gear-case belts | 2 000 | 2 | 155 | 0.30 | 2.70 | | 310.79 | 0.1554 | |
| — Straw carrier countermarch-rethreshing elevator belt | 1 000 | 1 | 155 | 0.30 | 2.70 | 155.80 | 0.1558 | 155.80 | 0.1558 |
| — Straw carrier countermarch-fan belt | 1 000 | 1 | 155 | 0.30 | 2.70 | 155.80 | 0.0390 | 155.80 | 0.0390 |
| — Fan-fan belt | 4 000 | 1 | 155 | 0.30 | 2.70 | 155.80 | 0.0390 | 155.80 | 0.0390 |
| — Chopper combined belt | 1 000 | 1 | 155 | 0.30 | 2.70 | 155.80 | 0.0390 | 155.80 | 0.0390 |
| — Engine- chopper activator belts | 2 000 | 1 | 155 | 0.30 | 2.70 | 155.80 | 0.0779 | 155.80 | 0.0779 |
| — Engine-grain hopper coupling belt | 2 000 | 1 | 155 | 0.30 | 2.70 | 155.80 | 0.0779 | 155.80 | 0.0779 |
| — Cooling system belt | 5 000 | 1 | 155 | 0.30 | 2.70 | 155.80 | 0.0312 | 155.80 | 0.0312 |
| Check cylinder-threshing concave | 250 | | | 0.08 | 2.70 | | 0.22 | 0.0009 | |
| Change oil in the chaff spreading box | 300 | 1 | 3 | 0.17 | 2.70 | | 3.76 | 0.0125 | |
| Replace lamp in the sifters box | 4 000 | 1 | 1 | 0.03 | 2.70 | | 1.16 | 0.0003 | |
| Replace cylinder beaters | 1 200 | | | | 4.00 | 12.00 | | 48.00 | 0.0400 |
| Replace cylinder bearings | 1 875 | 2 | 42 | | 8.00 | 12.00 | | 179.97 | 0.0960 |
| Replace grain hopper conveyor | 200 | 1 | 219 | | 2.00 | 12.00 | | 242.52 | 1.2126 |
| Replace rethreshing elevator conveyors | 200 | 1 | 154 | | 3.00 | 12.00 | | 189.74 | 0.9487 |
| Replace the elevator ball bearings and chain: | 750 | | | | 4.00 | 12.00 | | 48.00 | 0.0640 |
| — Ball bearings | 750 | 4 | 21 | | | | | 83.97 | 0.1120 |
| — Chain | 750 | 1 | 135 | | | | | 135.00 | 0.1800 |
| Replace clean grain conveyor (includes changing the conveyor, ball bearings and gears) | 1 500 | | | 2.50 | 12.00 | | 30.00 | 0.0200 |
| — Conveyor | 1 500 | 1 | 259 | | | | | 259.12 | 0.1727 |
| — Ball bearings | 1 500 | 2 | 34 | | | | | 67.18 | 0.0448 |
| — Gears | 1 500 | 2 | 51 | | | | | 101.78 | 0.0679 |

### 7. Wheels and brakes

| | | | | | | | |
| Check braking system (1) | 15 000 | | | 1.00 | 12.00 | 12.00 | 0.0008 |
| Check braking system (2) | 15 000 | | | 1.00 | 12.00 | 12.00 | 0.0008 |
| Check braking system (3) | 600 | | | 1.00 | 12.00 | 12.00 | 0.0200 |
| Check levels of brake and clutch fluid | 10 | | | 0.03 | 2.70 | | 0.09 | 0.0089 |
| Change brake fluid (fluid DOT 4, DOT 3 or SAE J 170) | 2 100 | 0.35 | 2 | 0.50 | 2.70 | | 2.22 | 0.0011 |
| Tighten wheel nuts and bolts (2) | 15 000 | | | 0.25 | 2.70 | | 0.68 | 0.0000 |
| Tighten wheel nuts and bolts (3) | 600 | | | 0.25 | 2.70 | | 0.68 | 0.0011 |
| Check clutch play and adjust if necessary (before 300 h) | 15 000 | | | 0.20 | 2.70 | | 0.54 | 0.0000 |
| Check clutch play and adjust if necessary | 600 | | | 0.20 | 2.70 | | 0.54 | 0.0000 |
| Check steering (1) (check along with hydrostatic transmission) | 15 000 | | | | | | | 0.00 | 0.0000 |
| Check steering (2) (check along with hydrostatic transmission) | 7 500 | | | | | | | 0.00 | 0.0000 |
| Check steering (3) (check along with hydrostatic transmission) | 600 | | | | | | | 0.00 | 0.0000 |
| Check and adjust the windage of steered wheels (2) (check along with the head) | 15 000 | | | | | | | 0.00 | 0.0000 |
| Check and adjust the windage of steered wheels (3) (check along with the head) | 600 | | | | | | | 0.00 | 0.0000 |
## Annex 1 (cont.)

