Detailed Design Document

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Document revision history

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1.0	2023-03-29	Created the document	Claes
1.1	2023-04-12	Added section 3 and section 4	Anisa, Julia, Dilan, Michael, Claes

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Contributions

Date		**Contribution**	**Contributor**
2023-03-29		Initial Commit	Oliver, Claes, Lasse, Tobias
2023-04-12		Section 3	Julia, Anisa
2023-04-12	Section 4	Dilan, Michael	

1. Scope

1.1 Identification

The system which this document describes the design off, is an add on to the powerflow header form AGCO, with reported inadequate height control. The system consist of hydraulic controlled wheel, which rides on the ground to provide stability to the header. The hydraulics are controlled by feedback sensors on each wheel, which feedback to a controller that regulates the hydraulics accordingly. The hydraulic pressure is supplied by connecting the system to the existing hydraulics of the header.

1.2 System overview

The system described in this document aims to alleviate the problems reported by farmers concerning the powerflow headers from AGCO. The header is subject to instability when operating in uneven terrain, do great dissatisfaction to the user. The system is designed as an add-on to the existing powerflow headers that will act as a stabilizer, limiting the problems reported by users.

1.3 Document Overview

This document will contain how the system and subsystem will be structured to satisfy the system requirements. It is the primary reference for subsequent implementation, and it will contain all the information needed by developers to construct the system.

This document is intended for internal use only and should not be distributed. External holders of the document should delete the document once the purpose for their access has been completed.

2. Referenced documents

This document references System Requirements Document version 1.1, hereafter referred to as the SRS.
This document references Preliminary Design Description version 1.1, hereafter referred to as PDD.
This document references Interface Control Document version 1.1, hereafter referred to as ICD.
This document references Tracability matrix version 1.1

3. System-wide design decisions

This section will describe the system in detail and describe the design decision being made accordingly.

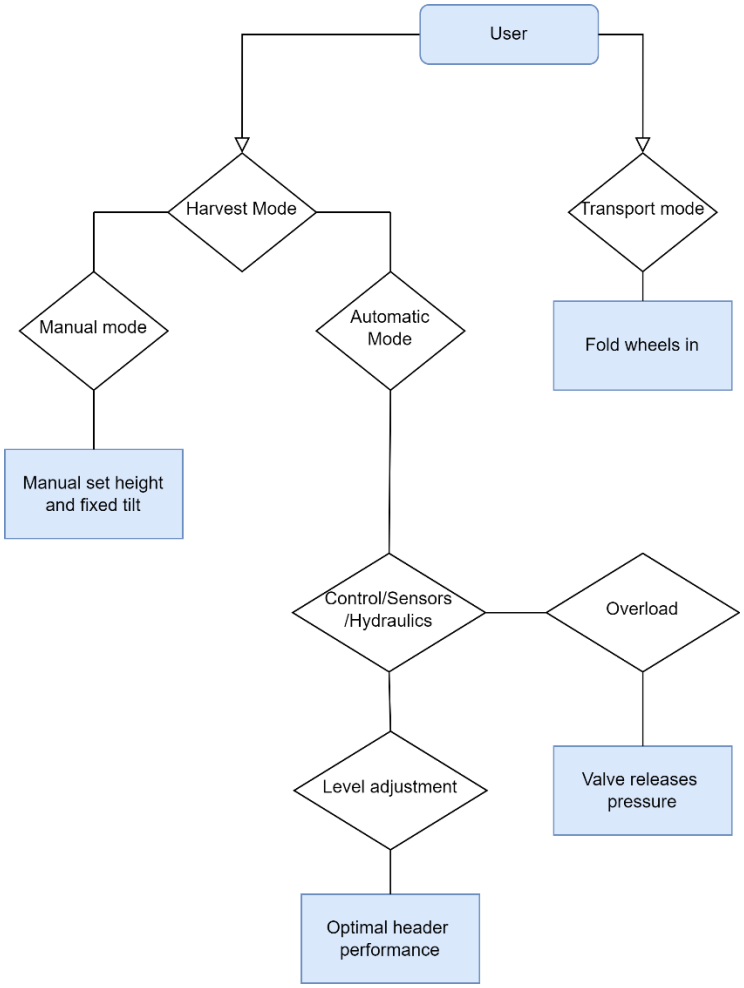


Figure 1 - Flow diagram of system functions

a) Design decisions regarding inputs the system will accept and outputs it will produce.

