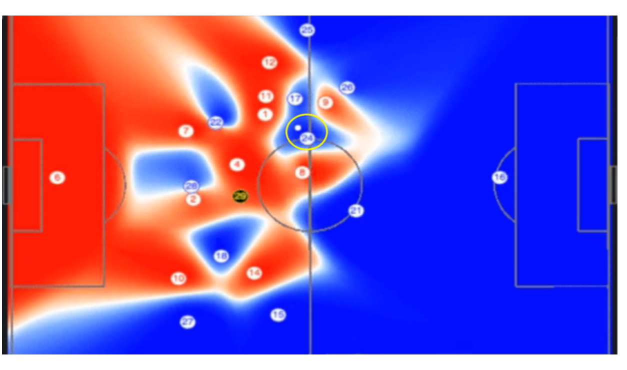
Pitch Control

1. Introduction

Tracking data, (x, y) co-ordinates of every player plus the ball during a football match, permits a wide range of analysis to be performed. One of the most interesting applications of this type of data in the last few years is undoubtedly pitch control models, allowing visualizations of the game that were previously impossible, thus providing a new way of looking at the game.

Calculations are made to find the probability that each team would control the ball at every point on the pitch given the current player and ball positions and velocities.

Whilst awareness of space on a pitch is taught from the youngest levels of youth football, a way of quantifying the control each team has over every position on the pitch, and visualizing how this changes with player and ball movement in real time, is set to be part of the data revolution in football.



Pitch control visualization example

PITCH CONTROL MODELS ARE EVIDENCE FOR THE OPTIMAL WAY OF PLAYING THE GAME

For any football fan who still reminisces over the joy of watching those glory years for spanish football around the turn of the 2010's, those countless perfect performances (Spain 2012 Euro final, Barcelona 2011 Champions League final and 5-0 demolition of Real Madrid always stand out for me!) are a mastery of the football space-time continuum! The heartbeat of those teams, Xavi, has spoken in interviews of how he looks at the game through this lens of space and time. He speaks of this constant relationship of players finding space, having more time to think, and passing to the next player in space to move the game into optimal attacking positions. Whilst there are many different perspectives on how to play the game, this school of thought stemming from the famous Cruyff teams in the early 1970's, is widely considered the very peak of quality football. How interesting it is then, that these new pitch control models also point heavily towards the game being played in this way. The following sections now delve in to how these models are created and used.

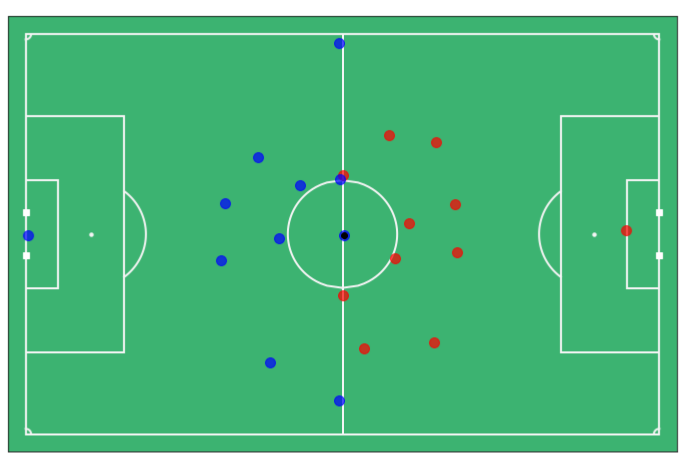
2. Tracking Data

The sample of 2 matches is provided by Metrica Sports, along with some helpful functions shared on GitHub by Laurie Shaw via the Friends of Tracking initiative. Note that some operations have to be performed on the raw data, such as transforming the metrica coordinate system to metres, in order for calulations relating to speed and accelerations to be made for pitch control.

Firstly, lets look at the tracking data and plot a simple pitch map that shows all the player positions to visualize an instance of the game.