| Maintenance and repair items | Periodicity [h] | Materials [quant.] | Materials [$] | General labour [h] | General labour [$ h⁻¹] | Specialised labour [h] | Specialised labour [$ h⁻¹] | Total [$] | Mean [$ h⁻¹] |
|-----------------------------|----------------|-------------------|-------------|--------------------|------------------------|-----------------------|------------------------|----------|-------------|
| Check tyre pressure         | 10             |                   | 0.30        | 2.70               | 0.81                   | 0.0810                |                        |          |             |
| Replace front tyres         | 3 500          | 2                 | 817         | 1.50               | 2.70                   | 1638.93               | 0.4683                 |          |             |
| Replace back tyres          | 1 750          | 2                 | 136         | 1.00               | 2.70                   | 274.40                | 0.1568                 |          |             |

### 8. Lubrication with grease

- Clean grease nipples before lubricating
- Grease all grease nipples (includes oil check of all racks)
- Lubrication with grease

|                          | Periodicity [h] | Materials [quant.] | Materials [$] | General labour [h] | General labour [$ h⁻¹] | Specialised labour [h] | Specialised labour [$ h⁻¹] | Total [$] | Mean [$ h⁻¹] |
|--------------------------|----------------|-------------------|-------------|--------------------|------------------------|-----------------------|------------------------|----------|-------------|
|                          | 10             |                   | 0.08        | 2.70               | 0.22                   | 0.0216                |                        |          |             |

### 9. Electrical system

- Check batteries (2)
- Check batteries
- Change batteries
- Check dashboard indicators and instruments
- Check warning devices work
- Check grain loss control installation
- Check bulbs and thermoemitters (1)
- Check bulbs and thermoemitters (2)
- Check bulbs and thermoemitters
- Check starter motor (1)
- Check starter motor (1)
- Check alternator (1)
- Check alternator

Replace:
- System check lights (10 bulbs)
- Windscreen wipers
- Full beam headlights
- Dip lights
- Parking lights
- Hopper lights
- Unloading tube lights
- Indicator lights
- Beacon lights
- Cabin light
- Cabin warning lights
- Fuses (do not wear)
- Protection fuse for the electric motor running the cylinder speed changer (replaced in case of accident)
- Bulb for the revolution control system of the separation and cleaning device (bulb 12V/2 sec)

### 10. Air conditioning

- Clean condenser cooler
- Replace refrigerant FREON 12

### 11. Accident prevention

- Check protection systems

Purchase value of the wheat/soy platform: $27,200

(1) During the first 20 h. (2) Before 100 h. (3) From 300 h.
### Annex 1 (cont.)

**Maize platform Mainero 2000 (10 furrows at 70 cm)**

| Periodicity [h] | Materials [quant.] | General labour [h] | Specialised labour [h] | Total [$] | Mean [$ h⁻¹] |
|-----------------|--------------------|--------------------|------------------------|------------|--------------|
| Replace oil in reducers | 500 | 10 | 2.25 | 4.0 | 2.70 | 33.3 | 0.0666 |
| Repair reducers | 2 000 | | 16 | 2.70 | 43.2 | 0.0216 |
| Ratchets (6 per reducer) | 2 000 | 60 | 7.20 | | | |
| Bearings (not replaced) | | | | | |
| Repair of roller blades (4 blades per roller) | 1 000 | 80 | 3.75 | | | |
| Replace lifting chain system | 1 500 | | 1.50 | 2.70 | | 4.05 | 0.0027 |
| Lifting chains (9 × 25-30 cm chains) | 1 500 | 2.7 | 153 | | | |
| Gears (2 per chain) | 1 500 | 18 | 61.9 | | | |
| Replace activation chain (step ASA 50; 2 × 2 m chains) | 1 000 | 4 | 93.9 | 0.5 | 2.70 | 377 | 0.3769 |
| Replace cross-pieces of cardan joints (2 cardan joints; 4 cross-pieces) | 2 500 | 4 | 54.7 | 2.0 | 2.70 | 224 | 0.0897 |
| Replace and adjust spike snapper metal sheets (2 sheets per furrow, incidental) | | | | | |
| Replace metal edges (1 per furrow; incidental) | | | | | |