Inputs	Outputs
Combine is in harvest mode. AHHC enable button is pressed by operator.	AHHC system is engaged, and the header will level automatically to reduce stubble wobble when driving on uneven ground.
Combine is in harvest mode. Manual level control enable button is pressed by operator.	Lever for level control is unlocked and operator can adjust height of the header.
Transport mode button is pressed by operator.	The wheels of the AHHC system are retracted and placed in the appropriate mode for transportation of the header.
Over-pressure sensor is triggered indicating a load of more than 500 kg on the structure.	Pressure release valve is opened and pressure is drained from actuators reliving the load on the wheel and structure.

b) Design decisions on system behaviour in response to each input or condition, including actions the system will perform, response times and other performance characteristics.

Task: Enable transport mode

Input (trigger): Transport mode button is pressed by operator.

Precondition: Combine is in harvest mode

Response time: 20s

Subtasks:

i. Auto Header Height Control system receives the signal that the button is pressed
ii. The AHHC system sends the request to the actuator to retract the wheels
iii. The actuator retracts the wheels

Task: Enable manual control

Input: Manual level control button is pressed by operator

Precondition: Combine is in harvest mode. Combine is in automatic mode.

Response time: 1s

Subtasks:

i. AHHC system receives the signal that the button is pressed
ii. The AHHC system sends the request to the lever to unlock the level control
iii. The lever unlocks the level control

Task: Enable automatic control

Input: Automatic level control button is pressed by operator

Precondition: Combine is in harvest mode. Combine is in manual mode.

Response time: 1s

Subtasks:

I. AHHC system receives the signal that the button is pressed
II. The AHHC system sends the request to the lever to lock the level control
III. The lever locks the level control

Task: React to load of more than 500kg on the structure

Input: Over-pressure sensor is triggered

Precondition: Combine is in harvest mode.

Response time: 20s

Subtasks:

i. The sensors send a signal to the AHHC system about over-pressure
ii. The AHHC system sends request pressure release valve to be opened
iii. The pressure valve opens and the pressure is drained from the actuators

c) Design decisions on how system databases/data files will appear to the user.

Not applicable

d) Selected approach to meet safety, security, and privacy requirements.

The relevant requirements regarding safety, security and privacy and how they are approached are listed below.

Category	Req. ID	Requirement description	Approach
Safety	R18	The wheels and structure should be overload protected in case the load excess 500 kg.	Use sensors to monitor the pressure

e) Design and construction choices for hardware or hardware-software systems, such as physical size, color, shape, weight, materials, and markings.

Wheels

Design and construction choices regarding the wheels are proposed by the subcontractor.

The chosen wheel solution consists of two farming tires (T448) with extra strong treads and easy rolling patterns. Each tire should be able to fit on a rim with the size: 6.75 x 14.5 - 8 mm. The technical specifications of the chosen tire and rim are found below.

TIRES 14.5”

SIZE	PR/LI	TREAD PATTERN	MAIN RANGE OF USE	RIM	PERMITTED RIMS	OD mm +/-1,5%	SW mm +/-2%	MAX. AIR PRESSURE bar	MAX. LOAD kg	SPEED (km/h)	RC mm +/-2,5%
200/60-14.5	10	T448 Extra	Farming	6.75	8.00	620	206	5,0	950	30	1841

Table 1 - Technical specifications of the chosen tire from Trelleborg Wheel Systems

DIAMETER [INCHES]	RIM SIZE	DISC THICKNESS [MM]	WELDED WHEEL	BOLTED WHEEL	WHEEL WITH INTEGRATED HUB	WHEEL WITH CENTER BORE
14.5	6.75X14.5	6/8	•		•	
	6.75X14.5	6/8	•			•

Table 2 - Technical specifications of the chosen rim from Trelleborg Wheel Systems

The suggested rim type is the one with an integrated hub as shown in the figure below.