In [1]:
```
import Metrica_IO as mio
import Metrica_Viz as mviz
import Metrica_Velocities as mvel

# set up initial path to data
DATADIR = r'C:\Users\steff\Documents\Football Analytics\FOT Tracking Data - Laurie\sample-data-master\d
ata'
game_id = 2 # let's look at sample match 2

# read in the event data
events = mio.read_event_data(DATADIR,game_id)

# read in tracking data
tracking_home = mio.tracking_data(DATADIR,game_id,'Home')
tracking_away = mio.tracking_data(DATADIR,game_id,'Away')

# Convert positions from metrica units to meters (note change in Metrica's coordinate system since the
 last lesson)
tracking_home = mio.to_metric_coordinates(tracking_home)
tracking_away = mio.to_metric_coordinates(tracking_away)
events = mio.to_metric_coordinates(events)

# reverse direction of play in the second half so that home team is always attacking from right->left
tracking_home,tracking_away,events = mio.to_single_playing_direction(tracking_home,tracking_away,events
)

# plot player positions at kick-off
KO_Frame = events.loc[0]['Start Frame']
fig,ax = mviz.plot_frame( tracking_home.loc[KO_Frame], tracking_away.loc[KO_Frame] )
```

```
Reading team: home
Reading team: away
```



Next, to calculate the probability of a team taking control if the ball were to arrive at any point on the pitch, the ball and all player velocities must be calculated.

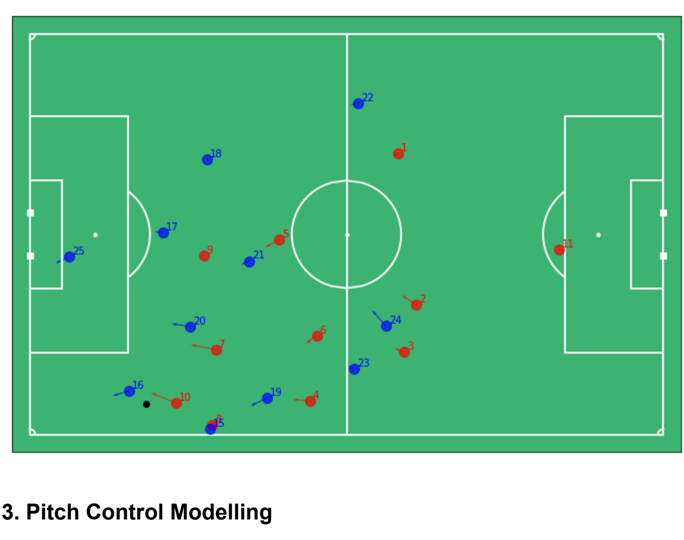
The function calc_player_velocities() performs this calculation by cycling through each player in the team and performing 2 simple steps with the tracking data. Note that x1, x2 = x coordinate in metres at time 1 and time 2 respectively, and t = time difference between x1 and x2. The same logic applies for y1 and y2. The 2 steps to calculate velocity are:

```
(1) x_velocity = abs(x1 - x2) / t
    y_velocity = abs(y1 - y2) / t
(2) velocity = sqrt( x_velocity^2 + y_velocity^2 )
```

Following the player velocities being calculated, this information can be added to the plot above to demonstrate these values. Player velocity is key in evaluating the probability of a player reaching a position on the pitch. These velocities are added below where the length of the arrows indicate the direction and magnitude.