**Purchase value:** $22,862

### Annex 2. CASE Axial Flow 2188 harvester

**Maintenance and repair items**

| Periodicity [h] | Materials [quant.] | General labour [h] | Specialised labour [h] | Total [$] | Mean [$ h⁻¹] |
|-----------------|--------------------|--------------------|------------------------|------------|--------------|

1. **6TA-830 engine (280 CV)**

- Check condition and tension of belts 10 0.05 2.70 | 0.14 | 0.0135 |
- Check oil level 10 0.10 2.70 | 0.27 | 0.0270 |
- Check cooling system 10 0.20 2.70 | 0.54 | 0.0540 |
- Clean radiator grill 10 0.20 2.70 | 0.54 | 0.0540 |
- Check air restriction indicator 10 0.05 2.70 | 0.14 | 0.0135 |
- Clean alternator grill 10 0.05 2.70 | 0.14 | 0.0135 |
- Drain water separator filter 50 0.05 2.70 | 0.14 | 0.0027 |
- Change engine oil: oil CASE IH no. 1 125 21 2.55 | 0.20 | 2.70 | 54.0 | 0.4323 |
- Change oil filter 125 1 64.8 | 0.20 | 2.70 | 65.4 | 0.5230 |
- Clean air filter 200 0.30 2.70 | 0.81 | 0.0041 |
- Check/tighten water hose clamps 250 0.20 2.70 | 0.54 | 0.0022 |
- Check refrigerant level in radiator 250 0.10 2.70 | 0.27 | 0.0011 |
- Change refrigerant fluid filter 250 1 17.0 | 0.20 | 2.70 | 17.5 | 0.0701 |
- Change fuel line filter (water trap) 500 1 17.5 | 0.10 | 2.70 | 17.8 | 0.0355 |
- Change the engine main fuel filter 500 1 21.5 | 1.10 | 2.70 | 24.4 | 0.0489 |
- Change the engine secondary fuel filter 500 1 13.4 | 2.10 | 2.70 | 19.1 | 0.0382 |
- Change air filter primary element 750 1 102 | 0.20 | 2.70 | 102 | 0.1365 |
- Change air filter secondary element 750 1 63.9 | 0.20 | 2.70 | 64.5 | 0.0860 |
- Grease steering wheel supports 750 0.25 5.35 | 0.20 | 2.70 | 1.88 | 0.0025 |
- Empty diesel tank (end of harvest) 750 0.17 2.70 | 0.45 | 0.0006 |
- Check valve clearance with engine cold 1 000 0.3 | 21.00 | 6.30 | 0.0063 |
- Check injectors (3) 1 200 | 1 21.00 | 21.0 | 0.0175 |
- Check accelerator cable adjustment 1 500 0.08 | 2.70 | 0.22 | 0.0001 |
- Adjust ignition switch in neutral gear 1 500 0.08 | 2.70 | 0.22 | 0.0001 |
- Replace injectors (primed and calibrated; Bosch 17 mm) 2 000 6 147 | 0.67 | 21.00 | 896 | 0.4478 |
- Change cooling system fluid (includes conditioner) 2 000 38 17.7 | 0.17 | 2.70 | 669 | 0.3343 |
### Annex 2 (cont.)