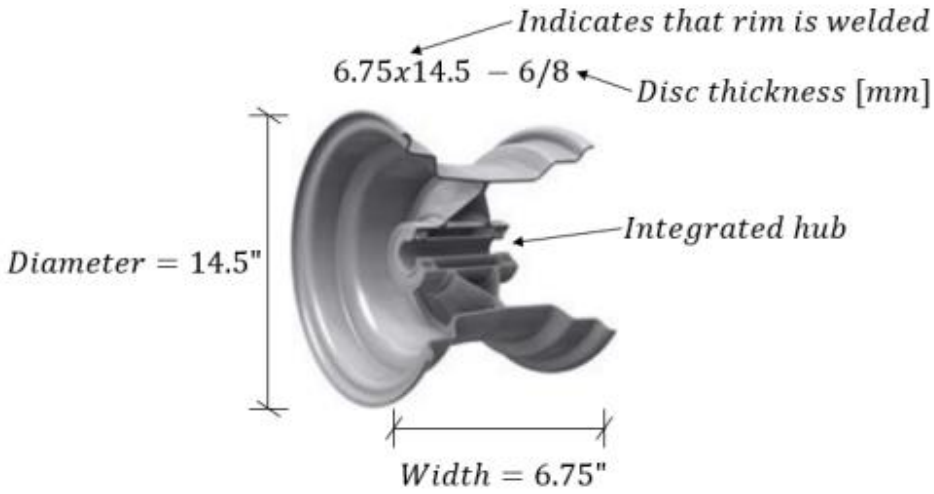


Figure 1 - Cross-sectional view of the integrated hub rim with dimensions

The chosen tire is illustrated in the figure below.

Figure 2 - Illustration of the chosen tire model (T448) with dimensions

Sensors

A proposed sensor for the system:

https://www.sick.com/dk/da/vskesensorer/tryksensorer/pbs-plus/c/g507653

Actuators

A proposed actuator for the system:

https://www.linak.dk/produkter/lineaere-aktuatorer/la36/

f) Other system-wide design decisions made in response to requirements, such as selected approach to providing required flexibility, availability, and maintainability

Req. ID	Requirement description	Category	Design decisions
R6	Operator shall be able to enable and disable wheels from cabin.	Flexibility	Button to switch between manual and automatic mode

4. System Architectural Design

4.1 System components

The following section describes the system components with unique ID's, associated requirements, purpose, development status, and resources used by the component. Previously described component descriptions from the ConOps document section 3.4.1 are re-used when relevant.

4.1.1 Component overview

Component	**Component ID**	**Requirements**	**Development**
Combine Header	C1	R2, R15, R21	Finished
Header Position Control	C1.1	R12, R15, R21	In iteration
Auto Header Height Control system	C1.1.1	R15, R21	In iteration
Active Support Wheels	C1.1.1.1	R21	In development
Feederhouse	C2	R21	Finished
Processor	C3	R21	Finished
Cleaning system	C3.1	R21	Finished
Bin Filling	C3.2	R21	Finished
Sensor	C4	R7, R21	Finished

4.1.2 Component Description

C1: Combine Header

Purpose: Combine header controls how the header moves and where it is positioned using hydraulic power.

Description: The header of the combine harvester operates mainly in 4 states. When the harvester is operating at a field, the first thing to occur is the crop being fed into the header. The crop is then cut at the stem before being transported into the collector, which handles and distributes the crop into the combine harvester.

Resources: The header utilizes a Header Position Control system to control the orientation of the header.

C1.1: Header Position Control

Purpose: Controlling the orientation of the combine header.

Description: A header position control is controlling and managing the lift, pitch, and tilt angle of the header to control orientation, which is automatically controlled by the Auto Header Height Control (AHHC) system. The position and orientation of the header is hydraulically actuated. Dragod sensors are used to detect the ground; rods are connected to potentiometers, which are used to measure the DOF angles.

Resources: The Header Position Control utilizes the AHHC system.

C1.1.1: Auto Header Height Control system

Purpose: Controlling the height of the harvester

Description: The AHHC system is an automatic system that controls the orientation of the header during operation.

Resources: The AHHC system utilizes the Active Support Wheel system to assist in stabilization by using wheel support.