In [11]:
```
tracking_home = mvel.calc_player_velocities(tracking_home,smoothing=True,filter_='moving_average')
tracking_away = mvel.calc_player_velocities(tracking_away,smoothing=True,filter_='moving_average')

# plot a random frame, plotting the player velocities using arrows.
mviz.plot_frame( tracking_home.loc[1000], tracking_away.loc[1000], include_player_velocities=True, anno
tate=True)
```

Out[11]:
```
(<Figure size 864x576 with 1 Axes>,
 <matplotlib.axes._subplots.AxesSubplot at 0x200c39ed0d0>)
```



3. Pitch Control Modelling

Assumptions

Before modelling, some assumptions have to made about certain factors such as expected ball velocity, the maximum player velocities when trying to control the ball, and player acceleration. The assumed values for these factors have been taken from model estimates created by William Spearman, Liverpool F.C, and are listed below:

- Ball velocity ~ 15 m/s
- Maximum player velocity when seeking to control the ball ~ 5 m/s
- Final assumption that each player takes the shortest trajectory to each position.

Pitch Control Calculations

Now that we have the necessary data, there are 3 essential components that need to be calculated in order to formulate a pitch control model:

```
(1) How long it will take for the ball to arrive at a location
```

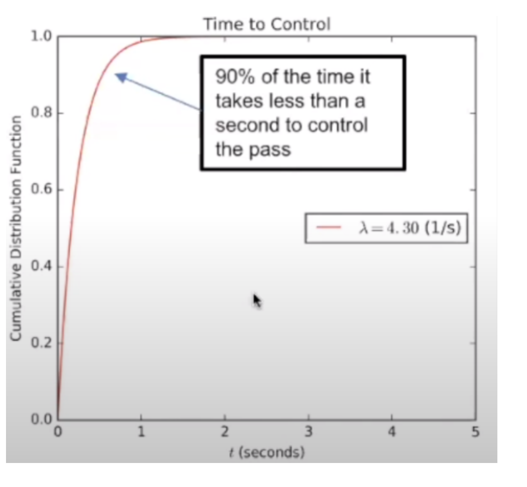
This is a simple calculation given the assumed ball velocity. A time value is calculated for the ball to arrive at each position away from the current position of the ball.

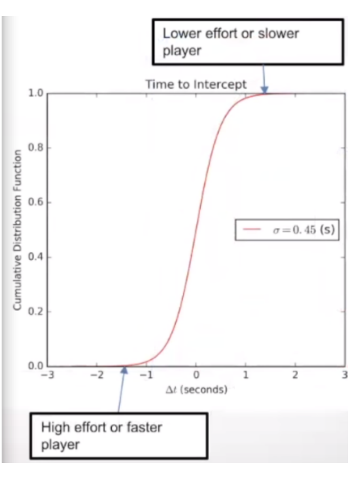
```
(2) How long it will take for each player to arrive at a location
```

The time for each player to arrive at each position is broken down into 2 steps. A 'reaction' period of 0.7 seconds where each player continues in the current path with no change in velocity. Then, the player follows the shortest trajectory to each position with the assumed maximum velocity.

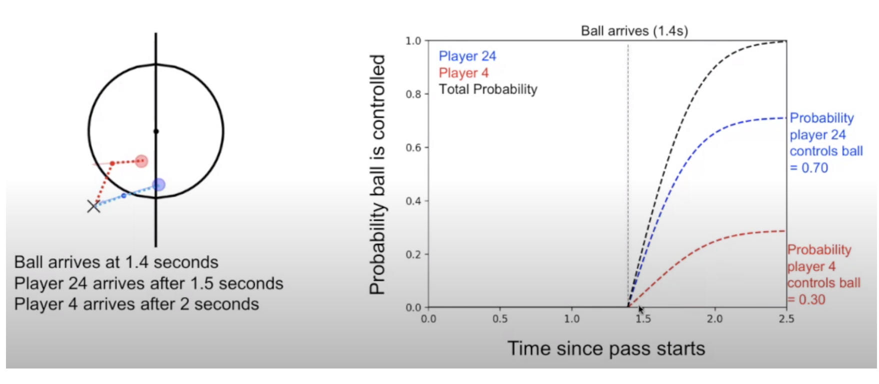
```
(3) The total probability that each team will control the ball once it has arrived at a location
```

Control probability is a more involved calculation. Reference to the following 2 figures below will be made to explain. The probability that a player actually takes the ball under control once arriving at the position is modelled by Spearman as a fixed rate estimated to be ~ 4.3 s^-1 * change in time. This is shown in the figure below on the left, 'Time to Control'. In conjunction with this, uncertainty is added to this due to the probability of an opposing player intercepting the control. This is modelled by Spearman as a sigmoidal distribution dependant on defensive intensity or speed of the defensive player, shown in the figure below on the right, 'Time to Intercept'.