| Maintenance and repair items                                      | Periodicity [h] | Materials [quant.] | General labour [h] | Specialised labour [h] | Total [$] | Mean [$ h⁻¹] |
|------------------------------------------------------------------|-----------------|--------------------|--------------------|------------------------|-----------|--------------|
| Check injection pump (3)                                         | 3 000           |                   | 1                  | 21.00                  | 21.0      | 0.0070       |
| Replace alternator belt                                          | 3 000           | 1                  | 17.1               | 2.70                   | 19.8      | 0.0066       |
| Replace turbo-fan belts                                          | 3 000           | 2                  | 51.3               | 2.70                   | 107       | 0.0355       |
| Rectify/Time engine (performed by a third party workshop)       | 10 000          | 1                  | 3.000              | 0.3000                 | 3.000     | 0.3000       |
| Complete engine repair                                           |                 |                    |                    |                        |           |              |
| Specialised labour                                               | 10 000          | 43                 | 21.00              | 0.0903                 | 903       | 0.0903       |
| Spares (including sleeve, piston, rings, pitman, bed metals and axial bearings, set of engine gaskets and sump seals) | 10 000          | 1                  | 1.608              |                        | 1.608     | 1.608        |

#### 2. Transmission

- Check TDF fluid level
- Check transmission oil level
- Check oil levels in final drives
- Change TDF oil
- Change TDF oil filter
- Change transmission oil
- Change oil in final drives
- Change TDF oil (3)
- Change TDF oil filter (3)
- Change TDF oil (2)
- Change TDF oil filter (2)
- Change TDF oil (oil CASE IH HY-TRAN PLUS) (1)
- Change TDF oil filter (1)
- Complete transmission check (dismantle, check condition of gears and reassemble)
- Complete check of final drives (2 drives)

#### 3. Hydraulic system

- Check hydraulic fluid level
- Clean hydraulic breather
- Change hydraulic fluid (oil CASE IH HY-TRAN PLUS)
- Change system oil filters

#### 4. Cutting head and transporter duct

- Check blade reducer oil level
- Change blade reducer oil (85-140)
- Adjust feeder switch
- Replace blade (full bar)
- Replace platform rudders
- Replace platform conveyor
- Replace blade control belt

#### 5. Threshing and cleaning system

- Check chain and belt tensions
- Check grease nipples (when greasing)
- Replace:
  - Rotor control belt
  - Separator control belt
  - Auxiliary pump control belt
  - Grain tank unloading control belt
  - Feeder counter-axle control belt
## Annex 2 (cont.)