C1.1.1.1: Active Support Wheels

Purpose: Providing stabilization for the header and assisting the AHHC during operation using wheel support.

Description: Tires that at maximum will sink 25 mm into the soil under moist soil conditions across soil texture JB1 to JB7.

Resources: -

C2: Feederhouse

Purpose: Feederhouse's purpose is to gather the crop from the header and transfer it to the threshing mechanism in a consistent and efficient manner. The main use is transportation.

Description: The Feederhouse typically consists of a series of rotating augers, belts or chains that move the crop towards the threshing mechanism while also separating any large debris or foreign objects.

C3: Processor

Purpose: The purpose of the Processor is to perform several key functions during the harvesting process, including feeding, threshing, separating, and discharging the crop.

Description: The feeding function involves pulling the crop into the machine using a pickup or header, and then conveying it towards the threshing mechanism. The threshing function involves breaking apart the crop to separate the valuable grain or forage material from the non-valuable parts, such as stalks or leaves. The separating function involves separating the valuable material from the non-valuable material, which may be done using a variety of mechanisms such as sieves, blowers or gravity separators. Finally, the discharged function involves directing the harvested material to a storage container or wagon.

C3a: Cleaning System

Purpose: The Cleaning System is an essential component of crop harvesting equipment, as it helps to ensure the quality and purity of the harvested crop by removing any unwanted materials.

Description: The Cleaning System typically includes several stages or functions, including feeding, stratification, pre-separation, cleaning, and tailing. The stratification function involves separating the crop

into different layers based on size and weight. The pre-separation function involves removing any large debris or foreign objects from the crop before it moves on to the cleaning stage.

C3b: Bin Filling

Purpose: The purpose of the Bin Filling/Unloading system is to efficiently and safely transfer the harvested crop from the harvesting machine's storage bin to an external storage or processing facility.

Description: During the harvesting process, the harvested crop is collected and stored in a hopper or bin within the harvesting machine. When the bin becomes full, the Bin Filling/Unloading system is engaged to transfer the crop to an external storage or processing facility

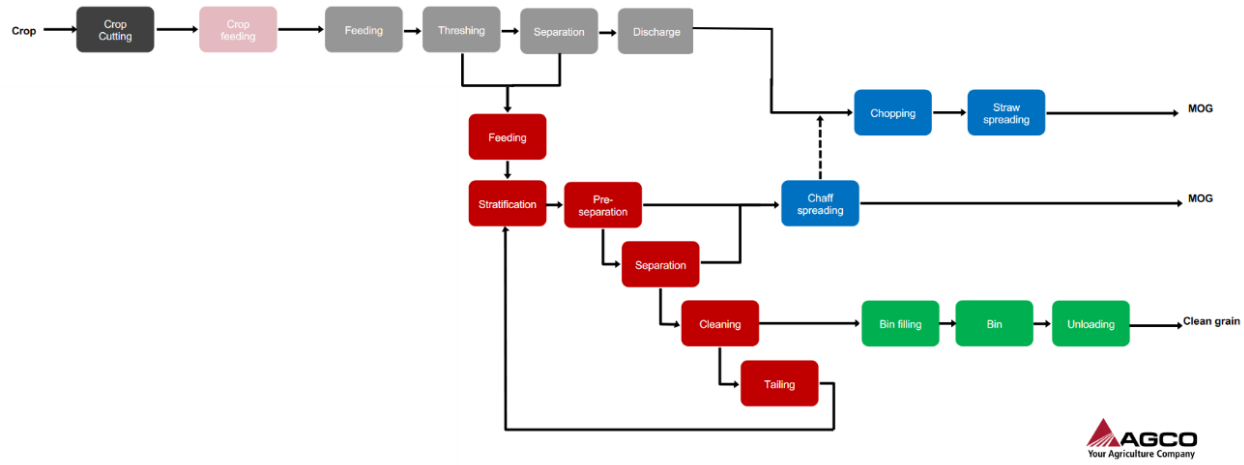
C4: Sensors

Purpose: The purpose of the sensors is to sense physical properties.

Description: Sensors provide readings about physical (mostly environmental) properties.

4.2 Concept of execution

Component Relationship Diagram:



4.3 Interface design

See Interface Control Description document.