A combination of these two elements provides the necessary components to calculate the 3rd part of the pitch control model. Finally, a value for the probability of each player controlling the ball at a given position can be calculated. An example of this completed process is shown in this figure below.



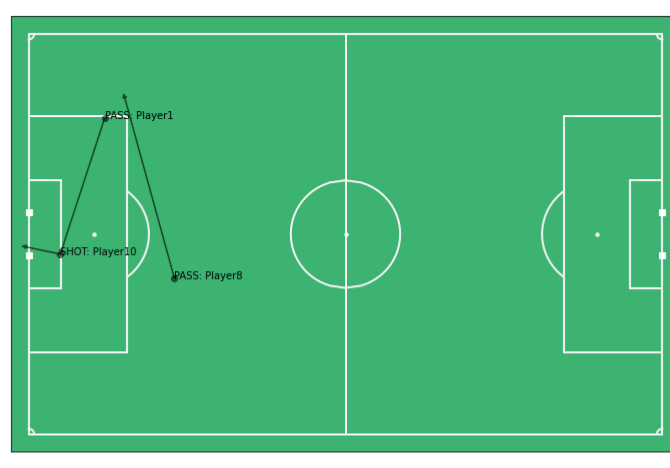
The entire pitch is broken down into a grid of pixels, and this pitch control calculation is made across all positions. Thus, a comprehensive view of the entire field of play can be visualized in terms of the probability of ball possession, were the ball to reach that position. This results in extremely valuable insights to analyse games.

4. Pitch Control Plots

Here we look at an example of the applications of the pitch control model. The chosen event extracted is the first goal scored in the sample data set, game 2, made available by Metrica Sports. The plot below shows the pass map for the crucial penultimate pass, and subsequent crossed assist for a goal.

In [12]:
```
mviz.plot_events( events.loc[196:198], color='k', indicators = ['Marker','Arrow'], annotate=True )
```

Out[12]:
```
(<Figure size 864x576 with 1 Axes>,
 <matplotlib.axes._subplots.AxesSubplot at 0x200c36730d0>)
```

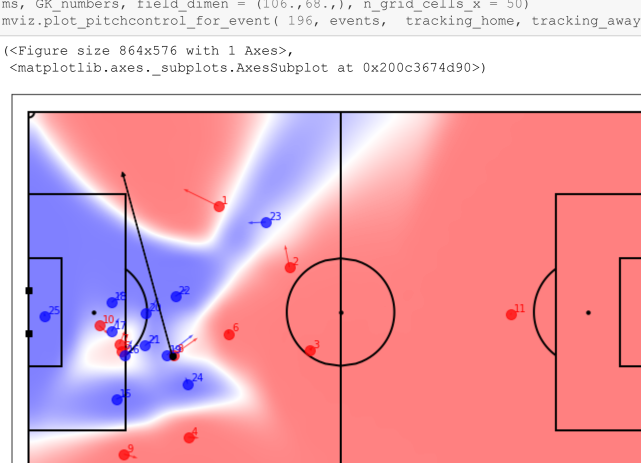


From this pass map alone, not too many insights can be drawn to analyse. Now, we see the power of the pitch control model.

The aforementioned calculations are performed using the function calculate_pitch_control_at_target() imported from the Metrica_PitchControl library. In turn, the function generate_pitch_control_for_event(), from the same library, is used to then plot all the resultant calculations at each position, to finally present the visualizations of pitch control shown below.