### Combine repair/maintenance costs

| Maintenance and repair items | Periodicity [h] | Materials [quant.] | General labour [h] | Specialised labour [$ h⁻¹] | Total [$] | Mean [$ h⁻¹] |
|-----------------------------|-----------------|-------------------|--------------------|--------------------------|-----------|--------------|
| Feeder control belt         | 4 000           | 1                 | 277                | 0.17 2.70                | 278       | 0.0695       |
| Fan control belt            | 4 000           | 1                 | 42.0               | 0.17 2.70                | 42.5      | 0.0106       |
| Lifter control belt         | 4 000           | 1                 | 239                | 0.17 2.70                | 240       | 0.0599       |
| Straw spreading control belt| 4 000           | 1                 | 94                 | 0.17 2.70                | 94.3      | 0.0236       |
| Straw cutting control belt  | 4 000           | 1                 | 68.0               | 0.17 2.70                | 68.5      | 0.0171       |
| Grease (lithium grease CASE IH 251H EP) (total per year): | | | | | 750 15 5.35 | 80.2 0.1069 |
| Cam supports of the rotor drive | 10             | 0.05              | 2.70               | 0.14 0.0135              | 14        | 0.0135       |
| Rotor pulley                | 10             | 0.05              | 2.70               | 0.14 0.0135              | 14        | 0.0135       |
| Unloading tube pivot        | 10             | 0.05              | 2.70               | 0.14 0.0135              | 14        | 0.0135       |
| Sieve of chaff suspender (right and left sides) | 10 | 0.10 | 2.70 | 0.27 0.0270 | 27 0.0270 |
| Support of the residue feeder conveyor | 10 | 0.05 | 2.70 | 0.14 0.0135 | 14 0.0135 |
| Auxiliary pump tension lever| 50             | 0.06              | 2.70               | 0.16 0.0032              | 3         | 0.0032       |
| Front rotor speed controller| 50             | 0.06              | 2.70               | 0.16 0.0032              | 3         | 0.0032       |
| Back rotor speed controller | 50             | 0.06              | 2.70               | 0.16 0.0032              | 3         | 0.0032       |
| Rotor driving pulley        | 50             | 0.06              | 2.70               | 0.16 0.0032              | 3         | 0.0032       |
| Unloader control tension lever| 50       | 0.06              | 2.70               | 0.16 0.0032              | 3         | 0.0032       |
| Straw cutter tension lever  | 50             | 0.06              | 2.70               | 0.16 0.0032              | 3         | 0.0032       |
| Straw spreader tension lever| 50             | 0.06              | 2.70               | 0.16 0.0032              | 3         | 0.0032       |
| Fan pulley                  | 50             | 0.06              | 2.70               | 0.16 0.0032              | 3         | 0.0032       |
| Cleaning tightening arm     | 50             | 0.06              | 2.70               | 0.16 0.0032              | 3         | 0.0032       |
| Feeder tension lever        | 50             | 0.06              | 2.70               | 0.16 0.0032              | 3         | 0.0032       |
| Header tension lever        | 50             | 0.06              | 2.70               | 0.16 0.0032              | 3         | 0.0032       |
| Fan tightening arm          | 50             | 0.06              | 2.70               | 0.16 0.0032              | 3         | 0.0032       |
| Transverse axis             | 100            | 0.07              | 2.70               | 0.19 0.0019              | 10        | 0.0019       |
| Unloading sleeve axis       | 100            | 0.07              | 2.70               | 0.19 0.0019              | 10        | 0.0019       |
| Exterior drive wheel coupling| 100         | 0.07              | 2.70               | 0.19 0.0019              | 10        | 0.0019       |
| Inner drive wheel coupling  | 100            | 0.07              | 2.70               | 0.19 0.0019              | 10        | 0.0019       |
| Axle support of the feeder reverser | 100   | 0.07 | 2.70 | 0.19 0.0019 | 19 0.0019 |
| Free gear with reversing stone collector | 100 | 0.07 | 2.70 | 0.19 0.0019 | 19 0.0019 |
| Tension lever with reversing stone collector | 100 | 0.07 | 2.70 | 0.19 0.0019 | 19 0.0019 |
| Feeder screw conveyor axis of the residue outlet | 100 | 0.07 | 2.70 | 0.19 0.0019 | 19 0.0019 |
| Slipping clutch of the elevator | 100 | 0.07 | 2.70 | 0.19 0.0019 | 19 0.0019 |
| Elevator inner axis support | 100           | 0.07              | 2.70               | 0.19 0.0019              | 19        | 0.0019       |
| Elevator outer axis support | 100           | 0.07              | 2.70               | 0.19 0.0019              | 19        | 0.0019       |
| Residue feeder screw conveyor axis support | 100 | 0.07 | 2.70 | 0.19 0.0019 | 19 0.0019 |
| Fan case support            | 100            | 0.07              | 2.70               | 0.19 0.0019              | 19        | 0.0019       |
| Outer self-driving wheel coupler | 100         | 0.07              | 2.70               | 0.19 0.0019              | 19        | 0.0019       |
| Inner self-driving wheel coupler | 100         | 0.07              | 2.70               | 0.19 0.0019              | 19        | 0.0019       |
| Inclined feed screw conveyor lower support | 500 | 0.10 | 2.70 | 0.27 0.0005 | 27 0.0005 |
| Rotor front support         | 500            | 0.10              | 2.70               | 0.27 0.0005              | 500       | 0.0005       |
| Hydraulic pump control      | 500            | 0.10              | 2.70               | 0.27 0.0005              | 500       | 0.0005       |
| Clean grain screw conveyor feeder axis | 500 | 0.10 | 2.70 | 0.27 0.0005 | 27 0.0005 |
| Slipping clutch of the agitator axis control | 500 | 0.10 | 2.70 | 0.27 0.0005 | 27 0.0005 |
| Cleaning feeder and fan gear case | 500 | 0.10 | 2.70 | 0.27 0.0005 | 27 0.0005 |
| Fan adjustable pulley       | 500            | 0.10              | 2.70               | 0.27 0.0005              | 500       | 0.0005       |
| Chains                      | 10             | 0.05              | 2.70               | 0.14 0.0135              | 10        | 0.0135       |
| Clean fan control belt      | 750            | 0.17              | 2.70               | 0.46 0.0006              | 460       | 0.0006       |
| Clean fan counteraxis belt  | 750            | 0.17              | 2.70               | 0.46 0.0006              | 460       | 0.0006       |
| Adjust elevator safety clutch | 750           | 0.10              | 2.70               | 0.27 0.0004              | 27        | 0.0004       |
| Adjust gear of the feeder conveyor bed control | 750 | 0.50 | 2.70 | 1.35 0.0018 | 13.5 0.0018 |
| Clean straw spreader        | 100            | 0.33              | 2.70               | 0.89 0.0089              | 89        | 0.0089       |
| Adjust intermediate axis limit switch | 750 | 0.10 | 2.70 | 0.27 0.0004 | 27 0.0004 |
### Annex 2 (cont.)

| Maintenance and repair items | Periodicity [h] | Materials [quant.] | General labour [h] | Specialised labour [$ h^{-1}] | Total [$] | Mean [$ h^{-1}] |
|------------------------------|-----------------|--------------------|-------------------|-----------------------------|--------|---------------|
| Replace mobile wheel blade reinforcement/change wearing plate (labour considered along with that of unloading conveyors) | 750 | 1 | 50.0 | | 50.0 | 0.0667 |
| Adjust concave (automatically from the cabin) | 750 | | | | 0.00 | 0.0000 |
| Replace rotor grinders | 2 000 | 64 | 12.0 | 1 | 2.70 | 768 | 0.3840 |
| Check feeder gear case and cleaning fan oil | 50 | | | 0.17 | 2.70 | 0.46 | 0.0092 |
| Change feeder gear case and cleaning fan oil | 500 | 2.6 | 2.10 | 0.17 | 2.70 | 5.9 | 0.0118 |
| Check lower unloader gear case oil | 50 | | | 0.05 | 2.70 | 0.14 | 0.0027 |
| Change lower unloader gear case oil | 500 | 0.86 | 2.10 | 0.17 | 2.70 | 2.26 | 0.0045 |
| Check rotor gear case oil | 50 | | | 0.05 | 2.70 | 0.14 | 0.0027 |
| Change rotor gear case oil | 500 | 3.8 | 2.10 | 0.17 | 2.70 | 8.4 | 0.0169 |
| Check straw cutter gear case oil | 50 | | | 0.05 | 2.70 | 0.14 | 0.0027 |
| Change straw cutter gear case oil | 500 | 3.1 | 2.10 | 0.17 | 2.70 | 7.0 | 0.0139 |
| Replace axle guards of the grain pan | 1 500 | 6 | 7.97 | 0.17 | 2.70 | 48.3 | 0.0322 |
| Replace rotor point bearings | 5 000 | 2 | 115 | 3 | 21.00 | 292 | 0.0584 |
| Replace conveyors: | | | | | | |
| Conveyor bed conveyors (along with conveyors) | 2 500 | 5 | 71.6 | | 21.00 | 463 | 0.1853 |
| Conveyor bed bearings | 2 500 | 5 | 42.8 | | | 214 | 0.0856 |
| Wooden blocks of the conveyor bed | 1 250 | 5 | 3.00 | | 1.5 | 21.00 | 46.5 | 0.0372 |
| Clean grain conveyor | 1 800 | 1 | 796 | | 2 | 21.00 | 838 | 0.4655 |
| Clean grain conveyor bearings (change with conveyor) | 1 800 | 2 | 42.8 | | | 85.6 | 0.0475 |
| Rethreshing conveyor | 2 750 | 1 | 588 | | 2 | 21.00 | 630 | 0.2292 |
| Rethreshing conveyor bearings (along with conveyor) | 2 750 | 2 | 42.8 | | | 85.6 | 0.0311 |
| Inclined supply conveyor | 2 750 | 1 | 1.194 | | 1.5 | 21.00 | 1.225 | 0.4456 |
| Inclined supply conveyor bearings (along with conveyor) | 2 750 | 2 | 1.605 | | | 3.209 | 1.1670 |
| Hopper conveyors (along with conveyor) | 2 750 | 2 | 583 | | 7 | 21.00 | 1.421 | 0.5166 |
| Hopper conveyor bearings | 2 750 | 2 | 42.8 | | | 85.6 | 0.0311 |
| Elevating vertical conveyor | 1 500 | 1 | 716 | | 5 | 21.00 | 821 | 0.5476 |
| Change oil in square cases (2 x 1.5 litre cases) | 1 000 | 3 | 4.00 | 0.25 | 2.70 | 12.7 | 0.0127 |
| Unloading tube conveyors (linked by a hexagonal joint and bearing) | 1 500 | | | | 4 | 21.00 | 84.0 | 0.0560 |
| Back horizontal conveyor | 1 500 | 1 | 637 | | | 637 | 0.4245 |
| Front conveyor | 1 500 | 1 | 637 | | | 637 | 0.4245 |
| Change square case oil | 1 000 | 1.5 | 4.00 | 0.25 | 2.70 | 6.67 | 0.0067 |
| Unloading screw conveyor square case bearings (labour considered along with conveyor replacement) | 1 500 | 2 | 42.8 | | | 85.6 | 0.0571 |