In [13]:
```
import Metrica_PitchControl as mpc

# first get pitch control model parameters
params = mpc.default_model_params()
# find goalkeepers for offside calculation
GK_numbers = [mio.find_goalkeeper(tracking_home),mio.find_goalkeeper(tracking_away)]

# evaluated pitch control surface for penultimate pass
PPCF,xgrid,ygrid = mpc.generate_pitch_control_for_event(196, events, tracking_home, tracking_away, para
ms, GK_numbers, field_dimen = (106.,68.,), n_grid_cells_x = 50)
mviz.plot_pitchcontrol_for_event( 196, events,  tracking_home, tracking_away, PPCF, annotate=True )
```

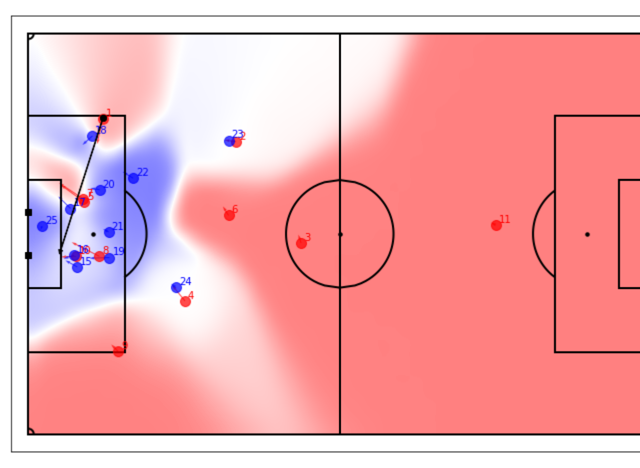
Out[13]:
```
(<Figure size 864x576 with 1 Axes>,
 <matplotlib.axes._subplots.AxesSubplot at 0x200c3674d90>)
```



Observing the pitch control visualization above highlights the various options available to the player on the ball. We can see the safe regions to simply retain possession and keep the pressure on, such as a pass back to player 6. However, more dangerous areas to play the ball into, where the attacking team is likely to retain the ball are available. A brilliant pass is made to the wide area where the teammate is in ample space to pick out a good cross. The result of this is seen in the following visulization.

In [14]:
```
# evaluated pitch control surface for cross assist
PPCF,xgrid,ygrid = mpc.generate_pitch_control_for_event(197, events, tracking_home, tracking_away, para
ms, GK_numbers, field_dimen = (106.,68.,), n_grid_cells_x = 50)
mviz.plot_pitchcontrol_for_event( 197, events,  tracking_home, tracking_away, PPCF, annotate=True )
```

Out[14]:
```
(<Figure size 864x576 with 1 Axes>,
 <matplotlib.axes._subplots.AxesSubplot at 0x200c1fafac0>)
```



The attacking pass played results in this great crossing opportunity, resulting in a goal. By comparing the two previous visualizations it is apparent that the penultimate pass was the key, as the defensive team has nothing left to do but to try to defend in the box. The pass out wide into space has split the defence and given a great opportunity to score.

5. Final Comments

This notebook has been a quick intro into tracking data, as well as a demonstration of the power of what can be produced using it, through pitch control analysis. A brief highlight over how the model is calculated has been presented and a very simple example has been show mainly just to demonstrate the pitch control visualization itself.

However, the applications of this are far reaching. These advanced analytics allow for in-depth understanding of opposition scouting, the impact of different formations and tactics on space, as well as the potential to explore how off the ball runs can contribute to creating goal scoring opportunities. The future pathways from this work are boundless. Which players are most effective in creating space? Which players play the optimal passes into dangerous spaces? Which tactics are optimal for attacking a percieved weakness in an opponent? These are just some of the examples, as the future of football analytics continues to grow and new techniques are developed, the dawn of an even greater level of understanding of the beautiful game is arriving.