6. Wheels, brakes and steering

| Check tyre pressure | 50 | | 0.30 | 2.70 | | 0.81 | 0.0162 |
| Adjust brake pedal | 4 000 | | 0.08 | 2.70 | | 0.22 | 0.0001 |
| Replace front tyres (35.5 L 32-10 screens) | 7 000 | 2 | 1.727 | 1.50 | 2.70 | 3.458 | 0.4940 |
| Replace back tyres (18.4-26-10 screens) | 1 800 | 2 | 632 | 1.00 | 2.70 | 1.266 | 0.7034 |
| Adjust wheel nuts and bolts | 1 800 | | 0.25 | 2.70 | | 0.68 | 0.0004 |

Grease:
- Steering axis (front and back pivots) | 50 | 0.20 | 4.60 | 0.08 | 2.70 | 1.14 | 0.0227 |
- Power guide axis (300 g grease): | 50 | 0.30 | 4.60 | | | 1.38 | 0.0276 |
- Ends of tensing bar (right and left) | 50 | | 0.04 | 2.70 | | 0.11 | 0.0022 |
- Steering roller ball-and-sicket joints (right and left) | 50 | | 0.04 | 2.70 | | 0.11 | 0.0022 |
- Steering hinge-left upper and lower parts | 50 | | 0.04 | 2.70 | | 0.11 | 0.0022 |
- Steering hinge-right upper and lower parts | 50 | | 0.04 | 2.70 | | 0.11 | 0.0022 |
- Adjustable control axis (absent in this model): | 50 | 0.20 | 4.60 | | | | |
- Tensing rod end (left and right) | 50 | | 0.04 | 2.70 | | | |
- Left and right steering roller ball-and-sicket joints | 50 | | 0.04 | 2.70 | | | |
- Right and left steering hinge | 50 | | 0.04 | 2.70 | | | |
- Left and right wheel support | 750 | | 0.04 | 2.70 | | | |
### 8. Electrical system

| Maintenance and repair items | Periodicity [h] | Materials [quant.] | General labour [$ h] | Specialised labour [$ h$^{-1}] | Total [$] | Mean [$ h$^{-1}] |
|-----------------------------|-----------------|-------------------|----------------------|-----------------------------|-----------|----------------|
| Check electrolyte levels in batteries | 100 | 1 | 0.50 | 0.08 | 2.70 | 0.71 | 0.0071 |
| Change batteries | 2 500 | 2 | 180 | 0.20 | 2.70 | 361 | 0.1445 |
| Check dashboard indicators and instruments | 10 | | | 0.03 | 2.70 | 0.09 | 0.0089 |
| Check warning devices work | 10 | | | 0.03 | 2.70 | 0.09 | 0.0089 |
| Replace: | | | | | | | |
| — Front headlights: | | | | | | | |
| • Full beam cabin lights | 4 000 | 3 | 20.4 | 0.13 | 2.70 | 61.5 | 0.0154 |
| • Dip cabin lights | 4 000 | 3 | 15.3 | 0.13 | 2.70 | 46.2 | 0.0115 |
| • Headlights under cabin | 4 000 | 2 | 17.4 | 0.08 | 2.70 | 34.9 | 0.0087 |
| • Side lights | 4 000 | 2 | 26.5 | 0.08 | 2.70 | 53.2 | 0.0133 |
| • After-cutting lights | 4 000 | 2 | 17.4 | 0.08 | 2.70 | 34.9 | 0.0087 |
| • Back floodlight | 4 000 | 1 | 52.1 | 0.08 | 2.70 | 52.3 | 0.0131 |
| • Tail lights (parking and turning) | 4 000 | 2 | 42.8 | 0.08 | 2.70 | 85.8 | 0.0215 |
| — Dashboard lights: | | | | | | | |
| • Indicator background lights | 4 000 | 2 | 1.30 | 0.10 | 2.70 | 2.9 | 0.0007 |
| • Dashboard background lights | 4 000 | 1 | 1.30 | 0.10 | 2.70 | 1.6 | 0.0004 |
| • Grain sweeping monitoring lights | 4 000 | 2 | 1.30 | 0.10 | 2.70 | 2.9 | 0.0007 |
| • Indicator lights | 4 000 | 2 | 1.30 | 0.17 | 2.70 | 3.1 | 0.0008 |
| • Grain hopper light | 4 000 | 1 | 20.4 | 0.08 | 2.70 | 20.6 | 0.0051 |
| • Unloading tube light | 4 000 | 1 | 14.8 | 0.08 | 2.70 | 15.0 | 0.0037 |
| Replace windscreen wiper blade | 7 500 | 1 | 4.12 | 0.05 | 2.70 | 4.26 | 0.0006 |

### 9. Air conditioning, heating and ventilation

| Maintenance and repair items | Periodicity [h] | Materials [quant.] | General labour [$ h] | Specialised labour [$ h$^{-1}] | Total [$] | Mean [$ h$^{-1}] |
|-----------------------------|-----------------|-------------------|----------------------|-----------------------------|-----------|----------------|
| Clean cabin air filter | 20 | | | 0.17 | 2.70 | 0.46 | 0.0230 |
| Change cabin air filter | 2 000 | 1 | 97 | 0.17 | 2.70 | 97.8 | 0.0489 |
| Replace air conditioning gas | 4 000 | | | | | 150 | 0.0375 |

Purchase value of the wheat/soy platform: $27,200

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### Annex 2 (cont.)

| Maintenance and repair items | Periodicity [h] | Materials [quant.] | General labour [$ h] | Specialised labour [$ h$^{-1}] | Total [$] | Mean [$ h$^{-1}] |
|-----------------------------|-----------------|-------------------|----------------------|-----------------------------|-----------|----------------|
| Check oil level of the roller gear-cases (8 cases) | 10 | | | | 1.07 | 0.1073 |
| Replace oil in the roller gear-cases (oil 85-140) | 1 000 | 12 | 2.00 | 3.00 | 2.68 | 32.05 | 0.0320 |
| Replace rollers (2 per furrow) (do not need changing) | 16 | 82.7 | 8.00 | 2.68 | 0.80 | 0.60 |
| Replace roller ends (labour included with that of rollers) | 1 750 | 16 | 71.0 | 2.50 | 2.68 | 6.70 | 0.0034 |
| Replace roller blades (4 blades per roller) | 900 | 64 | 23.0 | 10.0 | 2.68 | 1.49 | 0.1663 |
| Replace roller counterblades (1 blade per roller) | 900 | 16 | 17.0 | 4.00 | 2.68 | 283 | 0.3141 |
| Replace roller control system | 2 000 | | | 2.50 | 2.68 | 6.70 | 0.0034 |
| Control chains (1 per roller) | 2 000 | 16 | 45.0 | 2.50 | 2.68 | 720 | 0.3600 |
| Back gear drive (1 per roller) | 2 000 | 16 | 28.0 | 2.50 | 2.68 | 448 | 0.2240 |
| Front gear- tensor-bearing complex (1 per roller) | 2 000 | 16 | 17.0 | 2.50 | 2.68 | 272 | 0.1360 |
| Repair platform conveyor (does not need changing) | 5.5 | 40.0 | | 3.0 | 30 | 181.3 | 0.4534 |
| Replace reducer and conveyor drive chain (10 metres) | 400 | 10 | 18.0 | 0.50 | 2.68 | 4.57 | 3.943 |

Purchase value: $25,250